Ultra Wideband

This document consults on a position to adopt in Europe on ultra wideband devices in 3.1-10.6GHz

Consultation

Publication date: **13 January 2005**

Closing Date for Responses: **24 March 2005**

Contents

Section		Page
1	Executive summary	2
2	Introduction and history	6
3	Regulatory issues – statutory duties and the international work	12
4	Economic analysis	15
5	Technical analysis	23
6	Ofcom’s proposed position	31
7	Responding to this consultation	37
8	Consultation questions	42

Annex		Page
1	Ofcom’s consultation principles	39
2	Consultation response cover sheet	40
4	Analysis of previous technical studies	44

Section 1

Executive summary

Introduction

1.1 One of Ofcom's key statutory duties is to ensure the optimal use of the radio spectrum under its management1. Radio spectrum is a major asset to the UK, contributing some £24bn to the economy each year and underlying many aspects of our lives. Radio communication is critical to areas such as air travel, emergency services, cellular telephony, sound and television broadcasting, defence and our utilities.

1.2 A new technology called ultra wideband (UWB) has emerged which potentially could change some aspects of the use of the radio spectrum. Ofcom believes that it should develop a strategy towards UWB in order to meet its statutory duties, allow it to negotiate effectively at an international level and to optimise the benefits that UWB might deliver.

1.3 This consultation document asks for views on our proposal that we work with European bodies to achieving a harmonised approach throughout Europe to UWB and consults on what view we should present to these bodies.

Outline of the issues

1.4 Though the concept of UWB dates back many decades, it was only in the late 1990s that technology had advanced sufficiently for it to be practical in consumer electronics. UWB allows a high data rate to be achieved with relatively simple equipment but results in transmissions spread across large parts of the spectrum used by others. UWB might be used to deliver wireless connections between DVD players, displays and speakers, for example, simplifying installation and removing the need for unsightly wires. It might provide a wireless high data rate link between digital cameras and computers or link computers, PDAs and other computing devices in a local area. Other more specialised applications of UWB include radars that can see through walls or can probe the ground to find anomalies such as cracks in runways. Predicting future applications is rarely accurate, but with its unusual properties UWB might open up many innovative uses.

1.5 In accordance with Ofcom's general philosophy of letting market mechanisms apply, we have looked at whether market mechanisms can be used to determine if UWB should be introduced. Specifically, we have assessed the possibility for interference agreements to be made between UWB users and current licence holders. As explained later, given the likely applications for UWB technology, we think it will be appropriate to exempt most UWB devices (when operated within defined limits) from a requirement to obtain a licence, ruling out any practical discussion with existing licence holders. Hence it falls to the regulator to decide whether, and under what circumstances, UWB should be permitted[2].

1.6 In coming to a decision as to whether UWB should be allowed it is necessary to consider the arguments both for and against it.

[1] Ofcom does not manage the entire spectrum. Some is managed by Government Departments- primarily the MoD and CAA.
[2] The US regulator has already authorised UWB on a licence-exempt basis, with different legislation covering different classes of UWB devices such as ground probing radar, through-wall imaging and general communications systems.

- **For**. Allowing UWB would seem to Ofcom to be broadly in line with our statutory duties, as long as the conditions which are applied to use of UWB technology are appropriate. Ofcom's view is that, under appropriate regulation, UWB could bring substantial net economic benefits to the UK as well as promoting innovation.
- **Against**. Allowing UWB might cause interference to existing licence holders or other authorised services and as a consequence, might degrade the service they offer, or increase the cost of providing these services to consumers. The potential for interference, and the likely level of any such interference, needs to be weighed carefully against the potential benefits of introducing UWB.

1.7 While in principle the arguments for UWB appear strong, determining the potential for interference through technical studies has not been conclusive to date. The studies undertaken so far are sensitive to assumptions around device penetration levels and on how much of the tolerable interference level is allowed to come from UWB. As an example, the current international norms provide for an interference level of up to 1% of the noise floor of a primary service to come from a secondary service. Under these norms UWB would only be allowed to transmit up to some portion of this interference allowance. We have evaluated the existing studies, many of which are based on the US spectrum mask[3], and have conducted a number of our own. Our provisional conclusions, as discussed further in this consultation document, are that:

- We agree with the technical studies that suggest, depending on the spectrum mask chosen, that there could be potential interference to 3G, broadband fixed wireless access and radio astronomy.
- We recognise the concerns expressed in relation to potential interference to other services including fixed links, satellite receivers and radar systems, but we believe that such interference is unlikely to be significant in practice or can be mitigated with relatively simple mechanisms.

1.8 We believe that the risk of interference to 3G operators in their currently licensed spectrum can be reduced to insignificant levels by applying an appropriate mask outside the core UWB bands (which have been set in the US as 3.1 to 10 GHz). However, we cannot adopt this approach towards broadband fixed wireless access and radio astronomy, both of which use spectrum in the core UWB band, without potentially losing a substantial share of the estimated benefits. There are a number of possible solutions to mitigating the potential interference to broadband fixed wireless and radio astronomy which we would like to explore as part of this consultation including some new techniques recently offered for consideration in the relevant ITU-R forum.

1.9 Bearing in mind the substantial economic benefits that might derive from adopting UWB, and subject to finding a way ahead in those areas where we remain concerned about possible interference, Ofcom's proposal is that if UWB is allowed it should be limited to the same in-band power levels as permitted in the US but with tighter out-of-band limits. Such a mask should, in Ofcom's view, protect key services while maximising consumer benefits. In this document we suggest a particular mask that we believe might achieve these aims, namely one where the allowed emission level falls from -41dBm/MHz at 3.1GHz to -85dBm/MHz at 2.1GHz.

[3] UWB regulation sets out upper limits as to the amount of power that can be radiated at any particular frequency, considering frequencies both within the core band of 3.1 - 10.6GHz and outside of this band. This regulation is termed a "mask". The Federal Communications Commission (FCC) in the US has set out such a mask in its regulation of UWB.

1.10 We are now consulting on whether UWB should be allowed or not, and if allowed what the most appropriate mask would be. Subject to the outcome of this consultation, we will communicate our opinion to the EC, CEPT and ITU in order to aid the process of reaching international agreement and standardisation on UWB.

The risks of inaction

1.11 We believe it is important to consult now on this issue. If we do not form a position soon then it is possible that UWB devices conforming to the US specification will be imported illegally into the UK, eg in electronic devices purchased over the Internet. It would be extremely difficult to detect and halt this process since it is typically not possible to detect a UWB device outside of the room in which it is transmitting. As discussed above, we consider the US specification to be inappropriate for the UK and wish to minimise the risks from the use of equipment conforming to this specification being used in the UK. We think that the best way to minimise the incentives for UK consumers to import US equipment is to reach a decision on the appropriate standard as soon as it is practical. This might involve a rapid development of a pan-European specification for UWB, encouraging manufacturers to build and distribute products within Europe, and possibly worldwide, conforming to our preferred specification. If we are not able to form a position soon we believe that the outcome for spectrum users in the UK could be significantly worse than it might otherwise have been.

1.12 The development of a pan-European specification for UWB is already being considered in a number of international fora. In order to be able to meaningfully contribute to this process, and at an appropriate time, Ofcom considers it is important to begin the consultation process with our stakeholders now. For example, and as discussed further in this document, it is likely that the European Commission will be considering this issue at a number of junctures throughout 2005, and Ofcom is seeking to be in a position where we can helpfully assist in the development of a European position on UWB as part of the European Commission's process.

Different types of UWB devices

1.13 There are a number of different types of UWB devices, based broadly on the application to which they are likely to be put. In this consultation document, we have grouped the devices into two categories:

- Generic devices that might be used for a wide range of applications such as personal area networks (PANs).
- Specific devices used for ground probing radar, 'through the wall' imaging and a number of other specialist applications.

1.14 This document applies only to the former category. The latter set of devices are already allowed in the UK under licence and we are not proposing at this point to change this approach.

Key points for consultation

The key points we wish to gather opinion on are:

1. Whether it is appropriate for Ofcom to take a regulatory view on UWB.

2. Whether Ofcom has considered all the appropriate evidence and has analysed it correctly.

3. What our preference towards allowing UWB should be.

4. What our strategy should be towards influencing and co-operating with international bodies.

Question 1: *Are these the appropriate topics to be consulting on?*

After this consultation is complete, and subject to the responses and action in Europe, we envisage that a further round of more detailed consultation may be required to take into account responses to this document and fresh evidence expected to arise.

Section 2

Introduction and history

Introduction

2.1 Ultra-Wide Band (UWB) is a technology developed to transfer large amounts of data wirelessly over short distances, typically less than ten metres. Unlike other wireless systems, which use spectrum in discrete narrow frequency bands, UWB operates by transmitting signals over a very wide band of spectrum. For example, the FCC has defined a radio system to be a UWB system if it has a spectrum that occupies a bandwidth greater than 20% of the central frequency or an absolute bandwidth greater than 500 MHz. Under FCC rules, UWB devices are subject to certain power, frequency and operational limitations including being limited to the 3.1 to 10.6GHz frequency band.

2.2 UWB has a variety of possible applications. Those that are estimated to bring most economic benefits to UK consumers are likely to be in the PAN environment, which includes homes and offices. Other potential applications for UWB include ground-probing radar, positioning location systems, wireless sensors, asset tracking and automotive systems. It is generally assumed that the majority of UWB applications will fall into the category of consumer communications and high speed networking within PAN environments[4].

2.3 Until recently, almost all data connections between electronic devices in the home and office environments were made using cables (both wire and fibre), with limited deployment of infra red (IR). However, in recent years, there has been increasing interest in replacing cable and IR connections by 'wireless' links that transmit signals using radio spectrum. Prominent wireless technologies deployed to date include Bluetooth and the 802.11 series of wireless LAN (WLAN) technologies. Wireless links offer a number of benefits to the consumer, including greater flexibility in positioning devices, ease of making occasional connections and the aesthetic advantage of cable replacement.

2.4 UWB is a potential alternative to other local area wireless technologies, such as Bluetooth, WiFi and other WLAN technologies. The principal advantage of UWB over existing wireless alternatives is that it offers much faster data transfer rates (100 Mbits/s up to 1Gbits/s). Other advantages of UWB include extended battery life for consumer goods (owing to the low duty cycle and bursty nature of UWB connections leading to power savings) and cost (the anticipated volume of chipsets potentially on a global basis bringing economies of scale).

2.5 The characteristics and cost of UWB in the UK market may be affected by the regulatory approach adopted by Ofcom as described in later sections of this document.

[4] Up to 90% the UWB market is expected to be indoor applications in PAN environments (source: Mason Communications study for the Radiocommunications Agency, October 2003)

History

Introduction

2.6 The concept of UWB dates back many decades. However, it was only in the late 1990s that technology had advanced sufficiently for it to be practical in consumer electronics. It was at this point that regulatory interest also started. This section provides a brief overview of regulatory involvement, concentrating predominantly on the UK. From the history it can be seen that the commercial exploitation of UWB has been under consideration for around five years. The first part of this, from 1999 to 2002 was less intensive. However, after the FCC approved UWB in 2002, many of the international and national fora dealing with spectrum management concentrated their research efforts on the frequency bands specified by the FCC. A clear thread running through this history is the difficultly in reaching definitive technical assessments in the absence of data on UWB deployments and experimental evidence.

1999

2.7 Following a presentation of UWB technology from Time Domain the UK Radiocommunications Agency (RA) commissioned Multiple Access Communications Ltd to carry out an investigation into the potential impact of UWB transmission systems on other radio services. This initial investigation was completed in August 1999. The report was generally positive towards UWB[5]. It found that:

1. In rural areas, the interference on a noise-limited cellular system was predicted to be negligible, ie, less than 1dB degradation, for UWB source densities of less than 50 per km2. Similarly for urban areas, the interference on a CDMA system was predicted to be insignificant for UWB source densities of 100 per km2. For an interference limited FDMA/TDMA cellular system the maximum density of UWB sources in an urban area before causing interference was estimated as 2,500 sources per km2.

2. Up to five UWB devices in a typically sized residential home could be operated before a TV receiver's performance is degraded.

3. Published theoretical models conclude that the interference from terrestrial UWB devices will be harmless to navigational devices in aircraft.

4. A UWB microcellular system or wireless local loop system in an urban area could degrade the performance of cellular receivers in all street areas, because a cellular receiver is always within close range and in LOS of a UWB device.

In November 1999, the 3G Information Memorandum was published. On the topic of UWB it stated:

"Devices using ultra-wideband technology are in operation in the UK, including portable ground-probing radar. The 3G spectrum is within the operating range of these devices. The RA permits the use of ultra-wideband devices on the basis that they do not cause interference to, or claim interference protection from, other licensed systems.

[5] Note that these findings relate to UWB transmission in lower frequency bands than is currently proposed resulting in a greater interference potential to TV and cellular systems than the current proposals.

To date, ultra-wideband devices have not been identified as the source in any interference cases investigated by the RA. Nevertheless, the RA continues to monitor interference reports to determine whether there is any correlation between interference cases and the use of these devices.

In any case where interference to licensed 3G operations is linked to the use of ultra-wideband equipment, the RA would act to prevent the use of the ultra-wideband device causing the problem."

2000

2.8 By 2000 the FCC and the National Telecommunications and Information Administration (NTIA) in the US had completed extensive tests to determine the interference potential of UWB to conventional narrow band radio services. The NTIA expressed particular concern in regard to potential interference to a range of Federal systems including, for example, the Global Positioning System, Search and Rescue Satellite System, Air Traffic Control System and Meteorological Radar System. The Federal Aviation Authority (FAA) and the airline industry generally, were very vocal in their opposition to UWB during the public enquiry stages of the FCC studies.

2001

2.9 The first European Radio Office (ERO) UWB Workshop was held in March 2001. In May 2001one of the leading manufacturers gave a formal presentation on UWB technology to the UK's Spectrum Management Advisory Group (SMAG)[6].

2002

2.10 Early in 2002, the RA commissioned Aegis to study the compatibility issues pertaining to UWB. The primary objective of this study was to perform a literature search of compatibility issues relating to the implications of UWB technology on the existing technologies and to identify areas where further investigation might be required.

2.11 The literature survey revealed that compatibility analyses of UWB technology with respect to other radio services had been undertaken to various degrees by employing both measurements and theoretical analysis. It was noted that compatibility with the Global Positioning System and the Aeronautical Services had been investigated extensively while the implications of UWB emissions into terrestrial fixed, mobile and broadcast services had been examined to some extent. It was also noted that compatibility with Satellite Services, Radio Astronomy, the Amateur Service, Military Services and Licence-exempt systems required further investigations.

2.12 Furthermore, key issues surrounding UWB compatibility were noted to be:

- interference being dominated by a single nearby device or an aggregation of devices in the vicinity of the victim;
- the assumption that UWB signals resemble Gaussian noise;
- the difficultly in measuring UWB signals using conventional spectrum analysers.

2.13 On 14 February 2002 the US FCC issued a First Report and Order for UWB technology and authorized the commercial deployment of UWB technology, though subject to technological and operational constraints. This followed extensive

[6] SMAG was an advisory body to the RA. Ofcom has appointed a similar body called the Ofcom Spectrum Advisory Board (OSAB).

consultations that led the FCC to conclude: *"UWB devices can be permitted to operate on an unlicensed basis without causing harmful interference provided appropriate technical standards and operational restrictions are applied to their use".*

2.14 In Feb 2002, RA published a report on the effect of pulsed UWB to Bluetooth and GSM 1800 which was undertaken by RA Radio Technology and Compatibility Group (RTCG). The results showed that the UWB signal is noise-like as a source of interference.

2.15 In April 2002, RA published another RTCG report on UWB compatibility with T-DAB and DVB-T which measured the maximum protection ratio required by T-DAB and DVB-T against pulsed UWB interference. RTCG also carried out similar measurement on RLANs.

2.16 In April 2002 the second ERO / EC Workshop on UWB was held in Mainz, Germany and in July 2002 the IEE and RA held a joint colloquium[7]. This event presented the state of the art in UWB technology and its potential applications. The sessions addressed implementation and regulation issues.

2.17 In December 2002, RTCG produced another report on the assessments of UWB interference into a typical C band (3.6 - 4.2GHz) TVRO satellite earth station. The preliminary assessment suggests that no significant interference issues are expected from low power UWB transmitters, provided that the emissions comply with the FCC requirements.

2003

2.18 In January 2003 the ITU-R formed task group (TG) 1/8 to investigate all UWB issues including compatibility with other radio services.

2.19 In February 2003, the FCC published a Memorandum Opinion and Order and Further Notice of Proposed Rule Making in response to a number of petitions for reconsideration of its original decision. The FCC decided not to make any substantive changes to its recently adopted rules because there had neither been sufficient time to gain experience of the operation of UWB, nor for the completion of necessary tests being undertaken by various entities.

2.20 Also in February 2003, Masons Communications issued their final report on a study commissioned by the RA on the impact of UWB on 3G. The Report used a technical assessment to demonstrate the level of detrimental effect that UWB would have on a UMTS handset when the two devices were a few metres apart. The Report stated that the overall impact of UWB would depend on which of the UWB applications were used. In the case of re-distributing digital TV or updating a computer monitor the duty cycle will be high. On the other hand, using UWB as an enabler for downloading music files to a hi-fi, for example, might mean duty-cycles of only seconds per hour. The potential for interference is reduced when the fraction of active devices in a community is small. A methodology was recommended to carry out a structured market-based analysis approach.

2.21 In October 2003, Masons issued a second report on a study commissioned by the RA on the impact of UWB on 3G. Simulations were performed using a power spectral density (psd) of –65dBm/MHz in the 2.1GHz band. It was shown that under worst case cell edge conditions a UMTS to UWB coupling loss of 50dB was needed to ensure that no errors are introduced. Recommending a PSD emission limit in the 2.1

[7] http://www.ofcom.org.uk/research/industry_market_research/technology_research/tsc/uwb/

and 2.5GHz bands for UWB depends very much upon the actual expected coupling loss experienced between a UMTS Terminal and a UWB device when they are physically next to one another (e.g. terminal next to laptop PC, or on a set-top box). The report recommended that the actual minimum coupling loss be determined through experiment.

2.22 In October 2003 work on compatibility between 3G handsets and UWB devices was undertaken by the Ofcom laboratories to verify the assumptions used in the modelling of UWB signal in technical studies which confirmed that UWB looks like Gaussian white noise in the 3G channel, even for a low PRF.

2004

2.23 In January 2004 Aegis issued their final report on a study commissioned by the RA to assess the impact of UWB on the Fixed and Fixed Satellite Service. The report describes a study undertaken between October and December 2003 by Aegis Systems Limited for the RA into sharing between UWB systems and the UK Fixed Service (FS) point-to-point (PP) and Fixed Satellite Service (FSS) links operating in the band 3–10 GHz.

2.24 In February 2004 an interim policy statement on UWB was published on the Ofcom website. This explained that Ofcom (in whom the duties of the RA were vested at the end of 2003) was gathering evidence on the advantages and disadvantages of UWB and was participating in the work of CEPT, ETSI and the ITU-R. Ofcom was also initiating independent studies and gathering comments from interested parties. Until the results of the studies had been evaluated UWB operational systems would not be permitted for use in the UK.

2.25 In March 2004 Ofcom commissioned a study into the economic benefits of UWB. This is introduced in Section 4 of this document.

2.26 In April 2004 ECC TG3 was set up within CEPT to complete and report on the UWB work started by SE24 and SE21 and to develop the draft CEPT responses to the European Commission mandate to CEPT to harmonise radio spectrum use for UWB in the European Union. This Task Group provided a draft report to the EC during October 2004.

2.27 In June 2004, Ofcom conducted some measurements on the noise emitted by individual electronic equipment commonly used in an office environment and measurements undertaken provide an initial indication that, at many locations in a modern office environment, the sensitivity of certain victim services would be limited by the ambient radio noise in the environment, rather than the radio noise generated in the receiver.

Summary

2.28 In this chapter we have introduced UWB and considered the historical developments. We noted that:

- UWB is a novel technology potentially enabling innovative applications, particularly in the home and office.
- The possible interference between UWB and other wireless systems has been studied for some five years but despite considerable national and international effort this work has not succeeded in reaching a consensus on the issue of a common spectrum mask for UWB.

2.29 In the next chapter we look at the regulatory duties that inform Ofcom's decision on UWB and study international developments in more detail.

Section 3

Regulatory issues – statutory duties and the international work

Statutory duties

3.1 In line with its principal statutory duties under section 3 of the Communications Act 2003 (the 2003 Act), Ofcom seeks to further the interests of citizens in relation to communication matters and to further the interest of consumers in relevant markets, where appropriate by promoting competition. Ofcom has additional statutory duties relating to its activities in the area of spectrum management which stem from sections 4 and 154 of the 2003 Act. Section 4 in particular requires Ofcom to promote competition in the provision of electronic communications networks and services, and to secure that Ofcom's activities contribute to the development of the European internal market.

3.2 Section 154 of the 2003 Act additionally requires Ofcom, in carrying out its spectrum management duties, to have particular regard to the:

- Availability of spectrum for wireless telegraphy, and
- Current and likely future demand for spectrum.

And to the desirability of promoting:

- Efficient management and use of the spectrum
- Economic and other benefits arising from its use
- Development of innovative services; and
- Competition in electronic communications services.

3.3 Ofcom has also made it clear, as part of its published regulatory principles, that it aims to adopt a light touch approach, deregulating or simplifying regulation wherever possible.

3.4 Additionally, and prior to allowing the lawful use of UWB equipment in the UK, Ofcom has to decide under the Wireless Telegraphy Act 1949 how it will authorise use. Under Section 1 of that Act it is illegal to use radio apparatus without a licence granted by Ofcom, unless a regulation is made to exempt such use. In deciding whether to make an exemption, Ofcom needs to be satisfied that the exemption would not be likely to involve undue interference[8] to other authorised services.

3.5 Ofcom has carefully considered all of its relevant statutory duties in forming the proposals set out in this consultation document. Our analysis as to how these duties relate to UWB is as follows:

- **Availability of spectrum.** If UWB can be deployed without undue interference to other authorised services then it effectively increases the availability of spectrum. It does this not in the conventional sense of making more frequencies available, but by more efficiently using spectrum already allocated.

[8] In the Communications Act the term undue interference has the same meaning as harmful interference as defined by the ITU Radio Regulations (See RR 1.169).

- **Current and future demand for spectrum.** The economic study, discussed in Section 4, suggests there may be a demand for some novel applications that can only be provided using UWB technology. Therefore, allowing UWB would be in line with this duty.
- **Efficient management and use of the spectrum**. Similarly to above, if UWB can be deployed without causing undue interference to existing applications then it increases the benefits that can be generated by the radio spectrum.
- **Economic and other benefits**. As discussed in Section 4, UWB is likely to bring significant economic benefits.
- **Development of innovative services.** UWB would allow a number of new innovative services to be deployed.
- **Promoting competition in electronic communications services.** Allowing UWB devices to be used would increase competition in the provision of a wide range of short range wireless devices and applications.
- **Development of the European internal market.** Working within Europe to harmonise any regulations concerning UWB would further this duty.

3.6 Ofcom therefore considers that allowing UWB subject to appropriate conditions and in accordance with any relevant European decision would be in line with the majority of Ofcom's statutory duties.

Question 2: *Do you agree with this analysis of our statutory duties? Are there any important factors that have been omitted?*

International work

3.7 The international work with respect to the analysis of the likely impact of UWB falls into three areas, the International Telecommunication Union (ITU), the European Conference of Postal and Telecommunication administrations (CEPT) and the EC. However, there is a close link between the CEPT and EC work since, under the EC Radio Spectrum Decision [676/2002/EC], the European Commission has the power to mandate CEPT to carry out work and has in fact done so in the case of UWB. The decisions of CEPT generally are not themselves legally binding on administrations, but can become so if endorsed by the Commission and made the subject of a decision under the Radio Spectrum Decision.

ITU

3.8 In January the ITU-R Study Group 1 (SG1) set up task group 1/8 (TG1/8) to provide a single focal point in dealing with regulatory and technical aspects of UWB. Its activities are divided into 4 working groups and it is responsible for the following outputs

- Recommendation on UWB characteristics.
- Recommendation and report on the impact of UWB on other radio systems.
- Recommendation on a spectrum management framework for UWB.
- Recommendation on techniques for measuring UWB emissions.

3.9 TG1/8 is planned to complete its work for presentation to the SG1 meeting in October 2005.

CEPT

3.10 In 2004, the CEPT's Electronic Communications Committee (ECC) created a new Task Group, ECC TG3, to develop a European position on UWB. ECC TG3 took over the work which was being carried out in a number of other areas within the CEPT. ECC TG3 is open to ETSI members in accordance with the terms of the CEPT/ETSI MoU. Its general mandate can be described as follows:

- To develop the draft ECC Report on UWB.
- To develop the draft CEPT responses to the European Commission mandate to CEPT to harmonise radio spectrum use for UWB Systems in the European Union.
- To coordinate European positions in preparation for ITU-R TG1/8 on UWB issues.

The EC

3.11 The European Commission, through the Radio Spectrum Committee established under the Radio Spectrum Decision, issued a Mandate to CEPT on 12 March 2004 under Article 4 of that Decision. CEPT was mandated to undertake all necessary work to identify the most appropriate technical and operational criteria for the harmonised introduction of UWB-based applications in the European Union. As explained above, this work is being taken forward within ECC Task Group 3 with contributions from administrations and industry. The target date for completion of the work is April 2005. The Commission may decide to produce a Decision, following completion of the CEPT's work which, as explained above, would become binding on Member States. It is this process which Ofcom intends to provide meaningful input into as a result of this consultation and the other work we are undertaking in relation to UWB.

Summary

In this chapter we have:

- Set out our statutory duties and Ofcom's view that allowing UWB subject to appropriate conditions and in accordance with an EC harmonisation decision would be in line with the majority of these.
- Provided details of the various national and international studies into UWB, of which that mandated by the EC may be the most important for us, because the EC has the power to determine the regulation of UWB throughout Europe.

In the next chapter we examine the economic assessment performed by consultants.

Section 4

Economic analysis

Introduction

4.1 One of Ofcom's statutory duties is to ensure the optimal use of the radio spectrum. Ofcom generally interprets this optimising the economic value of the spectrum. Often this will also be the most technically efficient use, since improved technical efficiency generally results in increased utilisation and greater economic value. Ofcom believes that the use of market mechanisms will result in the economically optimal use of the spectrum in most cases. This means that potential interference problems could be minimised and resolved by the parties that generate interference and those that are affected by it. However, this cannot to be expected to occur for UWB applications. This is because Ofcom considers that, if UWB equipment is to be allowed in the UK, it is most likely to be on a licence-exempt basis. In these circumstances, it seems unlikely that a multitude of UWB users or manufacturers of the devices could negotiate with the many hundreds of licence holders within the wide range of frequencies potentially affected by UWB. It is therefore very important that Ofcom, prior to taking a decision to allow UWB devices in the UK, is certain that such an approach would be in the best interests of the country overall. As part of the process of assembling a body of evidence to assist us in deciding whether UWB is in the interests of the UK, we commissioned an economic analysis of the costs and benefits.

Summary of the Masons study[9]

Introduction

4.2 During 2004, Ofcom commissioned Mason Communications Ltd and DotEcon to undertake a study to estimate the net economic benefits that might be generated in the UK by a decision to allow UWB. It is important to note that this study is just one of the pieces of evidence used by Ofcom in forming its proposals. Ofcom does not consider the study to be complete and has taken into account concerns over the study in considering UWB. As described in more detail below, Ofcom has commissioned further study to build on the work performed by the consultants.

4.3 This section provides a near-verbatim copy of the executive summary of the economic study. The full study is available on the Ofcom website. The study included an extensive consultation process with industry representatives.

Study Objectives

4.4 The aim of the study was to estimate the economic benefits and costs associated with UWB deployment for PAN applications. By ‘costs’ and ‘benefits’, the consultants mean negative and positive impacts respectively on social value (or welfare) generated for the United Kingdom. For the purposes of this study, they focused only on the net impact on value across the economy, not on the distribution of costs and benefits between different groups of firms and individuals.

4.5 Specifically, the study compared the net private benefits to consumers from using UWB-enabled devices (rather than alternative technologies) with potential external

[9] The conclusions of this study represent the views of Masons Communications and DotEcon as presented to Ofcom for its consideration.

costs in terms of spectral interference to other radio services. By offsetting total interference costs against total net private benefits, the consultants derived a first pass assessment of the overall value to the United Kingdom from UWB deployment. However, because they did not calculate all the relevant costs, their assessment must be considered to be preliminary and subject to further study. This further study is on-going and we expect to publish further results early in 2005 as discussed in more detail below.

Net Private Benefits from UWB

4.6 Using UWB to transmit data between enabled devices for applications generates private benefits for consumers wherever it offers better quality or lower costs compared with alternative wireless technologies. The consultants estimated the flow of net private benefits across the UK population by:

- Identifying PAN applications for UWB and comparing their characteristics and the likely cost of using UWB relative to alternative wireless technologies.
- Where there are quality differences, estimating the willingness to pay of UK consumers for UWB based on an hedonic pricing survey of existing devices for PAN applications that use wireless technology.
- Forecasting cost (relative to alternative technologies), take-up and usage of UWB devices.

External Costs from UWB

4.7 The consultants assumed that UWB devices would occupy spectrum from 3.1 to 10.6 GHz. Existing, and potential future, systems operating either in this band or neighbouring bands might be subject to interference from UWB emissions. This study focused solely on external costs to systems currently active within or neighbouring the proposed spectrum for UWB. As a result, it did not consider the costs for future systems, as yet not deployed or envisaged. This omission is discussed further below.

4.8 The consultants estimated interference costs based on current UK licensed use of the radio spectrum, by:

- Identifying those systems potentially vulnerable to UWB interference (particularly those which are likely to be used in close proximity to UWB devices).
- Modelling the impact of interference using Monte-Carlo techniques, based on their forecasts of UWB take-up and usage.
- Where there was a potential impact on Quality of Service (QoS), calculating the cost of the additional network measures (build and/or running costs) that would be incurred in restoring quality of service to the level without the interference being present.

Regulatory Scenarios

4.9 There is a variety of options available for regulating UWB deployment in the UK. The characteristics and price of UWB in the UK market, and the scope for interference with other services may be affected by the approach adopted. The consultants considered the impact of regulation of UWB PAN applications on net value to the UK under four alternative regulatory scenarios:

- **The FCC indoor mask** - the UWB transmission range and emission limits for UWB indoor communications applications adopted by the FCC in the United States.
- **The draft ETSI UWB mask** - the draft European UWB emissions mask for UWB indoor communications systems currently being considered within CEPT and ETSI. Relative to the FCC mask, this envisages introducing additional transmission limits on UWB at the edges of the 3 to 10 GHz operating band[10]. The consultants considered two variants of this mask:
  - The current version, which envisages a Power Spectral Density (PSD) of -65 dBm/MHz at 2.1GHz. This is termed the "ETSI mask".
  - A revised version, with a tighter PSD of -85 dBm/MHz at 2.1GHz. This is termed the "proposed Ofcom revision to the ETSI mask".
- Lower band only - restricting UWB PAN transmissions to the lower part (3-5 GHz) of the 3 to 10 GHz frequency band.
- Upper band only - restricting UWB PAN transmissions to the upper part (6-10 GHz) of the 3 to 10 GHz frequency band.

Assumptions

4.10 Within the scope of the study the consultants sought to develop a conservative methodology by deliberately taking conservative assumptions in modelling external costs and modelling a lower bound for net private benefits. Throughout the study, they have therefore made a series of conservative assumptions, for example, in relation to the potential benefits and cost levels of UWB relative to alternative technologies, and have attempted to reflect ‘worst case’ interference scenarios with current systems (particularly in terms of the likely co-incidence of UWB within the interfering range of other radio services) within the external cost assessment. However, there have been a number of services that they have not quantified including broadband fixed wireless access (BFWA) and systems not yet deployed.

4.11 As with any new technology, there is particular uncertainty about potential levels of take-up and usage of UWB. Therefore, for each of the regulatory scenarios, they modelled low, central and high cases for take-up of UWB-enabled PAN applications over the period 2004-2020.

Value of UWB

4.12 The study attempted to consider all external costs but was unable to do so in for some services. In some cases it identified that UWB will not create external costs for other radio services; in others, insufficient data existed to enable the consultants to accurately estimate the impact. Further work is underway to assess costs for BFWA and future systems not yet deployed which may change the overall conclusions of the report.

4.13 The main finding, subject to the further work needed, was that UWB has the potential to make a substantial contribution to the UK economy, generating about £4bn (discounted) in value over the next 15 years. For the period to 2020, net private benefits exceed external costs under all the regulatory scenarios considered (however, in the case of the FCC mask, a positive net value is not achieved until 2020 and significant external costs are present in the period preceding this). There are large

[10] This mask is still being considered within CEPT and ETSI; we consider the mask as it was envisaged in May 2004.

variations in value between the scenarios, as illustrated in the graph below[11]. The UWB emission level has a significant effect on UMTS costs, as does the level of UWB uptake (they compared high, central and low predicted uptakes within the report). Assuming the FCC mask, cumulative 'costs' rise to nearly £1bn per UMTS network for the period 2004-2020 (under the central UWB take-up forecasts). At an emission level of –65dBm/MHz (the ETSI mask), the cumulative costs are much smaller at £35m per network, again under the central uptake forecasts[12]. For an emission level of 85dBm/MHz, (the proposed Ofcom revision to the ETSI mask) under the central UWB uptake forecasts, the model predicts the impact of UWB on the UMTS network QoS is negligible, with very few instances of interference being measured.

4.14 The consultants concluded that the value to the UK is likely to be maximised if chipsets deployed in UWB PAN devices meet the draft ETSI standard, or the proposed Ofcom revision of this. By contrast, the FCC mask scenario does not look attractive, owing to the potential for very large external costs related to interference with UMTS networks, which significantly offset benefits. The lower and upper band scenarios also generate less value than the draft ETSI masks. The lower band restriction would not affect initial deployment of UWB but might affect future development of higher specification chipsets. The upper band restriction would mean that existing chipsets could not be deployed in the United Kingdom, and manufacturers would have to develop entirely new chipsets for the UK market. The consultants estimated that this could setback the launch of UWB by five years or more.

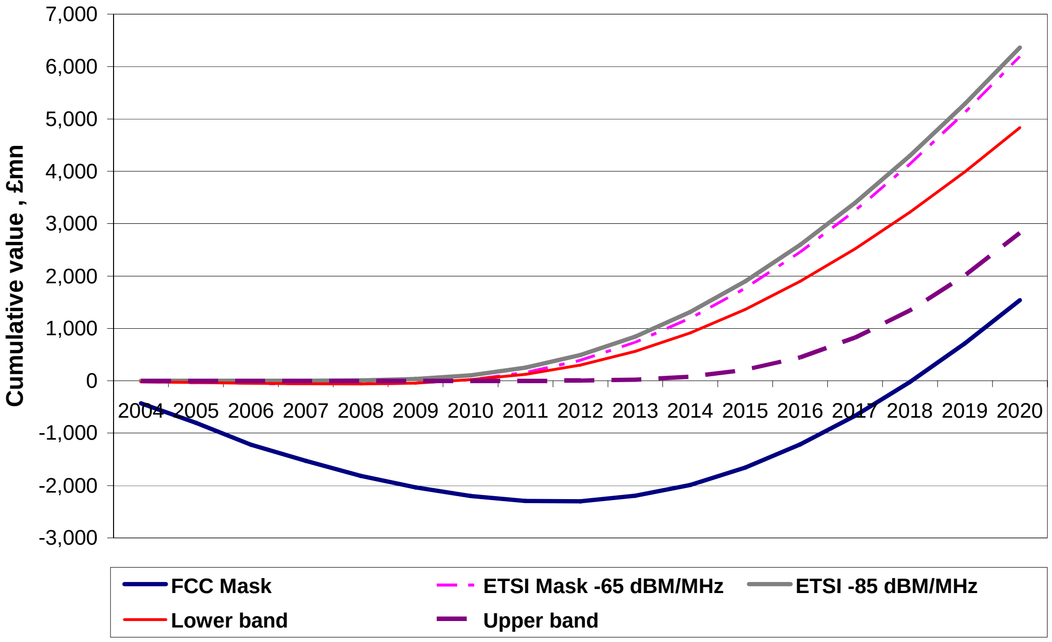

Figure 4:1 - Initial view, subject to further studies, of net value of UWB PAN applications under different regulatory scenarios, central case undiscounted (£m)[13]

Recommendations provided by the consultants

[11] The graph presented here illustrates net value, based on the central UWB uptake forecasts, with the UMTS reference year for costs set at 2015.
[12] UMTS costs are relative to a predicted degradation in QoS, which is significant at an emission level of –51 dBm (a 4% change). At –65 dBm the QoS change is still measurable but relatively small at around 0.1-0.2%.
[13] This graph reflects net value (benefits minus costs) assuming the central UWB uptake forecasts, taking the worst case QoS impact that the model predicts under this scenario (reference year of 2015).

4.15 Based on these conclusions and taking into account the limitations of this study that are fully described in the main body of their report, the consultants offered the following recommendations in relation to regulation of UWB for wireless PAN use:

1. Ofcom pursues a policy within Europe of promoting the draft ETSI UWB mask for indoor communications applications, possibly subject to modifications of the roll-off below 3GHz. This recommendation is based on an understanding from manufacturers that UWB chipsets can meet the tighter limits applying at the edge of the mask relative to the FCC mask, such that benefits predicted in this study are not affected.

2. There appears to be scope for tightening the roll off of the ETSI mask below 3 GHz to a level of –85 dBm/MHz without eroding UWB benefits. At this PSD level, the costs to UMTS operators will be minimal. Therefore, there does not appear to be any compelling reason for applying power restrictions below this level.

3. Based on an assessment of current UK frequency utilisation, it is recommended that both the upper and lower bands should be made available for UWB. Restricting UWB to the lower band would potentially constrain future value for no obvious benefits. Restricting UWB to the upper band only would be value destructive.

4. There is scope for further investigations into the interference effects of UWB on various services, including wireless broadband, UMTS and aeronautical radar. This might lead to additional insights in relation to the detailed regulation of UWB emissions for UWB PAN and other envisaged applications of UWB. However, it is unlikely that this will impact on the finding that net welfare from UWB for the United Kingdom is greatest under the draft ETSI UWB mask (or variant), because the level of UWB benefits occurring by 2010 in this scenario are predicted to significantly outweigh costs. As highlighted by the scope of work, the study does not address the potential impact of UWB on future technology investment. It is noted that within some industries considered in this study, notably 3G, there are ongoing developments in network technologies, implying significant future investment by network operators in systems using the 3 to 5 GHz portion of the spectrum. This is likely to include introduction of High Speed Downlink Packet Access (HSDPA) and potential expansion of mobile services into other frequency bands. Thus, Ofcom may wish to consider potential future utilisation of the 3 to 5 GHz portion of the radio spectrum in its setting of the UWB regulatory framework.

5. It is recommended that Ofcom should consider the adoption of rules governing the outdoor use of UWB in its overall policy determination on UWB. Such rules could be similar to those imposed by the FCC, for example prohibition on use of external antennas.

Note that Ofcom does not consider that this study is complete until the further work associated with estimating the costs to BFWA and future systems has been completed. Once this has been done, Ofcom will review whether these recommendations are still appropriate.

Question 3: *Do you agree with the economic study? Are there other studies that Ofcom should be conducting?*

Considering possible future deployments

4.16 In undertaking the economic study, after some debate and discussion, we guided the consultants not to consider the potential cost of interference from UWB to future systems, for example, equipment that might at some point be deployed in the 2500-2690MHz bands or possible 4G equipment. We came to this decision because we believed it would not be possible to quantify the cost to systems which in some cases have not yet been invented and for which there are no deployment plans. Further, we concluded that if UWB interference was predicted to be problematic for these new services, the licence holders would not be disadvantaged, because logically they would have taken this into account in making their bid for the spectrum. However, because of the concerns subsequently expressed by stakeholders we have revisited this decision.

4.17 We have divided future deployments into those that can be predicted with some confidence and those for which there is no current indication of spectrum, services and timescales. The former category we consider to be the 2500-2690MHz frequency band (sometimes termed the "3G expansion band") while in the latter we would include 4G (for which there is as yet no single clear definition).

4.18 We have commissioned a further study to attempt to provide additional quantification of the costs in the 2500 - 2690 MHz band. Here we consider it possible to develop a sensible range of scenarios based on existing understanding of how these bands might be used. We plan to publish this study early in 2005.

4.19 Turning now to the other class of future systems that cannot currently be predicted in any meaningful manner such as 4G, our view is that quantification of any costs is not sensible. Indeed, some have suggested that 4G might be a combination of multiple different access methods of which UWB might perhaps be one. Hence, it is possible that rather than being a potential interferer to future systems, UWB might be an integral part.

4.20 Finally, if it became clear that UWB was causing a significant economic impact to new technologies, there remains the option of modifying the UWB mask. Amending the mask would not be simple, as it is likely to require international agreement, but would none the less be possible were it judged sufficiently important.

Question 4: *Is there a better way that future use of the spectrum could be taken into account?*

Areas which were not considered in detail

4.21 Some uses of the spectrum were not quantified by the economic study because it was not felt that it was possible to place a value on them. These include broadband fixed wireless access (BFWA) and radio astronomy. However, we believe that it is possible to estimate at least the value on BFWA and have commissioned further work to assess this. Once we have determined a likely value, or range of values, we will add this to the other costs quantified in the economic study. Below, we discuss some of the issues associated with these areas.

Broadband fixed wireless access

4.22 The economic study identified BFWA deployments as potentially most at risk from interference from UWB devices. This is particularly the case for BFWA deployments where internal antennas are used (as opposed to those mounted on the outside of homes and offices). All BFWA operators in the UK are currently adopting or considering an approach of deploying systems with internal antennas. We have therefore commissioned a further economic study to model the potential cost to BFWA deployments of UWB under a range of different deployment scenarios and mitigation scenarios. We aim to publish this study early in 2005.

4.23 Subject to the results of that study, Ofcom considers that there may be a number of possible ways to mitigate the risk of interference, for example:

- The mask could be modified, with perhaps the lower frequency increased from 3.1 GHz to, say, 5 GHz, or "notches" inserted into the mask on a dynamic basis in the band currently used for BFWA (3.4 - 4.2 GHz). This might reduce the interference to BFWA, but it might also reduce the benefits of UWB by increasing device costs.
- Make it the responsibility of the end user to perform their own interference mitigation by advising affected BFWA customers not to use UWB devices in proximity to their BFWA antenna. This has the advantage of not reducing the benefits from UWB or BFWA but might not be preferred by affected users or operators, and might not be viable if, for example, the customer is using UWB to link their computer and monitor together.
- Increasing the robustness of the BFWA deployment, perhaps by using directional antennas. This has the disadvantage that it increases the costs of deploying BFWA.
- UWB devices could be required to cooperate with BFWA systems. One possibility is for UWB devices to detect BFWA signals prior to transmitting and if any are discovered to modify their behaviour accordingly. Another might be for BFWA devices to include UWB transmitters which would broadcast some form of "silence command" to other nearby UWB devices just before the BFWA was due to receive data[14]. This might work if BFWA operators in the 3.5GHz band choose to implement systems based on time division duplex (TDD).

We would welcome views on whether there are other possible solutions, and which is the most appropriate.

Question 5: *What is the most appropriate solution to the potential interference from UWB to BFWA?*

Radio astronomy

4.24 Ofcom invites views as to how it should consider the Radio Astronomy services identified in Annex D of the UK Frequency Allocation Table in balancing its duties around UWB. The nature of radio astronomy is such that natural signal levels cannot be increased, or measurements usefully be moved to other, less affected bands. The most likely solutions involve ensuring that UWB devices are not close by radio astronomy sites. This could be achieved through using a perimeter fence to physically

[14] For example, for the cooperation approach it would be possible to use the UWB Medium Access Control (MAC) protocol to synchronise the UWB devices to the BFWA transmit/receive cycle.

exclude devices, conducting measurements at night when UWB activity is likely to be lower, or through siting new radio astronomy sites well away from populated areas.

***Question 6:** Would it be possible to achieve sufficient isolation between radio astronomy and UWB through practical methods of physical separation?*

Options not considered in the study

4.25 There may be other options as well as those identified by the consultants. For example, we could allow UWB in the 3.1-10.6GHz band initially, but if the 3GHz and 4GHz bands became increasingly used for mobile applications, we could require UWB to migrate to the 6-10.6GHz bands. This would allow the benefits from UWB to be experienced as soon as possible but also not inhibit the potential expansion of mobile systems to higher frequencies. However, there is a potential disadvantage in that UWB equipment in the higher frequency bands might not be compatible with earlier equipment in the lower bands, requiring consumers to potentially replace equipment with earlier embedded UWB devices. If this equipment included plasma screens or other similar devices this might have a significant cost associated with it.

4.26 Alternatively, as suggested in the mitigation options for BFWA, we could raise the lower frequency limit for UWB from 3.1GHz to, say, 4GHz, or 5GHz. This would reduce any interference to users in the bands below this raised limit, but might reduce economies of scale and increase the costs of UWB.

***Question 7:** Are there any other options that we should consider?*

Summary

4.27 In this chapter we have:

- Summarised the economic study performed on behalf of Ofcom by Masons and Dotecon which suggests that there will be substantial economic benefits to the UK in deploying UWB if a different mask to that proposed by the FCC is adopted.
- Discussed future systems which have not yet been deployed and noted that we have commissioned a further study in this area.
- Noted that BFWA and radio astronomy had not been considered in detail, suggested some ways that interference might be mitigated, requested further guidance and noted that we have also commissioned a further study in the area of BFWA.
- Briefly considered whether there might be other innovative approaches which had not been considered.

4.28 In the following chapter we turn to look at the technical analysis that has been performed around the world and provide our own verdict as to whether we believe UWB will cause interference.

Section 5

Technical analysis

Introduction

5.1 A large number of technical studies have been performed by a range of bodies to assess the potential interference that UWB might cause. However, they have often come to differing conclusions because they have used differing assumptions, such as the likely density of UWB devices, or because they assume different levels of protection to existing services.

5.2 We have assessed a number of these studies and have come to the preliminary view that some of them are overly cautious since they look at the worst possible case for the existing service. This seems to be particularly true for studies relating to fixed links and satellite services, while studies relating to cellular phone systems seem more balanced. For example, one study suggested that UWB devices might cause interference if they were within a few kilometres of a satellite dish. When we conducted some measurements we found that the UWB device could be introduced to within a few metres of a dish before any noticeable degradation in service was observed. In other cases, our measurements suggest that the interference experienced from UWB transmitters might be less than that already experienced from PCs and laptop computers. We are carrying out further empirical work to carefully examine all the key studies on UWB. A more detailed description of all the technical studies along with our assessment as to whether they are appropriately objective is provided in Annex 4.

5.3 As part of the economic study, the consultants looked at the body of technical studies and conducted their own modelling work to produce technical assessments which they then used to determine any costs of interference. For example, in their report they state that "theoretic studies typically only allow a very small increase in the noise level at the affected receiver. In practice, system link budgets will tolerate higher levels than this, which would mean that a small noise increase does not commercially impact the affected system". The consultants concluded that there would be negligible interference into satellite systems and fixed link systems from UWB based on the operation of indoor Personal Area Networks.

5.4 In understanding the impact of interference, Ofcom considers that the areas where interference is most likely are those where UWB devices might be in close proximity with other radio systems. This is most likely to be the case for cellular handsets, cordless handsets, W-LANs and other radio devices used in the home and office. To date these all operate in the frequency band below 3GHz, for example cellular phones at 900MHz, 1800MHz and 2.1GHz, cordless phones at 1880MHz and W-LANs at 2.4GHz. UWB devices operate in the frequency band above 3GHz, although their emissions can tend to spill over into the lower frequency bands.

Summary of our interpretation of major technical studies

5.5 We have assessed what we believe to be the major technical studies on UWB. These fall into the following categories:

- Studies that Ofcom, or its predecessor, the RA had commissioned.
- Studies performed as part of the FCC's introduction of UWB.

- Studies performed on behalf of the ITU.
- Studies performed on behalf of CEPT as published in the draft ECC Report 64.

5.6 In practice, most of the technical studies that Ofcom or RA have commissioned have all been submitted as technical contributions to CEPT Task Group 3 and the ITU study group 1/8.

5.7 Studies underway within the ITU study are still in draft form and are not publicly available to non-ITU members. As a result they have not been considered further here. It is noted though that a strong degree of similarity exists between the studies of the two groups. So, in summary, by considering the CEPT studies, we include those studies conducted for the RA or Ofcom. We exclude the ITU studies since they are not publicly available but expect them to be similar to CEPT studies. We address the FCC studies in comparison to the CEPT studies in the section below.

5.8 The following table sets out a list of the publicly available studies undertaken by ECC Task Group 3 and a summary of our assessment as to whether we agree with the findings of each study, after comparison with some similar studies also undertaken by the FCC[15]. Comparison is also made with the difference in service deployment and technical characteristics used in the US. A more detailed assessment of each of these studies is provided in Annex 4.

[15] FCC ET Docket No 98-153, (2002); Erratum ET Docket No 98-153 (2002) and FCC ET Docket no 98-153 (2003)

Document and service covered	Ofcom's evaluation
Draft ECC Report on UWB below 10.6GHz Annex 2-1 Fixed Services	This is a conservative study indicating a large incompatibility with point to point (P-P) and BFWA services, requiring ~30dB more protection than the FCC UWB mask proposes. P-P links are indicated as being more susceptible than P-MP services. In practice, Ofcom does not expect any significant degradation of P-P fixed link services to be attributed to UWB for many years, if at all. Possible future mitigation options are available for the small number of P-P links which might be affected, and overall the risk to P-P services is assessed to be low. Ofcom anticipates that in practice BFWA services with indoor receivers located close to UWB devices are more likely to be affected than P-P links.
Draft ECC Report on UWB below 10.6GHz Annex 2-2 Mobile Satellite Services	This is a conservative study; Ofcom considers that aeronautical and maritime mobile earth stations (MESs) are unlikely to suffer impairment, and no harmful interference into mobile satellite service (MSS) satellite receivers at 1.6 GHz is expected. The risk of interference into Search and Rescue services at 406MHz would be severe were the FCC mask to be implemented; but this risk becomes negligible with the proposed Ofcom revision to the ETSI mask. Ofcom therefore assesses the risk of interference to be very low. The study identifies the most susceptible MSS terminals as being (licence exempt) land based mobile earth stations, requiring up to ~60dB additional protection. Ofcom regard these as being medium/low risk, noting that this is a conservative assessment and that mitigation options are available, including re-positioning to a better location.
Draft ECC Report on UWB below 10.6GHz Annex 2-3 Earth Exploration Satellite Services	This is mostly a conservative study. Passive measurements are shown to suffer some interference, radio altimeter and synthetic aperture radar operations are unlikely to suffer interference; and telemetry/data links with Earth may require the relocation of earth stations to areas with lower population (and thereby lower UWB deployment). Passive measurements in the most-affected bands are mainly related to moisture (land, vegetation and wind) and salinity, all of which may be less important during waking-hours over densely populated areas when UWB activity is expected to be highest. Overall operation may be able to accommodate contamination or loss of such measurements. If this mitigation is not appropriate Ofcom believes that there is a risk of degradation or loss of some measurements.

Document and service covered	**Ofcom's evaluation**
Draft ECC Report on UWB below 10.6GHz Annex 2-4 Radio astronomy	This study finds that radio astronomy as a high-sensitivity passive service remains incompatible with UWB. Large (40 – 70dB) negative margins remain. There is a potential for interference to measurements from UWB devices operating many kilometres away. Further study is recommended on the interaction of UWB signals with actual radio astronomy measurement scenarios before firm conclusions are reached. Consideration of 'energy-per-bit' of information transferred indicates that UWB devices, with appropriate constraints, could cause less adverse effects than the spurious emissions associated with conventional communications equipment.
Draft ECC Report on UWB below 10.6GHz Annex 2-5 Digital Video Broadcasting (DVB-T)	This is a conservative assessment and with mitigation techniques the probability of interference is low. The study concludes that out-of-band UWB emissions in the TV bands are required to be considerably lower than is currently expected from CEPT/ETSI EMC recommendations for other non-intentionally radiating devices. Ofcom considers that this is unrealistic. In Ofcom's view, simple mitigation techniques exist; e.g. moving the antenna. Ofcom is proposing using the current levels for EMC emission for UWB devices at frequencies below 1GHz and hence there is unlikely to be an overall effect.
Draft ECC Report on UWB below 10.6GHz Annex 2-6 Digital Audio Broadcasting (T-DAB)	This is a conservative assessment and with simple mitigation techniques the real probability of interference is low. Since the allowable UWB emissions in Band III are proposed to be set to levels similar to those for other devices already in the market, undue interference is not expected. For L band the minimum separation distances quoted in the study are <2m even with conservative assumptions. Ofcom considers that simple mitigation techniques are available: users could simply move the UWB device or radio or temporarily switch the UWB device off.
Draft ECC Report on UWB below 10.6GHz Annex 2-7 Bluetooth	This is a conservative study. The study concludes that the ETSI mask will provide sufficient protection to Bluetooth services, but not to a very sensitive Bluetooth receiver. In Ofcom's assessment, the proposed Ofcom revision to the ETSI mask will protect the most sensitive Bluetooth receiver based on the required PSD identified in the study.

Document and service covered	**Ofcom's evaluation**
Draft ECC Report on UWB below 10.6GHz Annex 2-8 Radio Local Area Networks (RLAN)	This is a conservative study, which concludes that the magnitude of incompatibility depends on the modulation and data rate used. In Ofcom's assessment, there might be slight fallback in data rates in a worst case interference environment when the receiver is operating at minimum sensitivity value and most sensitive modulation type. Ofcom considers that the probability of this is low and mitigation techniques such as increasing the separation distance between UWB and RLAN can alleviate this.
Draft ECC Report on UWB below 10.6GHz Annex 2-9 IMT2000	The study concluded that UWB PSD of -85dBm/MHz is required to protect the most sensitive IMT-2000 mobile receiver with no noticeable impact from UWB. Ofcom agrees with the conclusions the study.
Draft ECC Report on UWB below 10.6GHz Annex 2-10 Radio Navigation Satellite Service (RNSS)	A conservative to reasonable case study indicating further work is required to consider detailed interactions between UWB and RNSS signals. For noise-like interactions, the study concludes that compatibility between UWB and both GPS and Galileo in the band 1100-1600 MHz is marginal even with the proposed Ofcom revision to the ETSI mask. Ofcom considers that it is likely that already-marginal operation will be degraded, though US studies indicate that better signal processing implemented in GPS receivers already increases their resilience, and all Galileo receivers can be designed to be "UWB-aware". There is increasing dependence on RNSS signals, although their availability is not guaranteed. In summary, Ofcom considers that there is some risk of loss of service at the margins of current availability.
Draft ECC Report on UWB below 10.6GHz Annex 2-11 Fixed Satellite Services	This represents a conservative study - the downlink assessments require UWB PSD to be reduced to below -87dBm/MHz in some cases. Ofcom considers that the real situation will not be as pessimistic as depicted in the study, however the absence of viable mitigation options for downlink protection introduces a potential risk to FSS and MSS services. The uplink studies show no significant risk of interference arising.
Draft ECC Report on UWB below 10.6GHz Annex 2-12 Amateur	This represents a conservative analysis which concludes that there might be significant interference. Ofcom considers that with consideration of additional mitigation techniques such as building obstruction and shielding loss, the real probability of interference is low.

Document and service covered	Ofcom's evaluation
Draft ECC Report on UWB below 10.6GHz Annex 2-13 Maritime	*VHF/UHF communications*: The report concludes that there is a possibility of interference. Ofcom considers that this probability is minimal since the UWB spurious emissions are proposed to be set to those for other devices already in the market. *Radar*: Again, the report concludes that there is a risk of interference. In Ofcom's view, mitigation techniques such as physical separation and screening by buildings should reduce any interference significantly. On board ship UWB devices could be limited to below deck. Ofcom considers that appropriate controls on how much energy UWB devices can emit when not transmitting data should minimise the impact of outdoor emissions (Ofcom considers that most UWB data transfer will occur indoors).
Draft ECC Report on UWB below 10.6GHz Annex 2-14 Aeronautical	This is a conservative study which predicts significant interference and recommends safety margins (often combining to over 20dB) based on actual receiver sensitivities. The study covers communications systems (landing aids, direction finding) and radars (direction finding, secondary and altimeter). Ofcom notes that several services operate outside the likely core UWB band. Ofcom considers that the studies ignore actual operating conditions - e.g. that when an aircraft is near the ground and therefore exposed to higher UWB signal strengths, the wanted return signal strength for the radio altimeter should also be substantially above the sensitivity of its receiver. *Primary radars* are shown in the study to be incompatible with UWB, with particular concerns if UWB devices can enter the main beam of the radar, in which cases protection distances of many km are required. NTIA (in the USA) reached similar conclusions. NTIA studies also consider the expected return signal in addition to receiver parameters, which results in much more favourable assessment of *radio altimeters*. *DME/TACAN* (distance and bearing services) appear to be largely compatible. *Secondary radar* ground reception requires the proposed Ofcom revision to the ETSI mask. Aeronautical services operating below 500 MHz (voice, ILS, beacons) have not been considered in this Ofcom assessment as the cited protection requirements would be compatible with a -85dBm/MHz mask. International mobility and responsibilities are important considerations. Ofcom considers that there is a risk for some services - particularly primary navigation radars.

Document and service covered	**Ofcom's evaluation**
Draft ECC Report on UWB below 10.6GHz Annex 2-15 Meteorological radars	This study considers only meteorological radars. It is a conservative study indicating typically 20dB incompatibility with the proposed Ofcom revision to the ETSI UWB mask. The study does not specifically identify that this is largely due to the potential for UWB emitter to be located in a high-gain region of radar beam due to low operating angles of the radars, about which the NTIA study is more conclusive. It will be important to avoid main-beam interaction if UWB is to be compatible with weather radars.

Question 8: *Are there any major technical studies that we have omitted?*

Question 9: *Have we made an accurate assessment of the existing studies?*

Overall assessment of the studies

Although the studies, as published, suggest significant problems with UWB, our assessment is that in most cases this interference will not arise. This is for a range of reasons:

- Some studies are overly conservative, and when typical deployment scenarios are considered the likely level of interference is much reduced.
- Some studies assume the FCC mask, but if the proposed Ofcom revision to the ETSI mask is adopted the reduction in interference is sufficient to suggest that it will not be harmful.
- In some cases, simple mitigation techniques are possible, such that if interference were to arise measures could be taken to reduce its effects.

Taking these factors into account, we have come to the preliminary view that in general there will not be significant risk of harmful interference from UWB devices. However, there are some radio services where we remain concerned:

- In the case of BFWA and radio astronomy there appears to be a significant probability of interference and while there are many possible mitigation techniques for BFWA and a few limited options for radio astronomy, we are not yet fully satisfied that they will be effective.
- In the cases of mobile satellite, fixed satellite, earth exploration satellite and some radar systems (if in main beam) there may be a problematic level of interference. In these cases we are more confident that further study will show that the interference will not generally be significant in practice.

Summary

In this chapter we have:

- Listed the major technical studies that have been performed within CEPT and shown that in considering these we have assessed most major publicly available studies.
- Analysed these studies and concluded that in most cases they are conservative and overstate the risk associated with deploying UWB.

This concludes our assessment of the evidence pertaining to UWB. In the final chapter we consult on what our strategy should be in the light of the evidence presented.

Section 6

Ofcom's proposed position

Introduction

6.1 In previous sections of this document we have noted that:

- Ofcom's statutory duties predominantly incline it towards allowing UWB devices in the UK .
- An economic analysis suggests that the UK might gain significant benefits if UWB is allowed with an appropriate mask. However, further work is underway to add to this analysis in areas where Ofcom considers that the analysis is incomplete.
- Technical studies to date are inconclusive but we believe in many cases are conservative. In Ofcom's assessment, if we allow UWB devices subject to a restrictive mask there is unlikely to be a significant increase in the risk of harmful interference in most cases.

6.2 We have also noted that UWB has been allowed in the US. If we do nothing there are risks that UWB equipment will arrive in the UK in any case, and that the US mask, which we believe not to be optimal for the UK, will become the de-facto world standard. In light of this, Ofcom considers it to be particularly important to develop an appropriate European approach to UWB as soon as practicable.

The balance of the evidence currently seems to favour UWB

6.3 As we have set out throughout this document, Ofcom is required to balance competing interests in forming our policy with respect to UWB. If UWB devices are not allowed, we lose substantial economic benefits that might flow to the UK. If they are allowed, we run the risk that harmful interference might occur.

6.4 Given the current evidence as set out above, in our judgement, the likely economic benefits outweigh what appears to be the likely risk of interference. In Ofcom's view, subjecting UWB use to a tighter mask than that currently proposed by ETSI (as described below) will reduce the risk of interference to many existing applications (and in particular cellular operators) to levels which we consider to be insignificant. Ofcom notes that further study is needed in respect of the potential impact of UWB in some areas, and, as discussed above, has commissioned work in respect of BFWA and future services in the 2500-2690 MHz band.

6.5 As well as consulting on the evidence we have gathered so far, Ofcom is also consulting on the correct overall interpretation of the evidence, where there might be gaps in that evidence, and how we might go about closing off those gaps.

6.6 Ofcom is minded to present the evidence we have so far, as well as any further evidence we receive as result of additional studies and this consultation process, to the EC with the aim of the EC providing a pan-European framework for UWB.

***Question 10:** Do you agree that we should seek a common European framework for the introduction of UWB?*

We suggest a different mask to the FCC and ETSI

6.7 We believe that it is important at this stage to set out our current thinking on the parameters of a proposed mask. Without these parameters it would be difficult to perform appropriate analysis of the possibility for interference, which is key to Ofcom's proposals on allowing UWB. In coming to our proposals we have tried to balance the benefits of a single global standard with the need to protect national interests while aligning with emerging European proposals.

6.8 This has led us towards proposing the mask tentatively suggested within ETSI but with a tighter roll-off below 3.1GHz so that emission levels are below -85dBm in the 2.1 GHz band. This 'proposed Ofcom revision to the ETSI mask' is shown in Figure 6-1. The key features are:

- It is broadly the same as used in the US in that the upper and lower frequency limits and the in-band power limits are the same. The difference is in the speed of roll-off outside of these limits.
- The mask rolls off much more sharply than the US mask below the 3.1GHz lower limit for UWB operations to reduce interference with cellular and other services likely to be in proximity to UWB transmitters.

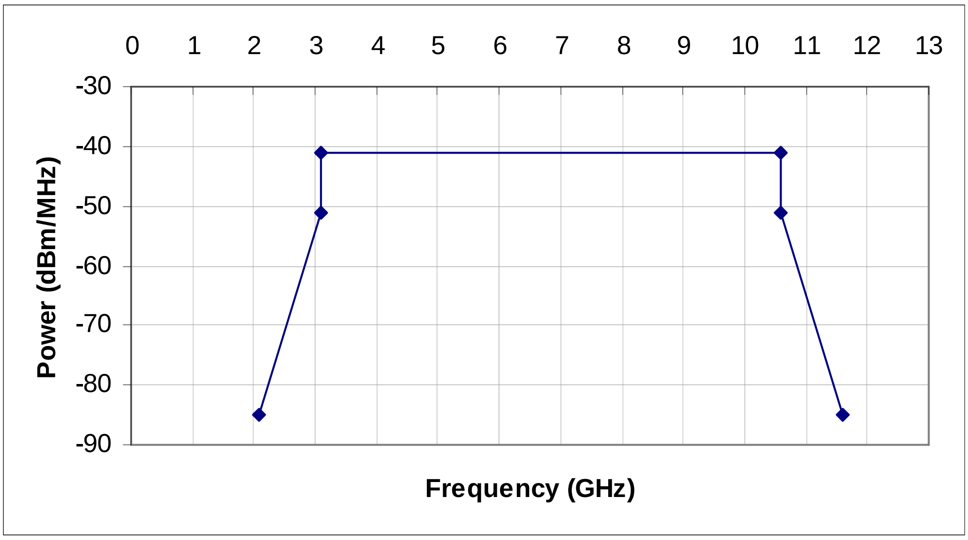

Figure 6-1 : The proposed Ofcom revision to the ETSI UWB Mask [16]

6.9 In Ofcom's view, this mask has advantages in minimising the cost of UWB to existing services while at the same time holding open the possibility of a single global standard for UWB.

6.10 Outside of the bands shown on this mask (ie below 2GHz and above 11GHz) we propose that general EMC emission limits apply. Where there are no defined limits we are proposing that the level of -85dBm/MHz apply.

Question 11: *Have we proposed the most appropriate mask? Will it be possible to deliver equipment conforming to this mask?*

[16] Key numbers are -85dBm at 2GHz, -51.3dBm just below 3.1GHz, -41.3dBm between 3.1GHz and 10.6GHz, -51.3dBm just above 10.6GHz and -85dBm at 11.6GHz.

We prefer a licence-exempt approach

6.11 If UWB is authorised in Europe we need to decide whether individual UWB devices should be subject to license, or authorised for use in accordance with exemption regulations. Our preference is for UWB to be licence-exempt for the following reasons:

- Under the Wireless Telegraphy Act 1949, Ofcom is required to allow licence-exempt operation if we judge that such operation is not likely to cause harmful interference. As discussed we still have some concerns over interference, but if ways were found to sufficiently mitigate such interference, then the use of UWB devices in accordance with appropriate conditions (including a mask) might be judged by Ofcom as unlikely to result in harmful interference.
- Practically, if UWB is embedded into devices such as laptops, DVD players and digital cameras, the logistics associated with licensing each transmitter would be burdensome and would prevent the market growing as rapidly as might otherwise have been the case.

6.12 The only benefit from licensing UWB devices is that it would enable Ofcom to have more control over individual devices, and perhaps apply different conditions to devices used in different circumstances. Ofcom would also be entitled to revoke the licence in certain circumstances, including where there is an interference problem, which is likely to lead to a recall of the device in question. However, even with a complete database of usage, recalling potentially millions of devices embedded in consumer goods would be hugely expensive and highly disruptive and would be a step that a regulator would be highly unlikely to take.

6.13 It should also be noted that licence exemption in no way gives exclusivity to that type of use. From time to time Ofcom will need to consider making further exemption regulations which allow the use of certain radio equipment on the same bands. There are already a number of exempt services using some of the frequency bands being proposed for UWB and these will need to co-exist. This is not something that Ofcom would co-ordinate. It will be up to users of each respective service to find the optimum locations for each type of device.

We are consulting on other details of the specification

6.14 As well as proposing a the mask, there are other parameters of UWB devices that, if allowed in the UK, it might be appropriate to define. For example:

- Should there be a minimum pulse repetition factor (PRF)? Low rates of PRF might make the interference less noise-like and potentially more problematic.
- Should devices that are not linked with other UWB devices ("non-associated device") limit their emissions? Non-associated devices might make emissions to alert other nearby devices to their presence. Limiting these would result in less noise but potentially increase the length of time for nearby devices to "find" each other.
- Should there be a mandated ability to turn UWB transmitters off? This might be valuable if users note that their UWB devices are interfering with other devices that they own (eg W-LANs) and wish to turn one off.
- Should UWB devices be required to use the minimum power for the data rate and range that they are trying to achieve? This might result in power levels

lower than the maximum being used for many applications, with resulting reduction in potential interference.

- Should there be any guidance provided to UWB users? The FCC issues detailed guidance about issues such as the use of UWB devices out of doors. If so, what should the instructions cover?
- Should there be a minimum bandwidth for UWB? The FCC have required a bandwidth of at least 500MHz. Suggesting a minimum bandwidth would seem to provide technological constraints when they might not be necessary.
- Are there are specific applications where the potential consequences of UWB outweigh the potential benefits, e.g. replacement of monitor cables due to high data rate combined with continuous operation? If so, would it be practical to limit the range of applications that UWB could be used for?

Question 12: *To what extent should we define parameters such as those listed above? What is the most appropriate definition for each of these parameters?*

Approach to international bodies

6.15 As set out in Section 3.2, there are important international developments on UWB. Of most importance to the UK is the work of the EC and the decisions that it might reach. We are consulting on whether it would be desirable for the EC and the rest of Europe to allow UWB under the mask we have proposed above. This will increase the economies of scale and the subsequent benefits accruing to consumers. Once we have received and analysed responses to this consultation, if appropriate, we will move quickly to present our evidence to CEPT and the EC.

Question 13: *Is our proposed approach to international bodies appropriate?*

Policy implications

Protection limits

6.16 In considering UWB we have noted that many technical studies are, in our view, overly protective of existing services. For example, some model the amount of interference that a fixed link could tolerate but then only allow UWB to provide a portion of 1% of this interference level on the basis that other fixed links might also provide interference. The effect of this for UWB is a very conservative limit on transmission power levels which is not reflected in practical measurements.

6.17 However, in concluding that the apportionment of a fraction of 1% is overly conservative, we effectively challenge the basis on which international frequency planning is performed. Without some guidance as to what levels of interference are acceptable, international bodies may find it difficult to reach decisions on sharing of spectrum.

6.18 As part of this consultation exercise we are seeking views as to how to handle these policy implications. Some of our initial thinking is provided below.

6.19 We do not believe that simply replacing the apportionment figure by a higher number will solve the problem. Although a higher number would result in less conservative decisions, it would be difficult to justify which number is right, and different levels might be needed in different circumstances.

6.20 One possibility is that a long term solution might be found in the formulation of spectrum usage rights as set out in the Spectrum Framework Review, published recently by Ofcom. A licence holder will be able to deduce the level of interference they might expect by considering the out-of-band emission limits in neighbouring licences. New technologies which increase the interference above these expected levels might generally not be allowed.

6.21 Another solution would be to consider each case on its merits, including understanding the economics of the situation, as we have done in this case with UWB. This provides maximum flexibility but perhaps less certainty for licence holders and increased difficultly in reaching international agreement.

Question 14: *How should we best deal with the precedent potentially set by its proposed approach to UWB?*

EMC

6.22 In some respects, the interference generated by UWB devices is similar to Electro-Magnetic Interference (EMI) generated by unintentional transmitters such as computer clock oscillators. Ofcom is currently considering its role in setting and monitoring EMC standards and would welcome input as to whether this should be a key element in its work going forwards, and if so how best it should be performed.

Question 15: *What should Ofcom's role be in setting and monitoring EMC standards?*

Enforcement issues

6.23 **Conformity assessment.** If UWB devices were allowed then, like any other radio equipment, they would need to comply with the requirements of the R&TTE Directive. They could demonstrate conformity to the essential requirements of the Directive either by complying with the appropriate Harmonised Standards developed by ETSI or by a technical construction file assessed by a Notified Body.

6.24 **Proactive measurements.** Ofcom generally does not undertake proactive measurements prior to interference complaints being received, and would probably not do so in the case of UWB where it is introduced in the UK. However, we might undertake periodic measurements of the overall noise floor to understand whether the noise floor was rising faster than predicted following any introduction of UWB.

6.25 **Interference complaints.** In line with our duties, and general statements in the Spectrum Framework Review, we would act to resolve interference complaints were any received following any introduction of UWB. Because we believe that the probability of interference is low, we do not expect to receive many, if any complaints. Nevertheless, we have commissioned some work on devices that can detect UWB transmission[17] which highlights the difficultly in detecting devices transmitting at very low power levels.

[17] http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/uwb/uwbmonitoringreportissue2.pdf

Summary

In this chapter we have:

- Suggested that the evidence presented here tends to favour the introduction of UWB.
- Suggested a new mask which provides greater protection than existing masks for services below 3GHz, such as 3G.
- Indicated that UWB, if allowed, should be licence-exempt.
- Raised a number of questions around the more detailed implementation aspects in the event that UWB is allowed.
- Indicated our intent to develop a policy and take this forwards to the EC and CEPT once this consultation is closed and the responses have been analysed.
- Noted there are some broader policy-related implications to our general proposals.
- Briefly discussed enforcement issues in the event that UWB is allowed.

6.26 We are now seeking consultation responses on these views.

Section 7

Responding to this consultation

How to respond

Ofcom invites written views and comments on the issues raised in this document, to be made by **5pm on 24 March 200524 March 2005**

Ofcom strongly prefers to receive responses as e-mail attachments, in Microsoft Word format, 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 2), among other things to indicate whether or not there are confidentiality issues. The cover sheet can be downloaded from the ‘Consultations’ section of our website.

Please can you send your response to william.webb@ofcom.org.uk.

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

Professor William Webb
6th Floor
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Note that we do not need a hard copy in addition to an electronic version. Also note that Ofcom will not routinely acknowledge receipt of responses.

It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 3. It would also help if you can explain why you hold your views, and how Ofcom’s proposals would impact on you.

Further information

If you have any want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Bill Fell on .

Confidentiality

Ofcom thinks 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 (when respondents confirm on their response cover sheer that this is acceptable).

All comments will be treated as non-confidential unless respondents specify that part or all of the response is confidential and should not be disclosed. Please place any confidential parts of a response in a separate annex, so that non-confidential parts may be published along with the respondent’s identity.

Ofcom reserves its power to disclose any information it receives where this is required to carry out its legal requirements. Ofcom will exercise due regard to the confidentiality of information supplied.

Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use, to meet its legal requirements. Ofcom's approach on intellectual property rights is explained further on its website, at www.ofcom.org.uk/about_ofcom/gov_accountability/disclaimer.

Next steps

Following the end of the consultation period, Ofcom intends to publish a statement in Spring 2005. It may be that a further consultation will be appropriate, depending on the responses received to this consultation, and the results of the further studies being undertaken on Ofcom's behalf.

Please note that you can register to get automatic notifications of when Ofcom documents are published, at http://www.ofcom.org.uk/static/subscribe/select_list.htm.

Ofcom's consultation processes

Ofcom is keen to make responding to consultations easy, and has published some consultation principles (see Annex 1) which it seeks to follow, including on the length of consultations.

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, whose views are less likely to be obtained in a formal consultation.

If you would like to discuss these issues, or Ofcom's consultation processes more generally, you can alternatively contact Tony Stoller, Director, External Relations, who is Ofcom's consultation champion:

Philip Rutnam
Ofcom
Riverside House
2A Southwark Bridge Road
London SE1 9HA
Tel: 020 7981 3585
Fax: 020 7981 3333
E-mail: philip.rutnam@ofcom.org.uk

Annex 1

Ofcom's consultation principles

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

Before the consultation

A1.2 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

A1.3 We will be clear about who we are consulting, why, on what questions and for how long.

A1.4 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 version for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A1.5 We will normally allow ten weeks for responses to consultations on issues of general interest.

A1.6 There will be a person within Ofcom who 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. This individual (who we call the consultation champion) will also be the main person to contact with views on the way we run our consultations.

A1.7 If we are not able to follow one of these principles, we will explain why. This may be because a particular issue is urgent. If we need to reduce the amount of time we have set aside for a consultation, we will let those concerned know beforehand that this is a 'red flag consultation' which needs their urgent attention.

After the consultation

A1.8 We will look at each response carefully and with an open mind. We will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 2

Consultation response cover sheet

A2.1 In the interests of transparency, we will publish all consultation responses in full on our website, www.ofcom.org.uk, unless a respondent specifies that all or part of their response is confidential. We will also refer to the contents of a response when explaining our decision, without disclosing the specific information that you wish to remain confidential.

A2.2 We have produced a cover sheet for responses (see below) and would be very grateful if you could send one with your response. This will speed up our processing of responses, and help to maintain confidentiality by allowing you to state very clearly what you don't want to be published. We will keep your completed cover sheets confidential.

A2.3 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 cover sheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A2.4 We strongly prefer to receive responses in the form of a Microsoft Word attachment to an email. Our website therefore includes an electronic copy of this cover sheet, which you can download from the 'Consultations' section of our website.

A2.5 Please put any confidential parts of your response in a separate annex to your response, so that they are clearly identified. 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: Ultra Wideband

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

What do you want Ofcom to keep confidential?

Nothing	☐	Name/contact details/job title	☐
Whole response	☐	Organisation	☐
Part of the response	☐	If there is no separate annex, which parts?	

If you want part of your response, your name or your organisation to be confidential, 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. It can be published in full on Ofcom's website, unless otherwise specified on this cover sheet, and I authorise Ofcom to make use of the information in this response to meet its legal requirements. 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 3

Consultation questions

***Question 1:** Are these the appropriate topics to be consulting on?*

***Question 2:** Do you agree with this analysis of our statutory duties? Are there any important factors that have been omitted?*

***Question 3:** Do you agree with the economic study? Are there other studies that Ofcom should be conducting?*

***Question 4:**: Is there a better way that future use of the spectrum could be taken into account?*

***Question 5:** What is the most appropriate solution to the potential interference from UWB to BFWA?*

***Question 6:** Would it be possible to achieve sufficient isolation between radio astronomy and UWB through practical methods of physical separation?*

***Question 7:** Are there any other options that we should consider?*

***Question 8:** Are there any major technical studies that we have omitted?*

***Question 9:** Have we made an accurate assessment of the existing studies?*

***Question 10:** Do you agree that we should seek a common European framework for the introduction of UWB?*

***Question 11:** Have we proposed the most appropriate mask? Will it be possible to deliver equipment conforming to this mask?*

***Question 12:** To what extent should we define parameters such as those listed above? What is the most appropriate definition for each of these parameters?*

***Question 13:** Is our proposed approach to international bodies appropriate?*

***Question 14:** How should we best deal with the precedent potentially set by our proposed approach to UWB?*

Question 15: *What should Ofcom's role be in setting and monitoring EMC standards?*

Annex 4

Analysis of previous technical studies

A4.1 In this annex we provide a more detailed summary of our assessment of each of the technical studies discussed briefly in the main report.

Fixed Service

Document: Draft CEPT ECC TG3 Report on UWB below 10.6 GHz Annex 2.1

A4.2 **Description**: The TG3 Annex presents an analysis of UWB interference into both Point-to-Point (P-P) and Point-to-Multipoint (P-MP) fixed wireless systems operating in the range 3.4GHz to 10.5 GHz.

A4.3 **Quoted Conclusions:** The report identifies a potentially large incompatibility (up to ~30 dB) between UWB operating at -41.3 dBm/MHz and the fixed service in bands below 10.6GHz when the number of UWB devices is around 10,000 devices/km2 (500 active devices/ km2). The report concludes that a single interferer at an unfavourable location will exceed FS P-P interference criteria by ~15/20dB. The annex identifies the most susceptible links to UWB interference as being the 4GHz P-P link as opposed to P-MP fixed wireless access services (FWA) [1].

Ofcom's Analysis:

- The assessment is based on conservative scenarios [2]. ITU Rec 1094 [3] is applied, which recommends that an FS system should be provisioned so that error performance and availability is not degraded in the presence of unwanted emissions from other systems.
- The analysis does not directly link the interference criteria to the fixed link availability requirements, nor take account of the presence of other ubiquitous man- made spurious emission sources that comply with CEPT 74-01 [4] yet which may also be contributing to the system noise floor.
- No references to practical measurements of interference on assigned link performance are presented or referenced in this report.
- Different ITU-R criteria of I/N = -20dB for P-P and outdoor P-MP and -6dB for (5 GHz band un-licensed WLAN) indoor FWA P-MP terminals are applied, and the current I/N studies indicate that unlicensed indoor FWA P-MP terminals using low gain antennas are less likely to receive UWB interference than licensed P-P systems. This view differs significantly from the Mason Economic study [5] and the expectations that a greater number of indoor FWA P-MP terminals will be deployed in close proximity to UWB. Additionally, practical considerations may require that a significant proportion of FWA P-MP terminals operate on a non-line-of-sight basis so that adequate cell coverage can be achieved.
- The probability of a single interferer being at an unfavourable location for point-to-point links is low since in the majority of cases fixed links are assigned to unobstructed paths, the primary sensitivity is within the main beamwidth of the antenna.
- No mitigation is applied in event of the single interferer situation.

- Studies have only recently begun to consider indoor P-MP FWA scenarios for equipment based on 3GPP standards. Initial studies by ITU-R indicate that an I/N of -13 dB would be necessary to protect indoor FWA terminals.

Mitigation analysis: UWB interference appears to behave similarly to Additive White Gaussian Noise (AWGN). If UWB was to be allowed the same interference budget as another P-P link, then in practice no significant reduction in P-P link availability is expected provided that the total interference does not exceed the wanted /unwanted ratio allowed for a single fixed link interferer. However, this may impact on and limit the number of FS links achievable in a given area.

At the outset, it is considered that the probability of widespread UWB interference into P-P fixed links will be low since the UK frequency assignment process favours the installation of links on paths which are effectively clear of immediate obstructions within the main Fresnel zone [7].

A substantial period of time may elapse before an assumed peak density of UWB deployment of 10,000 devices/km2 (500 active devices/km2) criteria is reached. In the few cases where P-P links may be adversely affected, options for mitigating interference (including facilitating a small increase in assigned EIRP where feasible) are possible which may be managed and applied within the assignment and annual licence renewal processes.

Overall Conclusion: Fixed links are a strategically important service, however we expect that there will not be any significant attributable impairment of P-P link availability due to UWB for the majority of links at least for many years, dependent on the take up and number of UWB devices deployed within a given area.

The report has correctly applied existing ITU methodology, however the unexpected reversal of sensitivities of P-P relative to P-MP suggests that detailed interference assessments based on C/(N+I) vs. availability may provide a more appropriate assessment methodology.

As discussed in the main document, Ofcom considers that there is a risk of interference to existing P-MP systems in the 3.4 - 4.2GHz band.

References:

1. Draft CEPT ECC TG3 Report on UWB below 10.6GHz. Annex 2.1 (s 4.3.3)

2. *Ibid* (s2.1)

3. Rec ITU-R F. 1094-1 Maximum allowable error performance and availability degradations to digital radio relay systems arising from interference from emissions and radiations from other sources.

4. CEPT/ERC/Recommendation 74-01E (Siófok 1998, Nice 1999, Sesimbra 2002) Spurious Emissions

5. Value of UWB Personal Area Networking Services to the United Kingdom, Final Report for Ofcom, Mason Communications Ltd. Ref Y85A004O.

6. TG3#4_02R1_Mainbody_approved-29-09-04. (Draft CEPT ECC TG3 Report on UWB below 10.6GHz p14 (s4.4.1).)

7. [OF 30W Fixed Point-to Point radio services with digital Modulation operating in Frequency Ranges 3.6 to 3.875 GHz paired with 3.925 to 4.

Mobile Satellite Service

Document: Draft CEPT ECC TG3 Report on UWB below 10.6 GHz Annex 2.2

Title: Mobile Satellite Service

Description: The TG3 Annex presents an analysis of UWB interference into Mobile Satellite Services operating in the range 0.4GHz - 1.6GHz including:

- Search and Rescue services COSPAR SARSAT at ground stations receiving downlink signals from GSO and LEO satellites in the range 1544-1545MHz.
- Satellite receiver for receiving Emergency Power Indicator Radio Beacons (EPIRB) uplinks at 406MHz.
- Two type of GSO MSS system terminals operating at 1.5 and 1.6 GHz for applications including aeronautical MES, maritime MES and land based MES.

Quoted Conclusions: Based a UWB PRF of lower than 1MHz:-

- The search and rescue COSPAR SARSAT satellite receiver for receiving EPIRB uplinks at 406MHz is unlikely to have compatibility problems (these results are independent of UWB PRF).
- A protection distance of 6km is required around each search and rescue earth station in the band 1544-1545 MHz.
- The aggregate interference into satellite receivers at 406MHz is unlikely to be problematic.
- The aggregate interference into the aeronautical MES terminals is unlikely to be problematic.
- It is expected that there will not be a problem of interference from a single UWB device into a maritime MES terminal deployed on board ships in international waters.
- A maximum separation distance of 286m is required for Type 2 land-based MES terminals; at 20m separation the maximum UWB EIRP density is -98.4dBm/MHz (non dithered) or -86.17dBm /MHz (dithered).

Ofcom's Analysis:

- The model used assumes 10,000 UWB devices per km2 with a LOS path and no attendant clutter. This density of devices is unlikely for many years, if ever, and LOS paths are rare. There are only about 40 such stations worldwide, and the listed UK station is located at Coombe Martin where the expected density of terminals will be significantly lower than that being used by the analysis.
- Regarding the MSS terminals, an analysis based on NTIA Bandwidth Correction Factor (BWCF) analysis has been used where the applied maximum permitted interference is one percent of thermal noise.
- The effect of signal carrier level/ noise ratio and antenna G/T are not taken into consideration so this is a conservative assessment.
- The studies does not take account of the presence of other ubiquitous man- made spurious emission sources that comply with CEPT 74-01 yet which may also be contributing to the system noise floor.
- The studies are incomplete as they do not consider MB-OFDM UWB sources.

- The terminals operate on a licence exempt basis.

Mitigation analysis:

- The requirement for separation distances of 132- 286m for the two types of MES land terminals are based on the FCC mask. If the modified ETSI mask is used the corresponding distances are 32 -69m.
- Mitigation is possible by repositioning of the land MES

Overall Conclusion: The report has correctly applied existing NTIA studies. Ofcom supports the conclusion of the studies in that the risk of interference into all MSS services is very low save for land based MES terminals.

The study identifies the most susceptible MSS terminals as being licence exempt land based mobile earth stations, requiring up to ~60dB additional protection at 20m separation. Ofcom regard these as being a relatively low risk, noting that this is a worse case assessment and that mitigation options include re-positioning to a better location.

Earth Exploration Satellite Service

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-3.

Description: This annex describes the potential interaction between UWB and space-borne passive sensors, radio altimeters, synthetic aperture radars and telecommand / data links in the following frequency bands:

1400-1427 MHz:	Passive sensing
6425-7250 MHz:	Passive sensing
10.6-10.7 GHz:	Passive sensing
5250-5570 MHz:	Active sensing
2025-2110 MHz:	Telecommand / data (Earth to space)
2200-2290 MHz:	Telecommand / data (space to Earth)
8025-8400 MHz:	Telecommand / data (space to Earth)

Quoted Conclusions: Taking into consideration the emission limits as given by the FCC and ETSI masks, the following can be concluded on the use of UWB devices:

- The frequency band 1400-1427 MHz is not compatible with UWB devices.
- The frequency band around 6.9 GHz requires UWB devices having lower EIRP than those already planned in order to achieve compatibility.
- The frequency band 10.6-10.7 GHz requires UWB devices having lower EIRP than those already planned in order to achieve compatibility.
- Compatibility can be achieved at 5 GHz.
- Compatibility can be achieved in the band 2025-2110 MHz.
- A protection distance of 4 km is required around each Earth station in the band 2200-2290 MHz.

- Compatibility can be achieved around each Earth station in the band 8025-8400 MHz.

Based on the analysis provided in this study, it is proposed to retain the following generic UWB PSD limits:

1400-1427 MHz:	-88 dBm/MHz
6425-7250 MHz:	-62 dBm/MHz
10.6-10.7 GHz:	- 57 dBm/MHz
5250-5570 MHz:	-21 dBm/MHz
2025-2110 MHz:	-35 dBm/MHz
2200-2290 MHz:	-70 dBm/MHz with a 4 km exclusion zone
8025-8400 MHz:	-41.3 dBm/MHz

Ofcom's Analysis: The passive measurements made in the 1400 1427 and 6425 7250 MHz bands are mainly related to moisture - sea temperature, moisture content, coastal winds, vegetation, soil moisture, etc, which may be less important for the core of densely populated areas during waking-hours where UWB operation would be expected to be highest. Ofcom is already proposing a tighter mask for the 1400 MHz band which reduces the apparent incompatibility in this band. The 10.6 GHz band beams have a small footprint and this would limit the loss of measurements if other mitigating factors, including a tighter mask, are insufficient.

The bands 5250-5570 (active sensing), 2025-2110 (Earth to space) and 8025-8400 MHz (space to Earth) appear to be compatible. Relocation of terrestrial receivers may, at a cost, address the remaining incompatibility between the tighter mask proposed by Ofcom and the -70 dBm/MHz suggested for the 2200-2290MHz (space to Earth) band, though the analysis did consider UWB interference entering through the 31dBi first side-lobe of these tracking antennas.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks. In Ofcom's view, the following would mitigate much of the interference predicted in this paper:

- Ofcom is already proposing a tightening of the UWB mask below 3.1 GHz which would address much of the perceived short-fall in the band 1400 1427 MHz.
- Acceptance that some measurements, particularly moisture-related for densely populated areas during waking-hours, may be compromised as UWB emissions increase. Terrestrial measurements may in some cases be required to complete data sets. Essentially asking whether, say, 98% continued measurement availability would be an acceptable compromise in order to permit UWB.
- Relocation, at a cost, of terrestrial receivers in the band 2200 2290 MHz to areas less affected by UWB emissions.
- Controls to minimise the energy radiated per bit of information transferred by UWB devices, and avoidance of high-rate, continuous applications.
- The OFDM UWB modulation scheme may allow emissions in certain bands to be reduced and could more easily provide reduced emission levels outside of the main UWB operating band.

- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and tighten the regulation if required.

Comparison with USA: NASA also participates in some EESS operations, though no information on US assessments was available. The US generally has larger areas between centres of high population density, and more stretches of sparsely populated coastline than Europe, and might therefore be expected to be able to tolerate loss of some measurement cells more readily than Europe.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, since it does not adequately addresses the probability of this happening. In Ofcom's view consideration should be given to the real importance of complete measurement sets including results from densely populated areas during waking-hours. Other interactions may be mitigated, at a cost. The current noise levels associated with emissions from consumer electronics and spurious emissions from existing communication systems should additionally be considered. Introduction of UWB would represent a medium-high risk for passive EESS measurements with the international aspect, and the 2 GHz downlink, and low risk for the other uses.

Radio astronomy Service

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-4.

Description: This annex describes the potential interaction between UWB and radio astronomy measurements.

Quoted Conclusions: The calculated maximum tolerable EIRP per UWB device is several tens of dBs below the levels of even the proposed Ofcom revision to the ETSI spectrum mask. It is noted that this difference depends strongly on the aggregated impact of UWB devices emitting towards a radio astronomy antenna. At this moment no accurate estimate of a realistic density of UWB devices is available. For any significant deployment of UWB devices, it is shown that significant separation distances must be respected for the protection of radio astronomy stations.

From these results, it can be concluded that there is currently significant incompatibility between UWB emissions and the radio astronomy service, for any practical scenario. Whether dedicated mitigation techniques capable of bridging the calculated gap of several orders of magnitude between expected and tolerable EIRP levels can be implemented is uncertain.

Ofcom's Analysis: Radio astronomy, when considered as a communications service with very sensitive receivers, remains incompatible with UWB deployment. There is an international aspect as a radio astronomy site in another country operating in accordance with the ITU RR could experience harmful interference originating from the UK in view of the large protection distances.

CEPT has not addressed the radio astronomy bands immediately above 10.6 GHz (10.60 10.68 GHz, co-primary with mobile under RR No. 5.149, and 10.68 10.70 GHz primary passive band under RR No. 5.340). This is very close to the proposed band for UWB emissions, and would be expected to be similarly affected as the other bands considered. These bands were considered for EESS.

The current situation of noise from consumer electronics, combined with spurious emissions from communications equipment is especially relevant in some of the bands used for radio astronomy, particularly those close to the operating frequencies of widely deployed handsets and similarity with the clock frequencies of current (2004) personal computers. In particular, permitted spurious emission levels are commonly at least an order of magnitude above the levels proposed for UWB devices, and even considering that emissions approaching such levels should be rare and avoided, it is highly likely that some such emissions would already be occurring somewhere within the cited 100km radii of concern around radio astronomy sites.

Radio astronomy receivers have been designed to detect and measure very faint signals and natural emissions. In addition to design measures, measurements normally employ significant integration times to further reduce the effects of measurement noise. These measurements should therefore be assessed in terms of energy, rather than instantaneous power as is the more usual consideration when considering compatibility between communications systems. However, enhanced sensitivities have been derived for use in compatibility studies which reflect the signal enhancements resulting from integration over time and assume that signals from the potential interferer can be considered to be continuous. The unusual characteristics of the proposed UWB emissions may make this an unreasonable assumption because individual users would be expected to have a finite daily requirement for data transfer. The fast transfer rates would therefore limit the necessary emission time, hence activity factor, and thereby reduce the energy potentially received by a radio astronomy receiver. To illustrate the difference, a whole DVD movie could be transferred in under a minute, while a 5% activity factor used in many studies equates to 72 minutes of emissions per day, with the potential to transfer up to 540 GB of data. It is likely that the spurious emissions from conventional communications devices, even if 40 dB below permitted levels, may equate to comparable energy emissions when the longer emission timescales are considered.

It is therefore appropriate to further investigate, with radio astronomers, the actual scenarios for radio astronomy measurements. Where appropriate, assessments should be reconsidered from an energy-received, rather than power perspective, and with receiver sensitivities appropriate for measurement timescales.

The studies employ agreed sensitivities from ITU R RA769 and similarly do not seek protection against UWB signals received from high-gain directions - possible when observations are made at low elevations. The actual situation could therefore be substantially worse than the study concludes in respect of a limited number of interactions between measurements and operating UWB devices.

ITU R RA769 also *recommends "that radio astronomers should be encouraged to choose sites as free as possible from interference".* Consideration should be given to whether compatibility concerns could, at a cost, be significantly eased by the relocation of radio astronomy receivers in the UK.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks and (very large) separation distances that could be employed by Ofcom to ensure a low probability of interference to radio astronomy measurements.

If a different assessment approach is adopted which considers the intermittent nature of UWB emissions which would be required to transfer given amounts of data (e.g. a piece of digital video, an email attachment) rather than providing a continuous data link (e.g. frame-by-frame update of a monitor during a game), the energy radiated by pulsed UWB devices becomes significantly less than even highly constrained spurious emissions of conventional communications devices when transferring similar volumes of data due to the brevity and extremely low pulse duty-cycle of the required UWB transmissions. Consideration of joules/bit may largely mitigate the incompatibility. It is recommended that further consideration is given to the assessment of energy received, rather than power, due to the measurement techniques employed in radio astronomy to achieve higher measurement resolutions.

In Ofcom's view, the following would mitigate some of the interference predicted in this paper:

- Ofcom is already proposing a tightening of the UWB mask below 3.1 GHz which would assist in some of the bands.
- Relocation, at a cost, of radio astronomy receivers to areas less affected by UWB emissions. It may not be necessary to relocate the associated research staff.
- Controls should be applied to UWB to minimise the energy radiated per bit of information transferred.
- The study did not explicitly cover OFDM UWB modulations, and these might allow emissions in certain bands to be reduced and more easily provide reduced emission levels outside of the main UWB operating band, though possibly not to the levels proposed to ensure compatibility.
- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and tighten the regulation if required.

Comparison with USA: No information on US assessments was available. The US has much more extensive areas with sparse population, and large tracts of land, particularly rural, that are under some form of unified control. It therefore has far greater opportunity to (re-)locate radio astronomy sites in areas that are expected to suffer least from man-made emissions. Such areas are less common and extensive in Europe.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, but does not feel it adequately addresses the probability of this happening. In Ofcom's view, consideration should be given to energy transfer into radio astronomy receivers rather than solely considering power, because of the unusual demands of radio astronomy measurements and expected brevity of many UWB interactions. The current noise levels associated with emissions from consumer electronics and spurious emissions from existing communication systems should additionally be considered.

Terrestrial Digital Television (DVB-T)

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-5

Description This annex describes two separate sharing studies to assess the likely impact of Pulsed Ultra Wide Band (UWB) transmission structure on European Terrestrial Digital Video Broadcasting System (DVB-T).

1. The first study is mainly an experimental study based on a Ofcom (RA) paper [1] which shows the maximum tolerable C/I ratios where the I is a differed pulse interference signal approximating to that expected from a spread spectrum UWB source. The measured C/I ratios are shown to be close to that expected from a Gaussian noise source. These C/I values are then converted into a minimum coupling loss and thence into a minimum separation distance for a variety of emission masks.

2. The second study also uses the measured C/I values in order to get a minimum separation distance. The main difference is that it attempts to do this for other frequency bands and for multiple UWB interferers and for different indoor and outdoor scenarios.

Quoted Conclusions: Both studies concluded that the FCC mask does not provide sufficient protection whereas a sloped mask, with limits below -100dBm/MHz in the band, will do so.

Ofcom's Analysis:

- Minimum coupling distance on its own is not a good way to determine the interference potential of UWB to DVB-T. One also needs to know the numbers of receivers that operate within a certain carrier signal level in order to determine the likely interference potential of UWB on DVB-T in the UK as a whole. This information is not given in the paper, but Ofcom believes that most consumers will not be operating close to minimum C/I levels after digital switchover and so will not be affected.
- Both studies find the maximum interference potential occurs using a 0dBi indoor antenna. Most UK consumers use an external antenna with up to 16dBi gain. The greater separation, forward to back ratio of the antenna and wall losses mean that the majority of consumers will not suffer the UWB interference predicted in the paper.
- The authors do not use a realistic minimum antenna coupling loss when DVB-T and UWB are close; hence many of the differences they state at close range are significant will not be so in practice.
- EMC limits and CEPT/ETSI limits for spurious emitters from unintentional radiators (e.g. [3],[4],[5]) are higher than the proposed UWB limits in these bands and hence emission from other, non-UWB, appliances will dominate over the UWB emissions. Furthermore, it should be noted that all the DVB-T television bands in the UK would be affected by UWB out-of-band emissions only (no information is transferred in these bands between UWB devices). Ofcom cannot see from this paper why the spectral distribution of out-of-band emissions from UWB should differ from those of other intentional or unintentional radiators.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks to control any UWB interference. In Ofcom's view, the following would mitigate all of the interference predicted in this paper:

- Moving the television receiver or antenna.
- Internalised interference mitigation. In appliances that might require both UWB and DVB-T present, many mitigation techniques are available to the manufacturers in order to prevent coupling including isolating antennas and notch filtering.
- Other sources of interference. Ofcom view is that there should be a requirement for a UWB device to meet current European EMC limits for frequencies less than 1GHz when the device is transmitting. This should make the emissions from UWB of similar magnitude to other devices.
- A requirement for UWB transmitters to be able to be switched off by the user and instructions included with the UWB device that would allow the user to implement simple mitigation techniques. This will enable the user to determine whether a UWB device is causing interference and remedy it.

- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and toughen the regulation if required before the noise increases to unacceptable levels.

Comparison with USA: Europe uses DVB-T; the USA uses 8-VSB. However, a study by the FCC [1] has compared the two technologies and found similar performance. 8-VSB is reported by some authorities to work better at lower C/N ratios (4dB) lower than COFDM, but this is contended by the DVB industry.

Overall Conclusion: Ofcom feels this paper overstates the probability of interference when the UWB masks in the TV bands are set close to current EMC and spurious limits. It relies too heavily on reducing the emissions to levels that are many orders of magnitude lower than mandated for other devices in order to eliminate all possibility of interference. In Ofcom’s view, radio devices operating below 1GHz already operate in an environment dominated by spurious and unintentional radiation and provided the mitigation techniques described above are implemented are unlikely to suffer further degradation from UWB.

References:

1. Project 739: UWB Compatibility with TDAB and DVB-T http://www.ofcom.org.uk/research/industry_market_research/technology_research/rtcg/?a=87101

2. OET Report OET/FCC 99-2 ‘DTV Report on COFDM and 8-VSB Performance’

3. CISPR 22 – 3rd Edition “Information Technology Equipment- Radio Disturbance characteristics, limits & methods of measurement’ International Electrotechnical Commission 1997

4. CISPR 14- 1 4th Edition 2000

5. CEPT/ERC/Recommendation 74-01E

Terrestrial Digital Audio Broadcasting Service (T-DAB)

Document Draft ECC CEPT TG3 Report on UWB below 10.6GHz Annex 2-6 T-DAB

Description: This annex describes two separate sharing studies to assess the likely impact of Pulsed Ultra Wide Band (UWB) transmissions on the Terrestrial Audio Broadcasting System (T-DAB).

- The first study is experimental and shows the maximum tolerable C/I ratios, where I is a pulsed signal approximating to that expected from a spread spectrum UWB source. The measured C/I ratios are shown to be close to that expected if a Gaussian noise source was used. These C/I values are then converted into a minimum coupling loss assuming the T-DAB is transmitting into L band and thence into a minimum separation distance for a variety of emission masks.
- The second study also uses the measured C/I values in order to get a minimum separation distance. The main difference is the analysis of other frequency bands and multiple UWB interferers.

Quoted Conclusions The first study concluded that at 1.5GHz the FCC mask does not provide sufficient protection for T-DAB whereas the ETSI mask will do so. The second study reached the same conclusions, but suggested that even the sloped mask would not guarantee protection in the L band (defined indoors as dmin<0.3m).

Ofcom's Analysis:

- Minimum coupling distance on its own is not a good way to determine the interference potential of UWB to DAB and to guide regulation in this area. Ofcom also needs to know the numbers of receivers that operate within a certain carrier signal level in order to determine the likely interference potential of UWB on DAB in the UK as a whole. This information is not given in the paper, but Ofcom believes that most consumers will not be operating close to minimum C/I levels in band III or band L and so will not be affected.
- The paper does not compare the link margin that is always applied to the link budget to counter fading (fast and slow) in L band with the extra interference expected from UWB devices. Hence the study needs to be probabilistic rather than just quoting worst-case separation distances. However, the required fade margins generally applied to these bands appear to be much greater than the increased interference due to UWB and therefore Ofcom considers that UWB interference will only produce a small extra increase in the probability of bit errors.
- The paper does not use a realistic minimum antenna coupling loss when the DAB and UWB devices are close; hence many of the problems they note as significant will not be so in practice. The design of UWB antennas generally gives them a large minimum coupling loss to other narrow band antennas. In particular, UWB antennas usually have a small size and in order to get a high bandwidth tend to have low emission efficiency.

o EMC limits and CEPT/ETSI limits for spurious emitters from unintentional radiators (e.g. [3],[4],[5]) are higher than the proposed UWB limits in these bands and hence emission from other, non-UWB, appliances will dominate over the UWB emissions. EMC emission limits are not set in Europe above 1GHz, but studies performed by Ofcom [6] suggest emissions do exist in these bands

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks to control any UWB interference. In Ofcom's view, the following would mitigate all of the interference predicted in this paper:

- Moving the radio receiver or antenna.
- In appliances that might have both UWB and DAB present in the same appliance, it is noted that many mitigation techniques are available to the manufacturers in order to prevent coupling including isolating antennas and notch filtering
- A requirement for UWB devices to meet current European EMC limits for frequencies less than 1GHz when the device is transmitting. This should protect DAB in band III to the same level as interference seen from other devices.
- A requirement for UWB transmitters to be able to be switched off by the user and instructions included with the UWB device that would allow the user to implement simple mitigation techniques. This will enable the user to determine whether a UWB device is causing interference and remedy it by moving the affected receiver.
- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and toughen the regulation if required.

Comparison with USA: The Federal Communications Commission has selected the IBOC system for digital audio broadcasting in the MF and VHF bands.

Overall Conclusion: Ofcom feels this paper overstates the probability of interference for the reasons given above. It relies too heavily on reducing the emissions to levels that are many orders of magnitude lower than mandated for other devices in order to eliminate the remotest possibility of interference. In Ofcom's view, other mitigation techniques apart from spectral masks should be employed to reduce the probability of interference from UWB.

Ofcom notes that radio devices operating below 1GHz already operate in an environment dominated by spurious and unintentional radiation and provided the mitigation techniques described above are implemented are unlikely to suffer further degradation from UWB. For DAB in L band, it appears to Ofcom that the margins currently required to counteract fading are much larger than any interference expected from UWB and this paper assumes too high a UWB antenna coupling at close ranges at this frequency.

References:

1. Project 739: UWB Compatibility with TDAB and DVB-T http://www.ofcom.org.uk/research/industry_market_research/technology_research/rtcg/?a=87101

2. OET Report OET/FCC 99-2 'DTV Report on COFDM and 8-VSB Performance'

3. CISPR 22 – 3rd Edition "Information Technology Equipment- Radio Disturbance characteristics, limits & methods of measurement' International Electrotechnical Commission 1997

4. CISPR 14- 1 4th Edition 2000

5. CEPT/ERC/Recommendation 74-01E

6. http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/emc/rep-5413-finreportv8.zip

   http://www.ofcom.org.uk/static/archive/ra/topics/research/topics/man-made-noise_finalreport.pdf

Bluetooth

Document Draft ECC CEPT TG3 Report on UWB below 10.6GHz Annex 2-7 Bluetooth

Description: This annex describes the likely impact of a pulsed Ultra Wide Band (UWB) transmission structure on Bluetooth. The interference criteria used is obtained from experimental study in terms of C/I ratios for three different test criterion, ie file transfer, voice and BER. The measured C/I ratios are shown to be close to those expected if a Gaussian noise source had been used. The maximum C/I value is then converted into a minimum coupling loss and a minimum separation distance is obtained for three emission masks and propagation models.

Quoted Conclusions: The study concluded that at 2.4GHz, the FCC mask does not provide sufficient protection for Bluetooth whereas the proposed ETSI mask will do so for Bluetooth equipment with a sensitivity of -70dBm. However, for Bluetooth receivers with sensitivities below -80dBm an emission level of-75dBm/MHz is required which is 5dB below the proposed ETSI limit for outdoor use.

Ofcom's Analysis:

- Bluetooth operates in the 2.4GHz licensed exempt ISM band. Services are allowed to operate on a non-interference non-protected basis.
- Minimum coupling distance is only an approximation and is not a robust way to determine the interference potential of UWB to Bluetooth .The probability of Bluetooth and UWB being active simultaneously and being located very near to one another is not studied.
- The paper uses a pessimistic value of minimum antenna coupling loss when UWB and Bluetooth are in proximity; hence it overstates the interference at close range. The design of UWB antennas generally provides a large minimum coupling loss to narrow band antennas. In particular, UWB antennas may use a smaller size antenna and in order to get a high bandwidth will have reduced emission efficiency.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks to control any UWB interference. It is expected that UWB may provide substitute technology for most Bluetooth applications and therefore the interference potential will be close to zero. However, in the cases where UWB and Bluetooth is operating in close proximity, the user can increase the separation distance between Bluetooth and UWB device if performance degradation is detected.

Comparison with USA: Bluetooth is a global wireless connectivity standard operating in the 2.4GHz licensed exempt ISM band. The interference effect predicted in Europe would be similar in the US.

Overall Conclusion: Ofcom believes there would be very low risk of UWB interference into a Bluetooth receiver using the proposed Ofcom revision to the ETSI mask. In any case, Ofcom would not normally consider protection of licence exempt services.

Ofcom notes that radio devices already operate in an environment dominated by spurious and unintentional radiation and are unlikely to suffer further degradation from UWB.

RLAN

Document Draft ECC CEPT TG3 Report on UWB below 10.6GHz Annex 2-8 RLAN.

Description: This annex describes the likely impact of pulsed Ultra Wide Band (UWB) transmission on a 5GHz IEEE802.11a RLAN transmitter. The interference criteria used is obtained in terms of measured C/I ratios for 10% frame errors for different modulations and data rates. The C/I value obtained is then converted into a minimum coupling loss and a minimum separation distance is obtained for three emission masks and propagation models. All emission masks give the same limit of -41.3dBm/MHz.

The impact of UWB peak power into the dynamic frequency selection (DFS) mechanism is studied and appropriate range of PRF and UWB peak power is given.

Quoted Conclusions: The study concluded that none of the masks provide sufficient protection to RLAN. When an active UWB device is within a distance of 2.5 - 8.0 m, RLAN can expect to suffer receiver desensitising and a reduction in data rate. With protection distances of '1 - 2 m' the RLAN victim will get a much smaller operational coverage range and show several steps of fallback in data rate.

In the conclusion of the ECC Main report, UWB PSD of -68.2dBm/MHz is required to protect RLAN at 36 cm separation distance. This was deduced from subtracting the UWB PSD value of -41.3dBm/MHz from the reduction in free space path loss obtained for reducing 8m separation distance to 36cm.

In order to avoid UWB triggering false alarm in the DFS performance requirement for RLAN, it is recommended to limit the UWB peak power at -46.5dBm/20MHz.

Ofcom's Analysis:

- The RLAN service operates in the 5GHz licensed exempt band where services are allowed to operate on a non-interference non-protected basis. However, this band was allocated primary allocation in WRC03.
- Minimum coupling distance is only an approximation and not a robust way to determine the interference potential of UWB to RLAN. RLAN equipment is designed to be robust and is expected to be able to operate in a 'harsh' interference environment.
- The paper applies a pessimistic value of minimum antenna coupling loss when the UWB and RLAN are close; hence interference probability will be lower in practice. The design of UWB antennas generally gives them a large minimum coupling loss to other narrow band antennas. In particular, UWB antennas may use a smaller size antenna in order to get a high bandwidth and will have reduced emission efficiency.
- CEPT/ETSI limits for spurious emissions from other RF transmitters are comparable with the Ofcom proposed UWB limits in the 5GHz bands. RLAN already works in the presence of a degraded noise floor.
- The recommendation to limit the peak power of UWB to protect the DFS mechanism might not be necessary as the implementation of DFS is based on detection of specific radar signal which are defined for PRF between 200Hz and 3kHz with specific pulse widths. The UWB signal is expected to operate at higher PRF than that.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from applying restrictive spectrum masks to control any UWB interference. In Ofcom's view, the following would mitigate the interference potential predicted in this paper:

- User to increase separation distance between UWB and RLAN. RLAN users are aware that there is no guaranteed quality of service when using an RLAN service.
- Internalised interference mitigation. In appliances that might have both UWB and RLAN present, many mitigation techniques are available to the manufacturers in order to prevent coupling, including isolating antennas and notch filtering. Several UWB manufacturers have suggested that the 5GHz band will be notched as there is fear of RLAN interference into UWB.
- Control on the minimum pulse repetition frequency (PRF) so as to ensure minimum chance of triggering false alarm in the RLAN DFS mechanism.

Comparison with USA: The RLAN standard in the US is based on IEEE802.11 standard whilst Europe uses the HIPERLAN/2 standard. However, both standards use the same physical layer performance requirement including the specified receiver sensitivities, but different frequencies. Hence, both systems are likely to have similar performance degradation from UWB.

Overall Conclusion: Ofcom believes there might be slight reduction in data rates in the worst case interference environment when the receiver is operating at the minimum sensitivity value and worst modulation type. However, the risk of this is low.

IMT-2000

Document: Draft CEPT ECCTG3 Report on UWB below 10.6GHz Annex 2-9

Description: This annex studied interference impact into IMT-2000 system for 3 scenarios:

1. Interference from single and multiple UWB into IMT-2000 mobile station receivers.

2. Interference from single and multiple UWB into IMT-2000 base station receivers.

3. Interference between UWB and IMT-2000 networks.

In depth analysis has been carried out for the 3 scenarios to consider the impact of interference on block error rate, capacity/coverage losses, throughput or quality of service degradation using deterministic, simulation, statistic and probabilistic Monte Carlo approaches.

Most of the material and the conclusion in the annex is from the work that RA/Ofcom commissioned to Mason Communications to study the impact of UWB to IMT-2000. Ofcom has also conducted measurements in its laboratories which have confirmed that UWB will look like Gaussian white noise in the mobile handset terminal even for UWB with low PRF values.

Quoted Conclusions: A UWB PSD value of -85dBm/MHz is needed at 36cm separation distance to protect the most sensitive IMT-2000 mobile station with no noticeable impact from UWB interference.

Ofcom's Analysis: Ofcom agrees with the PSD recommended to protect IMT-2000 mobiles which will normally be sufficient to protect the IMT-2000 base station depending on the assumed density of UWB devices.

Mitigation Analysis: Beyond the proposed Ofcom revision to the ETSI mask, Ofcom does not think that any further mitigation factors are necessary to protect IMT-2000 systems.

Comparison with USA: At present, there are no 3G deployments in similar bands using similar W-CDMA technologies so a direct comparison cannot be drawn.

Overall Conclusion: Ofcom supports the approach used in the study. We agree with the UWB PSD of -85dBm/MHz to protect IMT-2000 system against any noticeable impact from UWB.

Radio Navigation Satellite Service

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-10

Description: This annex describes the potential interaction between UWB and radio-navigation satellite service receivers (GPS, Galileo and GLONASS) in various bands between 1164 1610 MHz.

Quoted Conclusions: In the case of Galileo, safety of life and non-safety of life services have been considered in different scenarios. The worst case limit is obtained for the Galileo non safety of life applications with a maximum EIRP limit of -83.50 dBm/MHz, assuming a 1m protection distance.

For safety of life (typically aeronautical non-precision approach), a maximum EIRP limit of 79 dBm/MHz is obtained, assuming a 30m protection distance.

Ofcom's Analysis: The US identified serious potential incompatibilities between GPS and UWB early in its proposed rule-making process, and the FCC subsequently added a marked notch in the part 15 emission mask to provide increased protection. Ofcom's proposed mask further increases the protection for RNSS receivers. No information was available for this review on the protection requirements of restricted access signals. CEPT analysis indicates that the proposed mask would be marginally sufficient to protect Galileo receivers in both civil and safety-of-life use.

US studies revealed several potential interactions between types of UWB signal and GPS waveforms, and while this has been reflected in CEPT's consideration of Galileo, final conclusions are not yet available. No information is publicly available on compatibility of the protected signals of either GPS or Galileo.

GPS signals are made available for civil and commercial use on the express understanding that they may not always be reliable and may be subject to deliberately introduced errors. Such users are therefore strongly advised to have alternative, fall-back provision in place.

GPS reception is already dependant on the reception of a sufficient number of signals from different satellites, and with the mask proposed by Ofcom, it is expected that compatibility can be achieved subject to the loss of some marginal reception conditions in areas of high UWB activity. This might be at street-level between tall buildings or indoors, and fixed users may require externally-mounted, fixed antennas for continued reception of timing information.

The current level of noise from consumer electronics, combined with spurious emissions from communications equipment is especially relevant in these bands with their proximity to the operating frequencies of widely deployed handsets and similarity with the operating frequencies of current (2004) personal computers. In particular, permitted spurious emission levels are commonly at least an order of magnitude above the levels proposed for UWB devices, although emissions approaching such levels should be avoided where practicable.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks and (possibly small) separation distances between receivers and UWB emitters.

It is expected that personal users might relocate away from UWB emitters if their receiver could indicate that it was receiving interference. US studies noted that some consumer receivers failed to provide indications of error while presenting erroneous information before indicating complete loss of signal. NTIA measurements indicate differing levels of performance between receivers, and improved signal processing in light of expected UWB interaction may improve the performance of new receivers, and may be available for others as a firmware upgrade. Galileo may be in a better position as all its receivers should be designed to operate alongside UWB transmissions if these are permitted.

In Ofcom's view, the following would mitigate some of the interference predicted in this paper:

- Ofcom is already proposing a tightening of the UWB mask below 3.1 GHz which would assist compatibility in these bands.
- Users in static locations could use fixed, rooftop antennas if the service is degraded using current receivers.
- Receiver signal processing could be improved, particularly in the way the receiver reacts to compromised or marginal signals and provides such information to the user.
- Controls should be applied to UWB to minimise the energy radiated per bit of information transferred.
- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and toughen the regulation if required.

Comparison with USA: US assessments considered solely GPS, where sufficient concerns were raised for FCC to dramatically alter their proposed mask around GPS operating frequencies. Europe would be expected to have higher average area-density of UWB devices and wishes to adopt a different RNSS system - Galileo.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, but does not feel it adequately addresses the probability of this happening. The levels permitted by the proposed Ofcom mask are very close to the levels proposed by CEPT to protect Galileo. It is therefore suggested that any incompatibility will manifest itself as a loss of operation under marginal conditions in urban areas, rather than a dramatic and widespread loss of service. UWB is assessed to be low-medium risk for RNSS operation with some loss of coverage and service quality possible.

Fixed Satellite Service

Document: Draft CEPT ECC TG3 Report on UWB below 10.6 GHz Annex 2.11

Title: Fixed Satellite Service

Description: This document provides four uplink studies for the bands 5.725-7.075 and 7.9-8.4 GHz. They assess the potential impact of UWB interference to both FSS and MSS feeder uplinks.

Three downlink studies are presented for the bands 3.4 -4.2, 4.5-4.8 and 7.25-7.75 GHz , two being analytical and based on the impact of UWB interference on FSS and MSS downlinks. One of these applies NTIA-derived bandwidth correction factors (BWCF) for single entry and aggregate studies, whereas the second study applies a statistical Monte Carlo approach to assess the aggregate effect of UWB. Lastly a single entry measurement study on a downlink broadcast signals is presented.

Quoted Conclusions: The results indicate that the aggregate interference into the space-borne satellite receiver is unlikely to be problematic.

Both analytical downlink studies conclude that there is a significant risk of interference from UWB into the downlink earth station receivers, but present different conclusions:

The 1st study (using NTIA BWCFs) concludes that:

- A separation distance of 900 metres is required between satellite receiver and peak power emissions from a UWB device.

- A separation distance of 600 metres is required between satellite receiver and average power emissions from a UWB device.

In order to prevent interference, the study proposes that UWB EIRP densities need to be restricted as follows:

- The maximum permissible UWB EIRP density should be set equal to -63.56 dBm/MHz for average power emissions (both non dithered and dithered) with PRFs not less than 1 MHz.
- The maximum permissible UWB EIRP density should be set equal to -86.57 dBm/MHz for peak power emissions (both non dithered and dithered) with PRFs not less than 1 MHz.

The results of the 2nd study avoided the need for BWCF and concluded:

- Exclusion zone distances of 1-3km would be needed, which would likely be impractical.
- In order to fully protect the operation of FSS earth stations in the band, the study assumes that smaller exclusion zones (100m radius rural/50m Semi Urban/10m Urban) will surround the earth stations so that EIRP density of UWB must be reduced in order to provide an adequate protection to the FSS to the following levels -53dBm/MHz (rural area), -66dBm/MHz (semi-urban) area, -77dBm /MHz (urban area).

The measurement study found significant impairment arose when the pulsed UWB was brought within 6 metres of the earth station.

Ofcom's Analysis:

- The studies are incomplete as they do not consider MB-OFDM UWB sources.
- The analytical results are conservative in that the analyses do not take full account the size of the earth station antenna (G/T) or consider the effect of downlink carrier signal to (noise+ interference) on digital signal availability, and are based on the application of ITU criteria of I/N=-20dB for all aggregate sources.[1]
- The US NTIA [2] analytical studies were pessimistic, yet the US facilitated the deployment of UWB despite presence of C band TVRO and VSATs.
- The results from the single entry measurement differ substantially from the analytical assessment yet are representative only of one type of service. The measurement results have been independently replicated [3].
- The new EIRP levels proposed by the studies are significantly lower than the CEPT Rec 74-01E [4] spurious emissions limits that apply to other ubiquitous radiocommunication devices.

Mitigation analysis: There are very few mitigation options available to earth station operators that do not involve significant cost and/or which may require significant planning permissions.

Ofcom note that the application of a minimum UWB PRF of 1MHz would offer useful mitigation in terms of limiting the activity of UWB devices.

Overall Conclusion: The uplink studies show no significant risk of interference. The absence of available mitigation factors for downlinks clearly introduces a significant potential risk to FSS and some MSS services. Ofcom's view is that the current downlink assessment situation remains unresolved, however it is unlikely to be as bad as that depicted in analytical studies since these studies are worse case.

References

1. Recommendation ITU-R S.1432 Apportionment of the allowable error performance degradations to Fixed Satellite Service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 15GHz

2. NTIA special publication 01-43 Assessment of Compatibility between Ultra wideband devices and selected federal systems. January 2001

3. Doc IEEE 802.15-04/013r1 C Band satellite interference measurements at TDK RF test range" - IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANS) 12th January 2004

4. CEPT/ERC/Recommendation 74-01E (Siófok 1998, Nice 1999, Sesimbra 2002) Spurious Emissions

5. TG3#4_08R0 Impact of the FCC Average and Peak Constraints on the Power of UWB Radio Signals. IBM Research GmbH, Zurich

6. TG3#4_10R0: Effects of UWB- disturbances on radio communication services University of Karlsruhe.Michael Schmidt, Holger Jäkel, Friedrich Jondral

Amateur/Amateur Satellite Systems

Document Draft ECC CEPT TG3 Report on UWB below 10.6GHz Annex 2-12 Amateur/Amateur Satellite Systems

Description: This annex describes a link budget analysis showing the effect of UWB on a typical amateur station using Morse Telegraphy and SSB Characteristics for:

- S Band 1,240 – 1,300 MHz
- C Band 2,300 – 2,450 MHz
- B Band 3,400- 3,500 MHz
- A Band 5,650 – 5,850 MHz
- X Band 10,000 – 10,500 MHz

Quoted Conclusions: In order not to raise the noise floor of an amateur receiving system by 1dB, the UWB PSD required is:

- -85dBm/MHz for S Band 1.3 GHz;
- -61dBm/MHz for C Band 2.4GHz;
- -55dBm/MHz for B Band 3.4 GHz;
- -51dBm/MHz for A Band 5.7GHz;
- -46dBm/MHz for X Band 10 GHz.

Ofcom's Analysis:

- This study considers a conservative interference scenario where it's assumed that UWB is transmitting all the time and is in a line of sight path of an amateur station 10m away. Only free space propagation loss is considered. There might not always be clear path between UWB and amateur receiver. Building obstruction, indoor/outdoor attenuation, shielding and fading losses are not considered. With the additional mitigation losses, it is unlikely that the amateur station will suffer harmful interference from UWB.
- It has to be noted that the amateur receiver location can be located anywhere and the probability of amateur receiver being deployed in close proximity to UWB is not considered.
- Amateur receiver normally employed sophisticated filtering techniques to make it less susceptible to interference.
- CEPT/ETSI emission limits for spurious emission from other RF transmitters are comparable and sometimes higher than the proposed Ofcom revision to the ETSI limits in the bands considered. Amateur receivers already work in the presence of degraded noise floor.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from applying restrictive spectrum masks to control any UWB interference. The study estimated that there might be sharing difficulty in the A, B and X band. However, consideration of indoor/outdoor attenuation, building obstruction and other losses will likely mitigate UWB interference to an amateur receiver.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, but does not feel it adequately addresses the probability of this happening. Ofcom believes there would be very low risk of UWB interference into an amateur receiver. Ofcom notes that amateur radio receivers already operate in an environment dominated by spurious and unintentional radiation and are unlikely to suffer further degradation from UWB.

Maritime Mobile Service and Maritime Radio Navigation Service including the Global Maritime Distress and Safety System (Maritime)

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-13

Description: This annex describes a link budget analysis showing the effect of UWB on a variety of on-ship and shore based radio services including:

- Radiotelephony in the MF, HF VHF and UHF bands.
- Radar in the S and X bands, search and rescue transponders at 9GHz.
- Automatic identification systems in the VHF band.
- Radio navigation systems such as LORAN-C.

Quoted Conclusions:

- *UWB on ship interfering with ship systems:* VHF communication systems require a UWB EIRP of –75dBm/MHz at 158MHz. S- band radar requires –88dBm/MHz at 3GHz and X-band radar –78dBm/MHz at 9.4GHz. Hence the inference is that UWB devices should not be allowed on ship with the proposed Ofcom revision to the ETSI mask.

- *UWB on shore interfering with ship systems:* VHF communication systems need a UWB EIRP of –45dBm/MHz at 158MHz for a single UWB device and -75dBm/MHz for 1000 devices/km2. S- band radar requires –59dBm/MHz at 3000MHz and X-band radar –49dBm/MHz at 9.4GHz for a single UWB device. Aggregations reduce this by about 60dB in suburban case of 1,000 devices per km2. Hence UWB is not compatible with radar.
- *UWB on shore interfering with shore systems*: VHF communication systems require a UWB EIRP of –75dBm/MHz at 158MHz. Radars look out to sea and are blanked when scanning over the shore so no problems should be experienced with UWB.

Ofcom's Analysis: The paper does not consider the relative magnitude of UWB at MF to UHF frequencies with that of other noise sources such as CISPR EMC limits, CEPT limits on spurious emissions in these bands and natural emitters [1,2,3,4]. Since the CEPT/CISPR limits are nearly identical to the UWB limits proposed in these bands, it is unlikely that UWB interference will be detectable.

- *UWB on ship interfering with ship systems:* In this controlled environment, it will be up to the maritime authorities to decide whether they wish to allow UWB on board ship or not. However, Ofcom considers that the paper uses worst-case analysis for the systems under consideration. For example, the radio systems considered usually have external antenna whereas any UWB devices on ships are expected to be inside the superstructure. For A2 and A3 ships, the structure is either metal or contains a large number of metal components and hence a large attenuation of the interference signal can be expected.
- *UWB on shore interfering with ship systems:* The radar incompatibility with UWB is a direct result of the protection ratios used in the calculation (16dB) and the assumed antenna gain. These mean that the maximum UWB power into the radar is set at –150dBm/MHz in a 20MHz channel or 16dB less than that expected from thermal radiation. It is unclear from the data presented whether this is a realistic limit considering the radar scattering cross-section of targets seen in practice. Ofcom has identified that most UWB devices will be transmitting indoors and so expect building attenuation to severely limit the possibility of aggregation of UWB interference onto maritime radar. It is also noted that UWB pulses will be uncorrelated with the radar return pulses and have different pulse widths and rise time characteristics. As a result, removing them from a radar signature may be technically possible. Furthermore, it is noted that radar sensitivity for ship-born radar in these bands may be limited more by false return cancellation than by receiver sensitivity.
- *UWB on shore interfering with shore systems:* The required UWB EIRP limit for VHF transmission is much less than emissions already allowed for spurious signals from intentional and from unintentional transmitters in these bands (e.g. [1],[2],[3]). Ofcom expects UWB devices to have similar spectral characteristics at VHF as is found from unintentional transmitters and so expects no degradation in user experience.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks that could be employed by regulators to ensure a low probability of interference to existing maritime services. In Ofcom's view, the following would mitigate much of the interference predicted in this paper:

- Controls on how much radio energy UWB devices can emit in the 3.1 to 10.6GHz band when they are not transferring data to another compatible UWB device. Ofcom expects most high-rate data transfer to occur in bursts and predominantly in an indoor situation.
- Controls on how much UWB radio energy devices can transmit in the 3.1 to 10.6GHz band when they are not associated with another compatible UWB device. Ofcom expects most devices taken out of doors to be in this non-associated state.
- Controls on the minimum pulse repetition frequency (PRF) and pulse lengths so as to ensure data is sent in bursts with a minimum chance of interference to maritime radars.
- A requirement for UWB devices to meet current European EMC limits for frequencies less than 1GHz when the device is transmitting.
- A comprehensive man-made noise measurement programme that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and toughen the regulation if required.

Comparison with the USA: Largely the same as maritime systems are international.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, but does not feel it adequately addresses the probability of this happening. In Ofcom's view, maritime devices operating below 1GHz already operate in an environment where there is significant spurious and unintentional radiation and are unlikely to suffer additional degradation from UWB. Ofcom expects most of the predicted radar degradation in the S and X band to be limited by building and other losses in those areas where UWB is likely to be widely deployed.

References:

1. CISPR 22 – 3rd Edition "Information Technology Equipment- Radio Disturbance characteristics, limits & methods of measurement' International Electrotechnical Commission 1997
2. CISPR 14- 1 4th Edition 2000
3. RECOMMENDATION ITU-R P.372-8
4. CEPT/ERC/Recommendation 74-01E

Aeronautical

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-14.

Description: This annex describes the potential interaction between UWB and aeronautical use - primary and secondary radar, radio altimeters, MLS, DME/TACAN, VHF communications, ILS and HF beacons and communications.

This assessment is restricted to aeronautical use above 500 MHz and assumes that UWB emissions from UWB communications devices are limited to -85 dBm/MHz below 2 GHz. The following bands are considered:

- 960 1215 MHz DME/TACAN Distance Measuring and bearing
- 1030 MHz Secondary radar Airborne responder

- 1090 MHz Secondary radar Ground interrogator
- 1215-1350 MHz 23cm primary radar long range 200+ nautical miles
- 2700 3100 MHz 10cm primary radar within 100 miles of airfield
- 4200 4400 MHz Radio altimeters
- 5030 5150 MHz MLS microwave landing system
- 9000 9500 MHz 3cm primary radar ground operations at airfield

Quoted Conclusions:

- The calculations shown in table below are indicative figures based on the intra-system protection criteria for each aeronautical system.
- For all aeronautical systems, the effect of multiple UWB interferers will dominate that of a single interferer at a density of less than 50 active devices/km2.

System	Frequency band (MHz)	Rx Location	Minimum Separation Distance (m)	Single UWB PSD limit	Density of active UWB transmitters (/km²)		
					5	50	500
				(dBm/MHz)	UWB PSD limit (dBm/MHz)		
NDB	0.255 – 0.5265	A	300	-34.7	-46.6	-56.6	-66.6
HF Comms	2.85 – 22	G					
		A	300				
Marker Beacon	74.8 - 75.2	A	100	-16.5	-19.2	-29.2	-39.2
ILS Localiser	108 - 112	A	50	-55.6	-52.5	-62.5	-72.5
VOR	108 - 117.975	A	100	-57.1	-59.9	-69.9	-79.9
GBAS	108 - 117.975	A	30	-52.5	-45.2	-55.2	-65.2
VHF Comms, VDL Mode 4	108 – 137	G	30				
		A	300				
VHF Comms, VDL Mode 2&3	117.975 – 137	G	30	-54.9	-47.6	-57.6	-67.6
		A	300	-37.9	-49.8	-59.8	-69.8
VHF Comms, 8.33 kHz AM	117.975 - 137	G	30	-57.4	-50.1	-60.1	-70.1
		A	100	-43.0	-45.7	-55.7	-65.7
VHF Comms, 25 kHz AM	117.975 - 137	G	30	-57.4	-50.1	-60.1	-70.1
		A	100	-43.0	-45.7	-55.7	-65.7
ILS Glidepath	328.6 - 335.4	A	50	-37.4	-34.3	-44.3	-54.3
50cm Radar	590 – 598	G	30	-91.4	-84.1	-94.1	-104.1
DME/ TACAN	940 - 1 215	G	30	-61.2	-53.9	-63.9	-73.9
		A	100	-36.8	-39.5	-49.5	-59.5
Secondary Surveillance Radar	1030 & 1090	A	100	-34.8	-37.6	-47.6	-57.6
		G	30	-71.7	-64.4	-74.4	-84.4
23cm Radar	1 215 – 1350	G	30	-99.3	-92.0	-102.0	-112.0
10cm Radar	2700 – 3100	G	30	-102.6	-95.3	-105.3	-115.3
Satellite Comms	1545 - 1559 & 1645.5 - 1660	A					
		Sat					
Radio Altimeters	4200 – 4400	A	50	-47.3	-44.2	-54.2	-64.2
MLS	5030 – 5150	A	50	-43.3	-40.2	-50.2	-60.2
Weather Radar	5350 – 5470	A	300				
Doppler Radar	8750 – 8850	A	300				
3cm Radar	9000 - 9500	G	30	-98.7	-91.4	-101.4	-111.4

Notes

In systems that contain both an airborne and ground receiver, the dominant interference is at the ground receiver. This is largely due to a lower minimum separation distance in the ground environment. The only exception to this is the VDL Mode 2 & 3 airborne receiver which has greater typical bandwidth than the ground receiver.

For all ground receivers, the effect of multiple interferers becomes dominant over the single interferer case at a density of less than 50/km^2. This is due to a minimum separation distance of 30m being applied in all cases in the ground environment. It can be shown by calculation that this effect occurs at a density of approximately 26/km^2.

For systems that contain an airborne receiver only, the effect of multiple interferers always becomes dominant over the single interferer case at a density of less than 50/km^2.

Ofcom's Analysis: The studies were based on actual or estimated receiver sensitivities, and included conservative interference to noise ratios, an aeronautical protection margin of 6dB and a factor to apportion interference between other services of 6dB. This results in safety margins of typically 20dB, with a maximum of 37dB in the case of MLS for systems operating above 500 MHz. These need to be carefully considered and fully justified, in particular alongside consideration of how the system would actually respond to the UWB signal. Early NTIA studies use lower margins and also considered the wanted signal during system operation - e.g. the return from the ground is likely to be larger for radio altimeters when the aircraft is flying at low altitude and therefore closer to UWB devices, so in this situation it is S/I which is important rather than I/N. It is noted that several of the stated protection requirements are significantly more severe than either current EMC limits or permissible spurious emission levels.

The susceptibility of safety-of-life aeronautical services to interference is difficult to generalise, and, particularly in relation to primary radar, is significantly affected by individual operating conditions and user requirements such as the local environment and required detection zones. Additionally, primary radars may be configured for specific operating environments, and the receiver sensitivities used in the CEPT study are realistic for the maximum expected operating ranges of the radar systems.

Primary radars are expected to be more susceptible due to the 'there-and-back' nature of operation and particular difficulties are identified in relation to UWB devices at short to medium ranges which come within areas of high antenna gain. Large exclusion areas are predicted. The 50 cm radar is solely used by the UK, though it is noted that the protection requirement is lower than existing EMC limits. The assessment methodology derived a limit for the contribution to the noise received by the radar from a single UWB emitter assuming that this was coupled through the main beam of the antenna. It is not clear whether the assessment of aggregate interference from distributed UWB devices applied this figure to all directions, in effect giving the radar receiver omni-directional high gain. The assessment is also based on a minimum separation distance of 30 m for a UWB device intruding into the main beam of the radar. This would subject the UWB device to high field strengths at which it would be unlikely to operate and a distance of 300 m would be more appropriate, in terms of both RF exposure levels and the integrity and coverage of the radar beam.

The early NTIA study, which considered single UWB interferers, was much less concerned about radio altimeters since it included the increase in the strength of the wanted return signal when the aircraft was nearer the ground and simultaneously exposed to higher UWB signal strength.

DME/TACAN and Secondary Surveillance radar are expected to be compatible with a -85 dBm/MHz mask level, while MLS requires further consideration of whether antenna patterns and relative separation distances would effectively mitigate the indicated incompatibility.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks and (currently small) separation distances between receivers and UWB emitters.

All assessments include considerable margins (typically 20 dB, maximum 37 dB) and are based on actual or estimated receiver sensitivity. This might not be used in all cases - e.g. when the aircraft is close to the ground and most subject to UWB emissions its receiver may also be operating with a very good wanted signal strength and considerably above its receiver sensitivity. This would need to be assessed in individual situations.

The potential for interaction between the main beam of the primary radar and UWB devices is more difficult to mitigate for radars operating around airfields. Judicious location of the 3 cm radars may provide some mitigation. 23 cm radars would be expected to be sited remotely and probably on high land to maximise their range, particularly against aircraft at lower altitudes. 10 cm units are generally associated with airfields, with a high density in South-East England, and there is less freedom to relocate these. However more modern radar systems may employ modulated pulses to improve target recognition and this is not reflected in CEPT's analysis.

In Ofcom's view, the following would mitigate some of the interference predicted in this paper:

- Ofcom is already proposing a tightening of the UWB mask below 3.1 GHz which would assist compatibility in some of the bands used for aeronautical systems.
- The OFDM UWB modulation scheme may allow emissions in certain bands to be reduced and could more easily provide reduced emission levels outside of the main UWB operating band.
- Controls could be applied to UWB to minimise the energy radiated per bit of information transferred.
- The minimum range at which a UWB device might intrude into the main beam of the radar could be relaxed to 300m, giving a 20dB mitigation in the protection requirement.
- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and tighten the regulation if required.

The international mobility of aircraft and their radio equipment, the cross-border coverage provided by several of these services, and the responsibilities for ensuring public safety constrain the mitigation methods that may be applied for this service.

Comparison with USA: The US has a similar use of aeronautical bands to the UK and Europe, and mask levels appropriate for the US would be expected to largely satisfy European concerns - albeit with the higher average population density in Europe there would be reduced opportunities for (re-)locating systems in quiet areas to avoid interference. However the different approach adopted by the early NTIA study, and its focus on individual UWB interference, has resulted in different conclusions for some bands and services.

Overall Conclusion: Ofcom considers this paper to be a conservative analysis of what could happen if UWB was introduced, but does not feel it adequately addresses the probability of this happening. The mask proposed by Ofcom has been tightened and provides additional protection to several of these bands compared to the FCC mask, however both are significantly more severe than emission limits in either EMC standards or standards for spurious emissions.

Radars - meteorological

Document: Draft CEPT ECC TG 3 Report on UWB below 10.6GHz Annex 2-15.

Description: Meteorological radars working in the following frequency bands:

- 2700 2900 MHz
- 5650 5650 MHz
- 9300 9500 MHz

Quoted Conclusions: The document suggests that UWB devices operating according to the FCC mask are not compatible with meteorological radars.

Detailed simulations presented on both deterministic (single entry) and statistical (aggregate) basis generate the results in the following table giving the power density limit that would allow UWB applications to operate in the 2.8 GHz and 5.6 GHz frequency bands without producing harmful interference to meteorological radars.

Frequency band	UWB application type	Current US FCC power density limit	Power density limit necessary to protect Meteorological radars
2.8 GHz	Imaging (low density)	-41.3 dBm/MHz	-51 dBm/MHz
	Telecommunication (indoor)	-51.3 dBm/MHz	-61 dBm/MHz
	Telecommunication (outdoor)	-61.3 dBm/MHz	-71 dBm/MHz
5.6 GHz	Imaging (low density)	-41.3 dBm/MHz	-51 dBm/MHz
	Telecommunication (indoor and outdoor)	-41.3 dBm/MHz	-65 dBm/MHz
9.4 GHz	Imaging (low density)	-41.3 dBm/MHz	-54 dBm/MHz
	Telecommunication (indoor and outdoor)	-41.3 dBm/MHz	-60 dBm/MHz

Ofcom's Analysis: The conclusions are broadly similar, albeit without the aeronautical and multi-service margins, to assessments for aeronautical radar. A feature common to them all, and brought out more clearly in NTIA studies, is the difficulty when a UWB device couples energy into the main receive beam of the radar. This would subject the UWB device to the higher field strengths and increased separation distances would be appropriate in terms of both RF exposure levels and the integrity and coverage of the radar beam. Additionally these radars will have dispersed targets rather than large solid bodies typical of other radars, and may therefore not benefit to the same extent from processing gain. The conclusion is that compatibility largely depends on prevention of the UWB emitter from entering the region swept by the radar main-beam.

Mitigation Analysis: This paper does not consider other mitigation techniques apart from restrictive spectrum masks and (possibly small) separation distances between receivers and UWB emitters.

In Ofcom's view, the following would mitigate some of the interference predicted in this paper:

- Ofcom is already proposing a tightening of the UWB mask below 3.1 GHz which would assist compatibility in one of the bands.
- Controls should be applied to UWB to minimise the energy radiated per bit of information transferred.
- Reduce the capabilities of the radars to observe remote, near-ground conditions by raising the minimum operational elevation to reduce coupling from UWB devices.
- The OFDM UWB modulation scheme may allow emissions in certain bands to be reduced and could more easily provide reduced emission levels outside of the main UWB operating band.

- The minimum range at which a UWB device might intrude into the main beam of the radar could be relaxed to 300 m, giving a 20 dB mitigation in the protection requirement.
- A comprehensive man-made noise measurement program that could be repeated periodically to determine any increase as a result of UWB devices. This would allow Ofcom to monitor the situation and toughen the regulation if required.
- Require vertical separation between the radar and possible UWB devices within several kilometres of the radar site. This is under national control, but may have associated monetary and environmental costs.

Comparison with USA: The early NTIA study clearly identified the potential interference issue for UWB emitters in the radar main-beam, covering 2.8 GHz (NEXRAD) and 5.6 GHz (TDWR) systems, though not 9.4 GHz radars. US has regions with more severe weather than much of Europe, e.g. mid-west tornados, great-lakes snowfall, and is expected to have a denser network and place more reliance on weather radars.

Overall Conclusion: Compatibility between weather radars and UWB requires that UWB emitters remain outside the radar beam. This essentially requires a height differential - with the radar above the UWB emitter - to be maintained for distances of several kilometres around the radar. It might be possible to relocate some radars to provide coverage of similar areas, or raise the lowest elevation beams in some locations, although this would decrease coverage of ground-level conditions at greater distances.