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Study on Legal, Economic & Technical Aspects of 'Collective Use' of Spectrum in the European Community

Final Report

November 2006

The opinions expressed in this study are those of the authors and do not necessarily reflect the views of the European Commission

Mott MacDonald

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About the Authors

This report was prepared by Mott MacDonald Ltd, Aegis Systems Limited, IDATE, Indepen Ltd and Wik Consult for the Radio Spectrum Policy Unit (RSPU) of the Information Society Directorate-General of the European Commission. Mott MacDonald, Aegis Systems, IDATE, Indepen and Wik Consult wish to thank the RSPU for their assistance and for providing expert comments on the draft. We also wish to thank national spectrum management authorities and stakeholder representatives who participated in our interviews, questionnaire and workshop.

This report represents the work of Mott MacDonald Ltd, Aegis Systems Ltd, IDATE, Indepen Ltd and Wik Consult GmbH and does not necessarily represent the views of the Radio Spectrum Policy Unit or any other group.

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WIK-Consult provides contract consulting services to public and private institutions. As the convergence of telecommunication, media and information technology leads to new challenges for political and business decision makers, WIK-Consult provides sound recommendations on regulatory and policy issues based on solid, scientific analysis. WIK-Consult's clients include national and international regulatory authorities, the European Commission, and a wide range of corporate institutions.

0 Executive Summary

0.1 Introduction

This report presents the findings of a study on the Collective Use of Radio Spectrum, undertaken for the European Commission[1] by a consortium comprising Mott MacDonald Ltd, Aegis Systems Ltd, Indepen Consulting, IDATE and WIK-Consult GmbH[2]. Collective use of spectrum allows more than one user to occupy the same range of frequencies at the same time, without the need for an individual, exclusive authorisation. The term "spectrum commons" is sometimes used to describe such use; however collective use also includes certain types of licensed use where access to spectrum is on a shared basis. The potential benefits of collective use of spectrum include:

- lower barriers to market entry;
- the ability to address quickly niche applications;
- greater certainty of obtaining access to spectrum;
- more certainty of tenure;
- flexibility to adopt different technology and applications;
- reduced likelihood of illegal operation in licensed frequency bands;

This study considered how the extension of the collective use approach might contribute to broader EU policy objectives, with regard to optimising the use of scarce radio spectrum resources, strengthening the internal market, supporting innovation, and promoting competitiveness. Technical, market and regulatory aspects were analysed and policy options assessed. A number of recommendations emerged from the study, proposing measures at a national and Community level to support these objectives through the collective use approach.

An extensive review of the current status of collective spectrum use around the world was undertaken to inform the study. This involved extensive desk research, complemented by a series of interviews and questionnaire responses from a broad cross-section of spectrum management authorities (SMAs) and industry representatives.

0.2 What is collective use of spectrum and why is it so important?

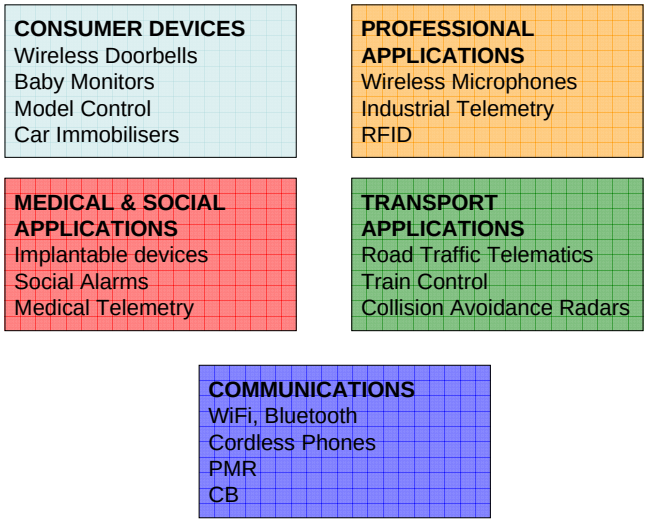
Collective use of spectrum underpins a multitude of wireless applications including wireless computer networks, consumer devices (e.g. wireless doorbells and key fobs), medical

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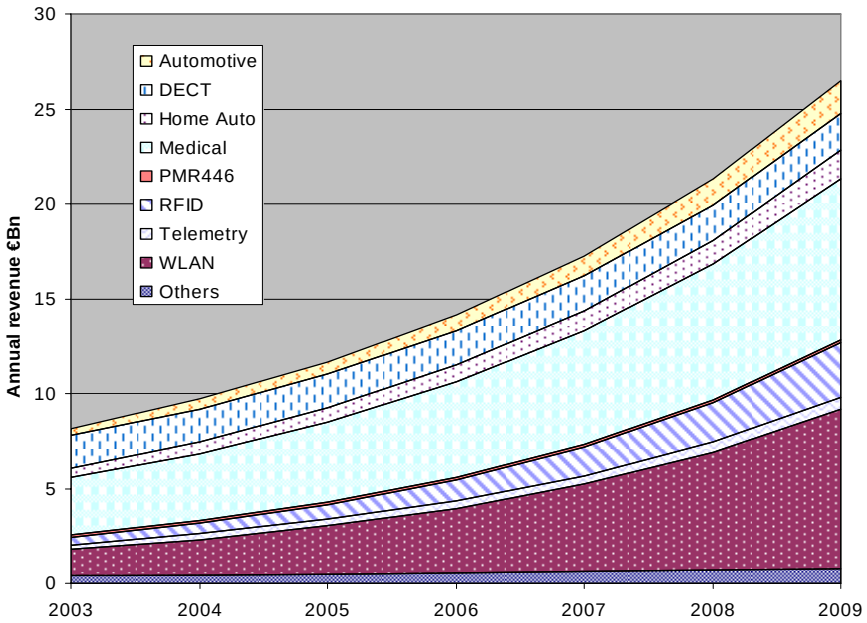
devices, industrial equipment and intelligent transport systems. Figure 1 shows the five main market sectors and provides examples of specific applications within each sector.

Figure 1: Main market sectors served by collective use applications



The size of the market for these devices is difficult to quantify, since for licence-exempt there are few reliable records of user numbers. However, our research suggests that the European market for products and services dependent on collective use of spectrum is currently around €15 billion annually and this is likely to grow to more than €25 billion by 2009. Figure 2 shows indicative estimates for market growth over the period 2003 – 2009. The economic importance of collective use is indicated by the economic benefits it provides in terms of system cost savings, productivity gains, reductions in congestion and accidents in transport networks, health and safety benefits, and user convenience. For example, public WiFi services depend entirely on collective use of spectrum and we estimate that the net present value of economic benefits derived from these services over the next 20 years in the EU could be around €600 billion.

Figure 2: Estimated size of the collective spectrum use market



0.3 Regulatory and Technology considerations

0.3.1 Regulatory framework for collective use of spectrum

Collective use is one of three main approaches to management of radio spectrum, the other two being the *administrative* model, whereby individual users are granted exclusive rights to use spectrum on an administrative basis by SMAs, and the *market based* model whereby exclusive rights are acquired by market mechanisms such as auctions or spectrum trading. Whereas the administrative and market based models generally provide spectrum users with a degree of statutory protection from interference, this is not the case for collective use. Depending on the application, interference may be moderated by restricting specific frequencies for specific applications, however in many cases there are no such constraints and only generic limits such as power or duty cycle are applied. The effects of interference can largely be mitigated by appropriate choice of technology, as evidenced by the recent rapid growth in applications such as wireless local area networks (WLANs) which depend entirely on collective use of spectrum.

The main objective of EU radio spectrum policy is to optimise the use of spectrum so as to maximise its value for society and to avoid harmful interference Since February 2005, the Commission has issued a number of policy statements aimed at promoting more flexible use of spectrum and greater use of market approaches to spectrum management. Most recently, as part of the 2006 review of the Regulatory Framework for Electronic Communications, the Commission has signalled its intention to adopt legally binding instruments to:

- Achieve the introduction of technology and service neutral spectrum use as a default position; and

- Establish a committee process to identify selected bands for use under general authorisation (i.e. for collective use).

The allocation of spectrum at a national and European level is the responsibility of SMAs operating within the European regulatory framework. The main organisations involved are the European Commission's Radio Spectrum Committee (RSC), the European Communications Committee (ECC) and the European Telecommunications Standards Institute (ETSI). ECC is a committee within the European Conference of Telecommunications Administrations (CEPT) which co-ordinates radio spectrum matters between the 47 CEPT Member States.

Historically, the approach to harmonising collective spectrum use in Europe has been predominantly based on Recommendations or Decisions issued by the ECC, although in some cases (such as DECT cordless phones) an EC Directive mandated the process. ECC Recommendations are voluntary in nature and there is no obligation on individual Member States to implement them. ECC Decisions carry greater weight, in that once Member States have committed to implement Decisions they are obliged to do so; however, there is no obligation to make such a commitment.

Collective use spectrum is mainly allocated to short range devices (SRDs). Specific ECC Decisions that are intended to allow free circulation within the CEPT area cover some of these; however, implementation of these by EU Member States varies. SRD spectrum management activities are mainly handled by the SRD Maintenance Group of CEPT, which maintains the principal European regulatory reference document for SRDs, CEPT Recommendation 70-03 (Rec 70-03). This document defines twelve specific SRD applications and a single generic category of "non-specific devices".

Since the introduction of the new EU regulatory framework there has been a move towards using Commission Decisions to support key harmonisation measures, to provide greater legal certainty. A draft Commission Decision on the harmonisation of the radio spectrum for use by SRDs was issued for public consultation on 8th August 2006. The document as drafted required Member States to make available, on a non-exclusive, non-interference and non-protected basis, a series of frequency bands for short-range devices, subject to the specific conditions and by the implementation deadline, defined in the Annex to the draft Decision. However, the current draft Decision only addresses those bands and applications that have already been implemented throughout the EU through the existing CEPT process. The EU's current role in this area appears therefore to be largely a reactive one, strengthening the status of existing harmonised allocations by incorporating them into EU legislation but not driving further harmonisation where this has failed under the existing arrangements.

Global harmonisation is increasingly important for many SRD applications, having been a significant factor in the growth and anticipated future success of Wi-Fi and RFIDs, for example. In some cases, market developments have driven moves towards global allocations, for example, the widespread availability of low cost FM micro transmitters in the U.S. and Asian markets has led to regulatory provision for such devices in Europe.

0.3.2 Technologies supporting collective use

Collective use of spectrum involves a wide variety of technologies, which have evolved over the years to facilitate sharing with both other collective users and with licensed (exclusive) users. The need for sharing has led to innovation in spectrum access methods and interference mitigation techniques to ensure that the technologies can co-exist and that the user experience is satisfactory in an environment where users are not protected from interference from other legitimate users.

At the simplest level, interference is managed by limitations on radiated power and/or duty cycle (i.e. the proportion of time during which the system transmits). More advanced interference mitigation techniques, such as listen before talk (LBT) and spread spectrum, are increasingly used to support more intensive sharing. Recently, these concepts have been stretched even further, with Ultra Wide Band (UWB) technology (where the signal is spread over a bandwidth of up to several GHz) and cognitive radio (where the transmission frequency responds dynamically to changes in the local interference environment).

However, many collective use applications still deploy basic analogue or digital technology that dates back many decades. This is particularly the case for low cost consumer devices, but also applies to some professional applications (e.g. wireless microphones) where digital technology cannot currently match the performance of analogue systems. Historically, SRD standards did not specify receiver characteristics and many devices had very poor receiver selectivity, which left them prone to interference from high power transmissions in adjacent bands. There have also been examples of non-harmonised SRD allocations that have delayed the implementation of harmonised bands or led to interference between licensed and licence-exempt services.

Our research and findings from the interviews and questionnaires undertaken as part of the study identified a number of specific regulatory issues that were of concern to industry. These focussed on three key areas, namely:

- speeding up and simplifying spectrum access
- addressing future spectrum demand growth
- furthering harmonisation of collective use spectrum

These areas are addressed in the following sections.

0.4 Speeding up and simplifying spectrum access

0.4.1 Introduction

The large number of different applications and technical standards referred to in Rec 70-03 acts as a barrier to the introduction of new applications that do not clearly fit into historic allocations. This is not compatible with a rapidly evolving consumer devices market and may act as a deterrent to the development of new, innovative wireless technologies or services. Improving awareness of market opportunities through readily available information on collective spectrum use in Member States and simplifying the conditions attached to using

such spectrum should help the development of innovative new wireless technologies and applications.

0.4.2 Simplifying spectrum access

There may be cases where it is appropriate to limit the applications or technologies used in a collective use band, for example for safety-critical, health or security applications, so that an acceptable quality of service (QoS) is maintained. However, where such considerations do not arise, as in the case of many consumer applications or wideband data systems where protocols are specifically engineered to cope with a hostile interference environment, a "minimal constraints" approach is likely to be more appropriate. To improve awareness of the opportunities provided by collective spectrum use and encourage new market entrants, there is a good case for simplification of the current regulations relating to collective spectrum use, as embodied in Rec 70-03.

We therefore propose that there should be a clear distinction between application or technology-specific allocations and general purpose allocations that have minimal restrictions, and that the former should be objectively justified on the basis of service quality and spectrum co-existence requirements. Steps should be taken to harmonise spectrum in the latter category throughout Europe, to provide developers with ready access to the entire European market in the same way that developers have access to the 902 – 928 MHz band throughout North America. A distinction should also be drawn between licence-exempt spectrum exclusively allocated to collective use and that which is shared between collective use and licensed services, or where some form licensing or co-ordination is required, as the latter is more constrained in its use.

Recommendation 1: Simplify categorisation of collective use spectrum

To facilitate understanding and awareness of collective spectrum use, we recommend that frequency allocations for collective use be grouped into three specific categories. This will differentiate clearly between allocations that are constrained to particular applications or technologies on quality of service / co-existence grounds and those that are available for general use with minimal constraints. The three categories should be defined as follows:

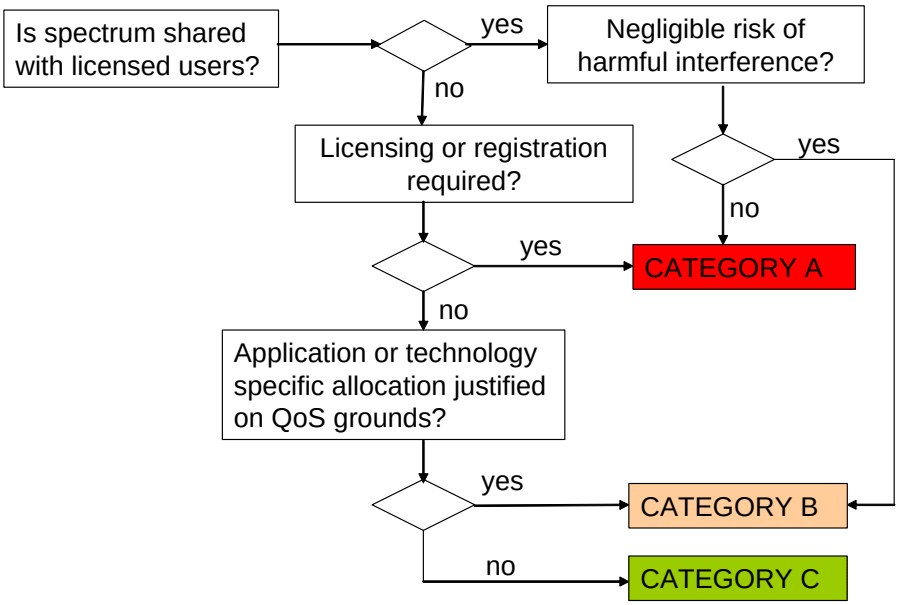
Category A: Licensing or co-ordination required to avoid interference to licensed, non-collective use applications, or to facilitate future re-farming.

Category B: Limited to specific applications and/or or technologies in order to reduce the risk of interference and maintain an acceptable quality of service.

Category C: No limitation on the applications or technology other than those required to avoid harmful interference.

Existing collective use designations should be categorised in accordance with the following flowchart:

Figure 3: Flow chart for spectrum categorisation



0.4.3 Speeding up spectrum access

The time taken to allocate harmonised spectrum for new applications can take several years, whereas consumer product lifecycles can be as little as 1-2 years. Much of the delay occurs because of the time taken to carry out technical work in standards bodies and CEPT. This work is generally undertaken by working groups whose members comprise SMA and industry representatives working on a part-time basis. The time could be shortened if work on these matters was undertaken on a full-time basis. There are a number of ways this could be achieved including:

- dedicated resources supplied by NRAs and industry for a specified period of time on projects;
- creation of a permanent team within CEPT to undertake technical analysis; or
- creation of a fund to procure the technical analysis through a competitive tendering processes.

We believe that the Commission and CEPT should establish a structure and process that allows more concentrated effort to be applied to any market or technical studies required to inform spectrum management decisions. This would reduce the time to gain harmonised spectrum allocations for new collective use applications and thereby reduce the time to market. The resource identified should undertake the Regulatory Impact Assessments and Compatibility Studies required in supporting decisions. In addition, prioritisation of effort for strategically important areas of spectrum and regulation needs to be managed by a central body – we consider that this would be an appropriate role for the EU Radio Spectrum Committee

Recommendation 2: Make provisions for a full-time resource to be available (either permanent or ad-hoc basis) to undertake the necessary market and technical studies to inform decisions on future spectrum allocations

0.4.4 Improving Information on Collective Spectrum Use

The European Frequency Information System (EFIS) is an on-line searchable database developed by CEPT and accessible via the Internet, providing information on European frequency allocations and uses on a country-by-country basis. We have found that Rec 70-03 and EFIS are inconsistent and in some cases information is incomplete and/or out of date. This means that developers need to contact up to 47 individual NRAs to determine the implementation status of collective use bands. This is a significant barrier to market entry particularly compared with the situation in the US where there is a single regulatory body.

EFIS has the potential to provide a definitive on-line information resource on harmonised collective use spectrum in Europe. Spectrum that is harmonised throughout the EU should be one of the high level choices when searching the EFIS database. The European Common Frequency Table, as accessed through EFIS, should also be enhanced to show clearly all spectrum where collective use has been harmonised across Europe, by CEPT and/or EC measures, with clear cross references to the relevant technical and regulatory conditions for use of the spectrum. The Commission could assist this process by requiring Member States to publish the relevant information on the status compliance with EC and CEPT harmonisation measures in their National Frequency Allocation Tables and to submit this information to CEPT at least every six-months.

Recommendation 3: A single, definitive, on-line information resource on harmonised collective spectrum in Europe should be established

0.5 Accessing future spectrum demand

0.5.1 Introduction

New spectrum allocations need to be considered well in advance, to allow for migration of existing users and development of appropriate technical conditions. Although there is not an immediate problem with congestion in collective use bands, rapid growth in the use of some bands is anticipated (e.g. the RFID band around 866 MHz) and more spectrum is likely to be required in the future. Demand for licensed radio spectrum is also likely to grow, to accommodate increasing demands for broadband mobility and to maintain quality of service for public wireless networks. There is a presumption built into the EU Regulatory Framework that collective use should be the preferred approach to spectrum allocation where there is a negligible risk of harmful interference. Designating a band as suitable for collective use relaxes some constraints on entry and use but almost invariably introduces new constraints, for example restrictions on power and requirements for interference mitigation. Hence, the costs and benefits of decisions concerning the allocation of spectrum to licensed versus collective use need to be assessed on a case by case basis.

There are three ways of catering for future demand growth for collective use spectrum, namely:

- finding additional spectrum allocations for collective use;
- developing ways of sharing spectrum between collective and licensed use;
- making greater use of existing collective use allocations.

The case for (or against) allocating spectrum to collective use and how this is done should take account of likely future demand growth, the potential to use new technologies and the implied opportunity cost in terms of spectrum denied to licensed use.

0.5.2 The balance between licensed and licence-exempt spectrum

Where there are competing demands for spectrum, economic welfare is maximised if users face the opportunity cost of their use. For licensed services this can be achieved by auctions, spectrum trading or the application of spectrum fees based on opportunity cost. Such approaches cannot be readily applied to licence-exempt collective use. A *private commons*, whereby an organisation buys spectrum and makes it available to others on a collective basis might however provide one way of introducing market forces and may be practical if:

- The party buying the spectrum obtains significant benefits from collective use by others; or
- A group of users who club together to pay for the spectrum collectively obtain significant net benefit from this use.

In both cases, the following issues would need to be addressed:

- Would “free riders” undermine the viability or quality of the service?
- Can markets take account of the social benefits arising from the spectrum use?
- Would acquisition of spectrum on a single-country basis be sufficient to support equipment production?

On balance, we conclude that private commons may play a limited but potentially useful role in meeting demand for collective spectrum use for certain types of user. However, in practice we believe that most decisions on whether to designate spectrum for collective use will need to be made administratively. Such decisions should be made in a transparent manner considering all feasible options and using all available information on the costs and benefits of these options. The EC’s regulatory impact guidelines provide a template for making such assessments and we recommend that the Commission and CEPT when considering potential candidates for collective spectrum use in the future adopt this.

The analysis should consider the benefits and costs associated with exclusive or collective use of the spectrum and should be based on information such as the following:

- The extent of use of collective use spectrum, gathering through monitoring activities undertaken by SMAs or possibly industry.

- Trends in the deployment of collective use applications/equipment. This will need to be supplied by industry or possibly collected through consumer surveys conducted by SMAs or national statistics organisations.

- International trends in collective use applications gathered from industry and other SMAs.

To assist this process, the Commission should develop ways in which this information can be gathered on a systematic basis through co-operation with industry and SMAs.

Recommendation 4: Establish a transparent, objective methodology for deciding whether to allocate spectrum for collective use

0.5.3 Potential new frequency bands for collective spectrum use

The study considered a number of options for increasing the spectrum available for collective spectrum use, to cater for future growth and to facilitate innovative new uses. Issues addressed included the scope for extending existing frequency bands, the need to address anticipated growth in specific applications and identification of spectrum is unlikely to be in demand licensed services. On this basis the four frequency bands listed below were identified as potential candidates for future collective use.

Recommendation 5: The following frequency bands should be considered as potential future candidates fro collective spectrum use and analysed in accordance with Recommendation 4:		
Band	Category	Comments
47-68 MHz	C	Will no longer be required for broadcasting following digital switchover and is unsuitable for other licensed use due to the risk of interference arising from anomalous long-distance propagation effects. This band could be attractive for longer range, higher powered collective use applications.
862–872 MHz	C	This entire band should be made available on an application neutral basis subject to the use of spread spectrum technology to minimise the risk of interference to existing users of the band. This would provide a European alternative to the established and successful 900 MHz ISM band in North America. This extended band would make use of spectrum on either side of the existing 863 – 870 MHz collective use band that is currently allocated to other services in some Member States but is very underused in practice
915–917 MHz	B	Consideration should be given to the introduction of RFID interrogation systems in this band, to cater for growing demand for these devices. Compatibility studies should be undertaken to investigate the potential impact of such systems in a variety of deployment scenarios on GSM and UMTS base station receivers operating immediately below 915 MHz.
40.5–42.5 GHz	C	This band, currently harmonised for Multimedia Wireless Systems should be considered as an early potential candidate for collective use, in view of the absence of any current interest in the use of this spectrum for licensed system deployment. In the longer term, consideration should be given to making most of the spectrum above 40 GHz available for collective use, with the possible exception of those bands already identified for specific licensed applications, such as the fixed link band at 55 GHz, or where there are other services such as radio astronomy that may require protection at certain locations.

The possibility of further sharing between licensed (exclusive) and collective use was also considered. We concluded that the expansion of such sharing should be undertaken cautiously as these risks limiting the licensed users' flexibility and some of the necessary interference mitigation techniques are still rudimentary. The concept of provision for ultra-low power devices operating in licensed bands, similar to existing provisions in the USA and Japan was seen as more promising.

We therefore suggest that the Commission initiate steps to develop appropriate spectral masks for ultra-low power underlay operation in specific licensed bands. This would give certainty to licensed users concerning the potential underlay operations in their bands and create opportunities for new innovative applications and devices. The choice of bands for such operation should be undertaken cautiously as in some cases underlay operation may limit the licensed users' flexibility and may necessitate more advanced interference mitigation techniques than are currently available.

Recommendation 6: Provision should be made for operation of ultra-low power devices in licensed spectrum, akin to the provisions already in place in North America and Japan

0.5.4 Interference Mitigation

Interference mitigation techniques such as LBT/AFA have the potential to increase substantially the capacity of existing collective use allocations; however some argue that the mandatory use of such techniques goes against the technology neutrality requirement of the EU Framework Directive. A counter argument can be made from Article 3.2 of the R&TTE Directive, which states "*radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communication and orbital resources so as to avoid harmful interference*".

We conclude that when a high QoS is required (e.g. for applications that may have a safety element to them) it is appropriate to mandate mitigation techniques, otherwise it should be left to industry to arrive at a voluntary standard. In those situations where it is deemed appropriate to mandate mitigation techniques, these should be non-exclusive (e.g. a choice of either LBT or duty cycle limitation should be available) in order to minimise technology constraints and therefore maintain a significant degree of technology neutrality.

0.6 Furthering harmonisation of collective use allocations

Harmonisation in spectrum management terms can refer to either:

- the common designation of frequency bands for collective use across countries; or
- the designation of common minimum requirements to avoid harmful interference (e.g. transmitter power).

Note that neither of these includes adoption of common standards or technologies for collective use bands. Harmonisation does not necessarily require the same frequencies to be used in each country - multiple or overlapping bands can often be supported

economically using current technology. Multiple approaches can also be accommodated at a global level if the radio system includes a microprocessor that can choose the appropriate mode of operation for the local environment, in which case there is no need for user intervention.

0.6.1 Benefits and costs of harmonisation

The main benefits of harmonisation are:

- to reduce the likelihood of harmful interference between services operating in different countries;
- to create a European-wide market for equipment and services;
- to reduce equipment costs by limiting the number of frequency bands for which equipment must be made;
- to create the possibility for international roaming and cross border mobility;
- to provide greater certainty (protection) to users of spectrum that the spectrum will not be reallocated to other potential uses.

International harmonisation offers significant benefits in the case of applications embedded in:

- portable devices such as computers and mobile phones (e.g. Bluetooth, WiFi);
- vehicles e.g. road tolling and automotive radar;
- traded goods (e.g. RFID);
- individuals (e.g. medical implants).

The main costs are those associated with the loss of flexibility at a national level, namely:

- in matching spectrum supply to demand; and
- in allowing spectrum to be re-farmed or traded so that high value uses replace low value uses.

The benefits of harmonisation are less in the case of fixed applications where equipment can be made economically for national markets (e.g. telemetry, building alarms).

0.6.2 Furthering European harmonisation

There is strong interest from industry in achieving greater harmonisation of frequency allocations and associated regulatory conditions. The existing voluntary approach (ERC 70-03) has had some success but implementation is patchy, whereas the existing draft EC SRD Decision only covers those elements of ERC 70-03 that have already been implemented in

all EU Member States. There is therefore a need for a more proactive EU backed harmonisation process including mandatory implementation of agreed bands.

We estimate that the NPV to the EU of harmonising collective use spectrum lies between €463 billion and €898 billion. Such benefits are substantial. For example: the higher NPV of €898 billion is equivalent to a perpetual annual net benefit of €36 billion, or 0.35% of the EU's current GDP, if discounted at 4% per year. For the lower estimate, it represents €19 billion, or 0.17% of the EU's current GDP.

Our estimates are uncertain, however on balance we believe that they are likely to represent an under estimate rather than an over estimate.

Recommendation 7: Replace existing voluntary approach to collective use harmonisation with mandatory EU-wide allocations backed by an expanded EC Decision

The existing ERC Recommendation 70-03 allocations should be reviewed, re-categorised in line with Recommendation 1 and incorporated into a revised and expanded EC Decision covering all harmonised collective use allocations.

0.6.3 Furthering Global Harmonisation

As many new collective use applications are embedded in portable or mobile entities, international harmonisation has become of increasing importance for collective use applications. Indeed, regulators often have little choice but to follow decisions made elsewhere in the world; thus, global harmonisation effectively results from market and political pressure. Regulators often have little choice but to follow decisions made elsewhere in the world, as in the case of the recent adoption in Europe of a standard for low power FM micro transmitters, to overcome the problem of "grey" imports.

The implication is that the European spectrum management community should be more proactive in anticipating and responding to developments from other parts of the world that are like to make their way to Europe. This should include periodic dialogue between the EC and SMAs in other regions and jurisdictions to identify future opportunities for global harmonisation of collective spectrum use. This would also provide an opportunity to promote European spectrum allocation initiatives at a global level, to the potential advantage of European industry.

Recommendation 8: Establish greater liaison with other international spectrum Policy makers, to extend EU influence on global spectrum harmonisation.

1 Introduction

This report presents the findings of a study on the Collective Use of Radio Spectrum, undertaken for the European Commission by a consortium comprising Mott MacDonald, Aegis Systems Ltd, Indepen Consulting, IDATE and WIK-Consult GmbH. Collective use refers to the shared use of radio spectrum, typically by low power, short range devices (SRDs) operating on a licence-exempt basis. The term "spectrum commons" is sometimes used to describe such uses; however collective use also includes certain types of licensed use where access to spectrum is on a non-exclusive, shared basis.

Collective use of spectrum underpins a multitude of wireless applications including wireless computer networks, consumer devices (wireless doorbells, keyfobs, etc), medical devices, industrial equipment and intelligent transport systems. The size of the market for these devices is difficult to quantify (as they are licence-exempt there are few reliable records of user numbers), however our initial estimates suggest the European market for products and services dependent on collective use of spectrum is likely to be in excess of €20 billion by 2009.

Collective use is one of three main approaches to the management of radio spectrum, the other two being the administrative model, whereby individual users are granted exclusive rights to use spectrum on an administrative basis by national regulatory authorities, and the market-based' model whereby exclusive rights are acquired by market mechanisms such as auctions or spectrum trading. Whereas the administrative and market based models generally provide users with a degree of statutory protection from interference from other authorised users, this is not the case for collective use. Depending on the application, interference may be moderated by restricting specific frequencies for specific applications, or by appropriate choice of technology, as evidenced by the recent rapid growth in applications such as "WiFi", which depend entirely on collective use of spectrum.

The potential benefits of collective use of spectrum include:

- lower barriers to market entry;
- the ability to address niche applications quickly and at low cost;
- greater certainty of obtaining access to spectrum;
- more certainty of tenure;
- flexibility to adopt different technology and applications;
- reduced likelihood of illegal operation in licensed frequency bands;
- reduced congestion in licensed bands.

This study considers how the extension of the collective use approach might contribute to broader EU policy objectives, with regard to optimising the use of scarce radio spectrum resources, strengthening the internal market, supporting innovation and promoting competitiveness. Technical, market and regulatory aspects were analysed and policy

options assessed, taking account of the overall objectives of EU radio spectrum policy. A number of recommendations supporting these objectives emerged from the study, proposing measures at a national and Community level.

The study terms of reference were defined as follows:

- to inform the European Commission about the implications for the EU of technical and market developments and the resulting potential to rely more on 'Collective Use of Spectrum';
- to support the internal market for goods and services;
- to consider how the extension of the collective use paradigm could contribute to the deepening of the internal market for goods and electronic communications services and associated policy objectives such as innovation and competitiveness[3], as well as to the achievement of specific Community policy goals with regard to radio spectrum, such as efficiency and effectiveness;
- to consider whether the current regulatory approach to collective spectrum use in Europe supports these broad objectives.

The study complements previous studies covering other spectrum management paradigms[4] and considers how to identify the optimum "mix" of approaches at a policy level.

In fulfilling these terms of reference, this report considers current and future demand for collective use of spectrum and the implications of technology developments and the regulatory environment for meeting this demand. The economic benefits deriving from collective use are analysed and possible regulatory measures that might help to enhance these benefits are discussed. We consider whether the existing regulatory arrangements for collective use of spectrum in Europe could be improved and whether additional spectrum should be allocated to collective use. Policy options are assessed taking account of the overall objectives of radio spectrum policy at an EU level. A number of specific recommendations to the Commission are presented that propose measures required at a national and Community level regarding future regulatory arrangements and access to collective use spectrum.

Following this Chapter the remainder of this report is structured as follows:

- **Chapter 2** defines the collective use model, the market size and potential benefits of collective use of spectrum
- **Chapter 3** describes the regulatory framework for and status of collective use markets and technologies around the world.

[3] **i2010** – A European Information Society for growth and employment, Communication from the Commission, COM(2005) 229 final, June 2005

[4] "Study on conditions and options in introducing secondary trading of radio spectrum in Europe", Analysys et al, for the European Commission, May 2004.
http://rspg.groups.eu.int/doc/documents/meeting/rspg4/rspg04_40_study_secondtrad_summary.pdf

- **Chapter 4** analyses ways of simplifying and speeding up access to collective use spectrum in Europe.
- **Chapter 5** considers future demand for collective spectrum use and how this might be accommodated.
- **Chapter 6** considers the merits of international harmonisation of collective spectrum use.
- **Chapter 7** presents specific recommendations for action by the Commission.

2 What is Collective Use of Spectrum and why is it so important?

2.1 Introduction

Collective use of radio spectrum is an essential requirement for a large number of wireless applications that impact upon many aspects of day to day life. The benefits of collective use to individuals, businesses and to the public sector are substantial, although not always straightforward to quantify. This is partly because collective use is generally undertaken on a licence-exempt basis and therefore precise records of the number of users do not exist and partly because the benefits are often indirect or long-term. For example, it is difficult to quantify the efficiency benefits to businesses and consumers of devices such as wireless car key fobs or door openers. Similarly, the benefits derived from wireless medical implants, such as glucose monitors for diabetics, may not become apparent for many years (in the form of extended longevity or improved long term health).

For the purposes of this report, the term "collective use of spectrum" is used as an umbrella term to designate *all spectrum management approaches allowing more than one user to occupy the same range of frequencies at the same time, without the need for individual (exclusive) licensing.* In the following sections we explain the various types of collective spectrum use, describing in qualitative terms just how important the collective use of spectrum is to society and the European economy and provide indications of the market size and economic benefits that may arise. A more detailed discussion of the current situation with regard to market and technology development is given in Appendix D.

2.2 Types of Collective Spectrum Use

The term 'collective use of spectrum' includes the well-established use of spectrum on a licence-exempt basis, e.g. for Short Range Devices (SRDs), as well as more recently developed sharing concepts such as underlay and overlay, described below. Collective use spectrum can be application-specific, technology-specific, or neither of these. Each approach has its own merits depending on the applications that are expected to use the spectrum in particular, the required quality of service and the likely interference environment. The following categories of collective use have been identified in the study:

- **Licence-Exempt (commons) – non-specific applications:** No individual authorisation or co-ordination is required and no fee payable for using the spectrum. Access is regulated solely by adherence to pre-defined regulatory conditions (typically specified in the national frequency allocation table (NFAT) and/or national legislation, which may be based on EU or CEPT harmonisation measures). Any application is permitted so long as the regulatory conditions are adhered to, which are typically low power, short range devices and applications.

- **Licence-Exempt (commons) – specific applications:** No individual authorisation or co-ordination is required and no fee payable for using the spectrum. The equipment must comply with specific standard(s), either

harmonised standards or national interface standards which relate to specific applications that are typically low power short range devices.

- **Light licensing – few restrictions:** Registration or notification is required. No limits on the number of users but use may be application-specific. Typically, light licensing permits greater power than licence-exempt bands. A small fee may be payable to cover the costs of the registration / notification scheme. Light licensing is typically applied in situations where there is no immediate concern about interference but where there may be a need to make changes to the use of the spectrum in future, hence there is a need to maintain a record of those who are using the spectrum. For example, some European countries allow the use of the 5.8 GHz band for fixed wireless access services on a light licensing basis without the need to apply for an exclusive licence or right of use.

- **Light licensing – with restrictions:** Registration or notification is required, and there are limits on the number of users and/or requirements for co-ordination between users. Use may be application-specific and typically permits greater power than licence-exempt bands. A small fee may be payable to cover the costs of the registration/notification scheme. Recent examples include: 1) a registration scheme proposed in the U.S for use of the 3650 – 3700MHz band on a collective basis[5] for fixed wireless access where the risk of interference is mitigated by technical means, and where licensees are mutually obliged "to cooperate and avoid harmful interference to one another"; 2) the UK regulator Ofcom recently awarded through auction, twelve low power concurrent rights of use through auction for the frequencies 1781.7-1785MHz paired with 1876.7-1880MHz.[6] Licensees are expected to co-ordinate their use of the spectrum to avoid harmful interference.

- **Private Commons:** An individual right of use is required but access to spectrum may be "sub-let" to third parties on an unlicensed basis without the need for co-ordination, so long as pre-defined regulatory conditions are adhered to. Responsibility for avoiding interference with users outside the spectrum band rests with the right of use holder. In the U.S., the Federal Communications Commission (FCC) recently introduced rules permitting spectrum leasing under which a licensee may acquire a block of spectrum to create a private commons for use by thousands or even millions of new users. The FCC speculated that this type of private commons could be used by innovative equipment vendors to roll out a new service such as a private Wi-Fi business. This could offer a higher quality of services than Wi-Fi and other users must now accept in existing licence-exempt bands.

- **Experimental Commons:** Experimental licenses are intended for use on an experimental basis for some predefined and limited period of time. Licensing,

[5] Users are required to use contention-based protocols to minimise the impact of interference. See "FCC Opens Access to New Spectrum for Wireless Broadband in the 3650 MHz Band", March 10, 2005, available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-257309A1.pdf.

[6] The number of licences was determined by the auction. http://www.ofcom.org.uk/radiocomms/spectrumawards/completedawards/award_1781/documents/

registration or notification is dependent on the specific allocation, but there are generally no limits on the number of users, and there may be no restriction on the application. Operation is on a non-interference, non-protected basis, and operational constraints may apply (e.g. prohibition on provision of third party services). Technical constraints may apply generally or may be specifically negotiated. A small fee may be payable to cover the costs of the registration/notification scheme.

- **Underlay:** Underlay technologies operate in spectrum that is used for other licensed or licence-exempt use but at very low power levels. This allows the underlay use to share or collectively use the spectrum. Underlay use is not licensed. Ultra Wide Band (UWB) is an example of an underlay technology.

- **Overlay**: An overlay approach permits higher powers that could cause interference to existing users, but overcomes this risk by only permitting transmissions at times or locations where the spectrum is not currently in use.[7] This can be achieved either using technology (e.g. cognitive radio) or by regulatory means (e.g. only permitting use in certain geographic regions). Here we are concerned with overlay use that is not licensed.

These different categories may also be used in combination in a given frequency band. For example, a scheme, termed "private spectrum parks", is under consideration for wireless access services in Australia.[8] This approach combines licensed, registered and licence-exempt use in the same frequency range, with each approach applying to separate geographic areas. In this case licensed use applies in the main cities; registration (with co-ordination) applies in lightly populated rural areas and license exempt use applies in remote areas with very low population densities.

Unlike exclusive use of spectrum, collective use does not confer on the user any protection from other spectrum users (licensed or exempt) who are operating legally within relevant technical and regulatory parameters. For some types of collective use where quality of service is of particular importance (such as professional wireless microphones or wireless medical devices), the probability of interference can be minimised by allocating application-specific spectrum, applying additional technical constraints (e.g. power or duty cycle limits) or co-ordinating use with other users. In other cases there is a presumption that the user can tolerate a reasonable level of interference or that appropriate interference mitigation techniques will be adopted. In effect, the following hierarchy can be defined in terms of the level of protection that a user can expect:

- **Full protection**: Exclusive right of use required; provides legal recourse in the event of harmful interference

- **Partial protection**: Collective use, restricted to specific applications and/or technologies; no legal recourse against interference from other legitimate spectrum users

[7] Interference potential depends on power, frequency separation and distance to the "victim". Therefore at reasonable expected geometries and numbers of devices there is negligible or no risk of interference.

[8] Strategies for Wireless Access Services Australia Communications and Media Authority, February 2006: http://www.acma.gov.au/acmainterwr/_assets/main/lib100639/was_discussion.pdf

- **No protection**: Collective use, open to all applications and technologies subject to compliance with certain technical parameters; no legal recourse against interference from other legitimate spectrum users

2.2.1 Comparison of advantages and disadvantages of different approaches to Collective Use

Approach	Advantages	Disadvantages
Licence-Exempt (Non-specific)	Provides flexibility to accommodate innovative new applications with minimal delay and cost.	Greater potential for interference or congestion, as no restriction on what the band is used for.
Licence-Exempt (specific)	Allows immediate, low cost access to spectrum for specific applications. Interference risk is reduced as band is limited to specific types of application	Spectrum may remain unused if intended application is not successful. Difficult to anticipate and cater for market and technology developments
Light licensing (few restrictions)	Reduces risk associated with allocating new spectrum, by making subsequent re-farming easier to implement. Provides greater visibility of market size and spectrum utilisation	Increased cost and overhead for users Potential for illegal use – incurs enforcement costs for SMAs. Higher risk of interference than other types of licensed use
Light licensing (with restrictions)	Reduces likelihood of interference by limiting number of sharers and/or requiring co-ordination Reduces risk associated with allocating new spectrum, by making subsequent re-farming easier to implement. Can combine with market-based approach to ensure spectrum is licensed to those who value it most (i.e. through auctions).	Increased cost and overhead for users. Limiting number of users limits scope for competition. Restrictions imposed and/or cost of acquiring spectrum may deter potential market entrants.
Private commons	Provides rights holder with opportunity to develop market for higher quality services than in public commons bands. May enable groups of users with common interest to acquire spectrum for their own use.	Spectrum may remain underused if rights holder unsuccessful in market. High cost of spectrum acquisition likely to favour established market players rather than smaller niche players.
Experimental commons	Provides opportunity for new technologies or services to be tested at an early stage of development.	New spectrum may need to be found to accommodate service if trial is successful (to avoid interference or congestion).
Underlay	Enables existing licensed spectrum to be re-used for low power, short range applications. Stimulates development of new, innovative technologies (e.g. UWB).	Tighter power constraints required than in other collective use bands, hence much shorter range – restricts scope of applications.
Overlay	Enables licensed spectrum to be re-used in areas where it is not being used by the licensed user.	Requires advanced technology or some form of licensing / co-ordination to prevent interference to licensed user.

2.3 Potential Benefits of Collective Spectrum Use

The Authorisation Directive (Article 1) requires that "*Member States shall, where possible, in particular where the risk of harmful interference is negligible, not make the use of radio frequencies subject to the grant of individual rights of use*". In other words there is a presumption in favour of collective use.

Relative to licensed use, collective use of spectrum offers the following potential benefits:

- **Low entry barriers** including faster access, no access or usage fees compared with auction payments and licence charges, no upfront costs incurred in obtaining access, no coverage or other obligations.
- The ability to **quickly address niche applications** not covered by more general systems. Occasionally such niche applications can grow into major ones, such as the evolution of Wi-Fi from specialised Electronic Point Of Sales (EPOS) systems in the 2.4 GHz ISM band.
- The **certainty of obtaining access** so long as technical requirements are met because there are usually no limits on the number of users.
- More **certainty of tenure** because of the greater difficulties associated with reversing licence-exempt versus licensed allocations.
- In some spectrum bands the **flexibility to adopt different technology and applications**, which enables progressive development.
- The **reduced likelihood of illegal operation** in licensed frequency bands.

In addition, increasing the collective use of spectrum has the potential to relieve congestion in licensed spectrum bands, creating opportunities for additional rights of use to be offered in these bands, so enhancing competition. For example, the latest cellular phones incorporate WiFi connectivity and voice over IP technology alongside the established GSM and UMTS platforms. Hence additional capacity at traffic hotspots can be delivered using licence-exempt spectrum, reducing the pressure for additional licensed spectrum to support traffic growth and creating the potential for more players to enter the market. The ability to use licence-exempt and licensed spectrum together in this way also means that licensed spectrum can be used for content and applications where a high grade of service is required (e.g. voice or video streaming) whilst more delay tolerant applications may be carried over the licence-exempt spectrum, thus improving the overall level of network quality from the user perspective. Clearly for such benefits to be fully realised at the Community level there needs to be harmonisation of the frequencies and technologies deployed.

These benefits need to be set against the potential impact of increased interference that may occur with collective as compared with exclusive use: the impact could be mitigated or reduced through the application of new technology or regulatory arrangements such as light licensing. In this study we consider whether technology and market developments will allow movement away from licensed use to other collective use access models.

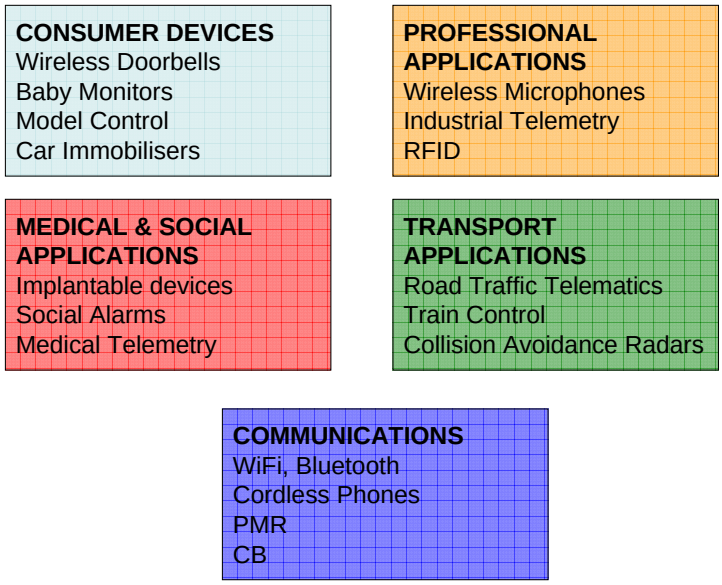
2.4 Markets Served by Collective Use of Spectrum

2.4.1 Overview

Collective use of radio spectrum is a fundamental requirement for a multitude of wireless applications catering for many different market sectors. These range from low cost consumer devices such as cordless phones to specialised professional applications in sectors such as transport, health and entertainment. What most of these applications have in common is the use of short range, autonomous communication with a low probability of interference. Consequently the cost and administrative effort that would arise from individually authorising such uses would far outweigh any benefits that might arise from authorisation. The benefit to the consumer and manufacturer arises from the simplicity that is brought about through licence-exemption, where in the majority of cases the item is immediately ready for use.

Figure 1 shows the five main market sectors that are served by collective use applications and provides examples of specific applications within each sector.

Figure 1: Main Market Sectors Served by Collective Use Applications



The demand for collective use applications is difficult to estimate and predict as there are no reliable user statistics. A summary of market estimates was presented in a recent report issued by the European Communications Committee (ECC)[9] and these are reproduced in Table 1 below. We have also collated some examples of forecasts for specific sectors that are presented in the following sections.

Evidence of recent rapid growth in licence-exempt applications is also given for the U.S. in Carter et al (2003), who used data on device authorisations and sales to suggest that use of unlicensed devices is growing at an exponential rate in the U.S.[10] Both sources suggest

[9] CEPT Frequency Management Work Group doc (FM(06)056 Rev 01

[10] Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed devices and Their Regulatory Issues, K Carter, A Lahjouji, N McNeil, May 2003, OSP Working paper 39, FCC

that the number of devices in use will grow rapidly in future which raises the question of whether additional spectrum should be allocated for collective use.

2.4.2 ECC Project Team 43 Volume Estimates

Table 1: Summary of ECC SRD Market Estimates

Sector	Comments
RFID	1.2 billion tags in use by 2012, at 30,000 locations within EEA
Meter Reading	Up to 200 million domestic outstations potentially in Europe
Asset tracking	Individual system sizes of over 2 million units are reported to be in the planning stage.
Medical devices	Potentially up to 50 million on-body ultra-low-power implants over the longer term
Security Alarms	Currently estimated to be 32 – 40 million systems in EEA
Home Automation	10 million devices annually are anticipated by 2010
Access Control	Over 100 million door openers and approximately 50 million car access units have been installed, mainly using 433 MHz – growing at 10 million units annually. Around 5 million 24 GHz automatic door sensors currently installed in the EU, increasing by approximately 1 million per year.
Telemetry	The telemetry and telecontrol market has been one of the longest to exist and is estimated to produce an annual turnover of approximately €1 billion globally

2.4.3 Sector Specific Forecasts

In the following sections we provide some examples of publicly available market forecasts for the various sectors served by collective use of spectrum. Note that most of the figures quoted do not refer exclusively to wireless products or services and should be taken as indicative only. They do however serve to illustrate the potential size of the market for collective use of radio spectrum.

i. Wireless Local Area Networks

According to Insight Research[11], the global market for WLAN equipment based on the WiFi standards is expected to grow from approximately €3.76 billion in 2003 to €19.1 billion in 2008, while service revenues will grow from about €1.8 billion in 2003 to €14.7 billion in 2008. Although starting from a lower base, the European market is expected to grow at a

[11] WiFi in North America and Europe, Insight Research, October 2003

faster pace than the U.S. over this period. It is estimated that the European market will probably account for around a quarter of the global value by 2008, i.e. €4.8 billion on equipment and €3.7 billion on services with a combined total of €8.5 billion.

ii. Automotive Market

The automotive electronics market is a fast growing sector. Strategy Analytics estimated the automotive semiconductor market to be worth €10 billion in 2003 with an annual growth rate of 14%. Europe leads the world in automotive technologies, driven predominantly by Germany. The European market in 2003 was worth €3.9 billion, approximately 39% of the total world market. Assuming a 14% growth rate this suggests a market of around €8.6 billion by 2008. An increasing proportion of this is likely to be accounted for by wireless systems such as collision avoidance and cruise control systems. In the longer term it is not unreasonable to assume that there will be at least one wireless device incorporated into every vehicle.

iii. Medical Devices

It has proven difficult to get estimates of the value of the market for active medical implants. However, one study[12] estimated that the market for implanted medical devices in the U.S. was worth €13.8 billion in 2004 growing to €19.2 billion by 2007. If scaled for EU expenditure on health care, this translates to a market worth €12 billion per annum in 2004 growing to €16.75 billion per annum in 2007 for the EU. In another study the global market for all medical devices was estimated to be €100 bn in 2002, growing to €120 billion by 2005 with a growth of between 7 and 9% through to 2007. Europe has approximately 30% of this global market[13]. This suggests a total European market of around €36 billion in 2007, rising to €42 billion by 2009. There is no data available on how much of this market is accounted for by wireless devices, although as in the case of automotive devices we expect the proportion to grow over the next few years, with greater reliance on implantable wireless devices for monitoring and treatment purposes. We have assumed that in both cases 10-20% of the market will comprise wireless applications (see table 2 below).

iv. Home Automation

Home automation systems provide households with integrated monitoring and control products, allowing automatic operation of many functional systems within the home, such as temperature control, distribution of audio-visual content, lighting control, security and controlled entry systems. They operate by networking signals around the home to integrate the function of devices under automatic operation or in response to the householder's instructions.

According to Frost and Sullivan[14], the European home automation market generated revenues of €133 million in 2002 and is expected to grow to around €307 million by 2009. During this period the average cost of an installation is expected to fall owing to competition

[12] Freedonia, "Implanted Medical Devices", 2005

[13] source: Frost and Sullivan

[14] "European Home Automation Market", Frost and Sullivan, February 2003

and technological advances so that the compound annual growth rate in the number of systems installed will be around 20%.

v. RFID

RFID is likely to be one of the fastest growing sectors over the next few years. According to Juniper Research, the Western European RFID market is set to grow from €356 million in 2004 to €1.43 billion in 2009[15].

According to a 2004 report from Soreon Research[16], the European market for RFID devices is expected to grow six-fold growth in Europe by 2008, to more than €2.5bn. The bulk of this market is expected to be in the area of transponders (tags), which are expected to account for 80 per cent of the total RFID market. According to Soreon, up to 13 billion items per year (around 5% of all retail products) could have RFID tags by 2008. There are also potentially enormous efficiency savings that can result from the use of RFID technology. For example: Walmart has estimated efficiency savings of up to €6.4 billion from the use of RFID, most of this arising from reduced labour costs by the elimination of manual bar-code scanning[17].

vi. PMR 446

According to a report produced by the UK SMA, Motorola estimated 2003 sales of its PMR 446 terminals around Europe to be around 3.5 million. At a typical retail price of around €40, this would make the market approximately €140 million per year.

vii. Cordless Telephones

According to the DECT Forum, annual sales of DECT terminals in Europe are expected to rise from 28.2 million in 2003 to 48.1 million in 2008. Assuming that the average terminal price falls from €60 to €40 over that timescale, it would imply a market value growing from €1.7 billion in 2003 to €1.9 billion in 2008.

viii. Machine to Machine (M2M) Communications

Wireless telemetry and other M2M communications form one of the largest potential markets for collective use of spectrum. For example, a recent report by Berg Insight AB*18* observed that Europe had 336 million energy meters. Assuming that by 2009 1% of these were to be converted to remote (wireless) reading at a cost of €100 each, that would imply a market of around €336 million annually. The existing global telemetry market is estimated to be around €1 billion, see Table 2 of which around a quarter is likely to be in Europe, implying a current European market of €250 million, rising to €590 million by 2009 if remote meter reading is included.

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[15] "RFID futures in Western Europe", Juniper Research, February 2005

[16] "On the fast track: The RFID-Market for Retail Trade in Europe 2004 – 2008", Soreon Research, 2004

[17] "Case Study: Wal-Mart's Race for RFID", e-Week.com, 15 September 2003

[18] "Strategic Analysis of the European Wireless M2M Market", May 2005

ix. Other Applications

The wide range of consumer applications (e.g. doorbells, baby alarms etc) served by collective use of spectrum suggests that it is reasonable to assume that by 2009 there will be at least one device per household in Europe (currently we assume the figure is around half this). Assuming an average retail price of €20 for a typical wireless consumer device and that a device is replaced on average every five years, this would suggest a total market of around €760 million[19].

2.5 Estimated Market Size for Collective Use of spectrum

High level estimates of the total market in Europe for key applications served by collective use of spectrum are detailed below in Table 2. To produce these estimates we have made assumptions about the percentage of the total sector value that is dependent on access to collective use spectrum. Where a range of figures is shown, the lower figure has been used to generate the 2003 value and the upper figure the 2009 value (reflecting the increasing use of wireless technology).

Table 2: Indicative Market Projections for Collective Use Applications

Sector	% dependent on collective use	2003 estimate (€Bn)	2009 estimate (€Bn)
Wireless LANs	100	1.39	8.5
Automotive	10 - 20	0.39	1.72
Medical Devices	10 - 20	3.0	8.4
Home Automation	50	0.51	1.54
RFID	100	0.4	2.9
PMR446	100	0.14	0.14
Cordless Phones	100	1.7	1.9
Telemetry / M2M	100	0.25	0.59
Other Applications	100	0.38	0.76
Total		8.16	**26.45**

[19] Assumes an EU population of 456 million and the average household size is 2.4.

3 Regulatory and Technology considerations

3.1 Introduction

This Chapter reviews the current regulatory framework and processes for collective use of spectrum in both Europe and from a global perspective. It also considers how technology developments are likely to influence demand for regulation of collective spectrum use in the future. The information reported in this section was compiled through desk research, a web-based questionnaire, targeted interviewing and the discussion and feedback gained from a public workshop.[20] Feedback was sought from a broad cross-section of SMAs and industry representatives, including:

- **European SMAs**: Belgium, Finland, France, Germany, Ireland, Italy, Spain and the UK;
- **Other SMAs**: U.S., Canada;
- **Equipment Manufacturers**: Alcatel, Cambridge Broadband, Intel, Rail Radio Solutions, Redline Communications;
- **Network Operators**: Orange, The Cloud, Swisscom Eurospot;
- **Trade Organisations**: European Telecommunications Network Operators Association (ETNO), Low Power Radio Association (LPRA), Alliance-TICS, Open Spectrum Foundation and WiMAX Forum;
- **End-User Organisation**: Association Française des Utilisateurs de Télécommunications (AFUTT) ;
- **Sector Specialists**: Wireless Microphones and RFID.

A summary of the responses to the web-based questionnaire and interviews can be seen at **Appendix B**. In addition, details on the status of harmonisation of collective spectrum, technical developments and applications are given in the following Appendices:

- **Appendix C**: Summary of Collective Spectrum Harmonisation;
- **Appendix D:** Collective Spectrum Technology Overview;
- **Appendix E:** Collective Spectrum Application Overview.

3.2 Approaches to Managing Radio Spectrum

Before addressing in detail the issues surrounding collective use of spectrum, it is helpful to review the different approaches to the management of radio spectrum and their relative merits. There are essentially three ways in which access to radio spectrum is currently

[20] Workshop presentations available from:
http://europa.eu.int/information_society/policy/radio_spectrum/presentation/index_en.htm

managed, namely: administrative, market based and collective use. The following section provides a brief description of each of these approaches. It should also be noted that in all cases, allocations must comply with internationally agreed allocations defined under the auspices of the International Telecommunications Union (ITU) and detailed in Article 5 of the ITU Radio Regulations, if the service concerned is to be protected from interference from other services in neighbouring countries.

3.2.1 Administrative Model

Historically, the default approach to the management of radio spectrum was the administrative model, sometimes referred to as "command and control", whereby a Spectrum Management Authority (SMA) was responsible for determining how different parts of the spectrum should be used (i.e. its allocation) and by whom it could be used (i.e. its assignment). Assignments are made by SMAs or national governments, although in some cases frequencies may be mandated internationally for provision of specific services and/or use of specific technologies, an example being the frequencies used in Europe for GSM telephony, which was mandated by way of an EC Directive. Assignments granted under the administrative model generally provide some degree of exclusive access to spectrum with protection from interference arising from other spectrum users but there are constraints on how the spectrum may be used.

The administrative model is essentially a legacy from the early days of radio, when governments or government-appointed bodies had a de-facto monopoly on access to radio spectrum. The progressive liberalisation of the telecommunications and broadcasting markets over the last few decades has led to massive growth in demand for radio spectrum. This is particularly so for the provision of commercial services and applications, to the extent that demand for radio spectrum often exceeds supply. Under the administrative model, this situation is often dealt with by the use of comparative selection procedures, sometimes referred to as beauty contests, whereby organisations are invited to apply for limited numbers of spectrum licences and the successful applicants are chosen on the basis of criteria specified by the SMA. EU legislation requires such criteria to be objective, transparent, non-discriminatory and proportionate. However in practice it can be difficult to establish categorically that these conditions have been met. As a result a number of countries have suffered delays to the introduction of new services due to legal challenges to the licensing process. It can also be difficult to define selection criteria in a way that ensures optimal use of the spectrum, particularly given the speed and uncertainty with which the electronic communications market evolves.

3.2.2 Market Based Model

Over the last decade, there has been a progressive move away from the use of comparative selection procedures with pre-defined selection criteria towards more market based approaches, notably licence auctions. For example, the majority of third generation (3G) mobile licences in the EU were awarded by auction rather than comparative selection. These approaches were pioneered in countries such as the U.S., Australia and New Zealand but have attracted increasing attention in Europe. Several EU countries have announced plans to introduce trading and liberalisation of spectrum use, and the EC has recently initiated a

consolation on proposals to extend such initiatives on an EU-wide basis for certain frequency bands and services[21].

The market based model, also provides a degree of exclusivity of access to spectrum and protection from interference from other users. However, there are likely to be fewer constraints on how the spectrum may be used than under either the administrative model and possibly also the collective use model. Current liberalisation proposals such as those that the EC is consulting on replace the traditional service-oriented spectrum licence with a "spectrum usage right" that would provide more latitude in how the spectrum may be used.

3.2.3 The Collective Use Model

Unlike the administrative and market based models, the collective use of spectrum does not provide users with exclusive access to specific radio frequencies or provide any legal entitlement to protection from interference from other authorised spectrum users. Instead, users are required to share allocated spectrum bands on a non-interference, non-protected basis[22]. Technical constraints are applied to the use of the spectrum to facilitate such sharing. Spectrum allocated for collective use is often referred to as "spectrum commons", in that anyone who conforms to the regulatory conditions attached to the allocation may freely access the spectrum. However, the term may also be used to describe situations where a limited number of users are permitted to share particular frequencies and an individual right of use is required to do so. Such an approach has long been applied to private mobile radio (PMR) services, where each frequency is able to accommodate typically a 100 or more mobile radios; it would be wasteful of spectrum to allocate a smaller number of users their own exclusive spectrum. This approach is effectively a hybrid of the administrative and collective use models.

It is sometimes the case that there is no clear-cut case for either a fully exclusive assignment or a completely licence-exempt collective use regime. This might arise for example where the available spectrum and technology makes it possible for a number of operators to co-exist in the same spectrum but QoS requirements make it necessary to limit the number of sharers. Alternatively, if it is thought that the spectrum may be needed in the future for some other application, it may be appropriate to have some kind of record of who is using the spectrum to facilitate future re-farming. In such cases a "light licensing" regime may be appropriate.

Recently, there have been attempts to combine the market-based and collective models, by auctioning spectrum to a number of users for operation on a shared, self-coordinated basis. The UK recently held an auction for twelve such licences to access 2 x 3.3 MHz of spectrum in the GSM 1800 band. This auction attracted a large number of bidders and winning bids ranged from €75,000 to €2.25 million.[23].

[21] European Commission DGINFSO/B4, Mandate to CEPT to Develop least restrictive technical Conditions for Frequency Bands addressed in the Context of WAPECs, 5 July 2006.
[22] This means that users must not cause harmful interference to licensed spectrum users and may not claim protection from interference arising from other spectrum users who are operating legitimately.
[23] http://www.ofcom.org.uk/radiocomms/spectrumawards/completedawards/award_1781/notices/030506.pdf

3.2.4 Application of the Three Spectrum Management Models

None of the three spectrum management models described above can be applied universally to all radio services. In practice, it is necessary to use at least a combination of the administrative and collective use models and as noted above the market based model is proving increasingly attractive for many services. The administrative model remains the preferred choice for management of spectrum where safety of life is involved and there are international agreements governing the use of specific frequencies; for example, aeronautical and maritime frequencies would fall under this category. The market based and collective use models essentially relate to the commercial or private (business or consumer) use of spectrum though in some Member States (e.g. the Netherlands and the UK) there have been proposals to apply the market based model to certain government uses. Which model is appropriate depends largely on how the spectrum is to be used. Services that provide a high quality of service (QoS) over a wide area to paying subscribers generally require exclusive access to spectrum since a known interference environment is required in order to design the network for the required capacity and QoS. Hence, services such as broadcasting and cellular telephony are unlikely to be suitable candidates for a collective use approach, although, as we will consider later in this report, access to collective use spectrum can provide operators of licensed networks with additional capacity for non-critical traffic.

Collective use is particularly attractive for applications operating over short distances, transmitting occasionally or intermittently, and where the use of the equipment is essentially autonomous (i.e. there is no direct connection to a wide area wireless network). It is also appropriate where the cost of the equipment used to access the spectrum is very low and the administrative overhead associated with licensing would therefore be disproportionately high. This is equally true where a high degree of international mobility is involved, since it would be impractical to obtain a licence in each country visited. Hence the main applications of collective use spectrum are low cost, short range devices (SRDs) such as cordless phones, WLANs wireless doorbells and the like, which are typically intended to operate over distances of 100 metres or less.

It is important to note that the three models need not be mutually exclusive. For example, a number of countries have developed licence award procedures that combine elements of both auction and comparative selection and it is possible for radio devices such as mobile phones to use either licensed or licence exempt spectrum to connect to networks. As noted above, in the context of PMR and the recent UK GSM 1800 auction, it is also possible to license spectrum on a shared basis, perhaps limiting the number of licensees in order to improve the QoS relative to licence-exempt spectrum.

Another area where collective use and licensed spectrum have complemented each other to good effect is in providing wireless access. This has been particularly so in the U.S., where several thousand wireless internet service providers (WISPs) have established services in the 2.4 GHz and 5 GHz collective use bands. More recently there has been growing interest in the use of licensed spectrum, notably the 2.6 GHz band formerly used for educational TV services and recently acquired under leasing arrangements by the national operators Clearwire and Sprint-Nextel, but there continues to be a thriving market for localised licence-exempt networks. A similar situation has emerged to some extent in Europe, with collective use bands such as 5.8 GHz providing fast and easy market access for smaller, localised players, or enabling larger players to test the market before committing

to buying licensed spectrum. The emerging WiMax standard is specifically targeted at both licensed and collective use bands, notably (in Europe) in the 3.5 GHz and 5.8 GHz bands.

There are also differing degrees of sharing that can be accommodated in collective use frequency bands, depending on the nature of the devices and services that are intended to use the bands and the extent to which technology can facilitate co-existence between users. In some cases it is even possible to accommodate collective use in bands that are also used by licensed services, for example wireless microphones operate on a collective basis in TV broadcast bands (by using frequencies that are not used locally for broadcasting). Also, in countries such as the U.S. ultra low power devices are permitted to use certain licensed bands on the basis that the power they emit is considered too low to present an interference threat to the licensed service. Restricting the power in this way also severely restricts the operational range, typically to a few metres or less, which limits considerably the utility of the spectrum.

3.2.5 Relevance of Rights of Use to the Three Spectrum Management Models

It is important to note at this stage that the concept of a "right of use of radio frequencies", as referred to in Article 5 of the Authorisation Directive, applies to all three of these management models. According to Article 5, these rights may take the form of an individual right of use or be included within the scope of a general authorisation. Generally, both the administrative and market based models are based on the assignment of individual rights of use, whereas in most cases collective use does not require an individual right of use. There is however an exception to this rule, in that occasionally it may be considered justifiable to require individual, *non-exclusive* rights of use. This might arise, for example, where an SMA decides that a block of spectrum can be shared by a number of users but that the service to be provided in the spectrum can only achieve a sufficient QoS if the number of sharers is limited. Article 7 of the Authorisation Directive defines the procedure that must be followed in such a case. Similarly, an individual right of use might be appropriate where collective use shares spectrum on a geographically constrained basis with a licensed service and there is felt to be a risk of interference to the licensed service. An example of this is the use of TV spectrum by wireless microphones in areas where it is not used for TV.

The situation may also arise where the SMA is of the opinion that future demand for collective use of the spectrum is uncertain and may wish to retain the option to re-farm the spectrum for an alternative use in the future, perhaps using the market based model, in the future. It is less clear whether this approach would be fully compatible with Article 5 of the Directive, which states that "*where possible*, *in particular where the risk of harmful interference is negligible",* spectrum use should not be subject to individual rights of use. However, provision for some sort of "light licensing" or registration regime that would provide visibility of who was using the spectrum and so facilitate re-farming in the future would seem to be compatible with the goal of ensuring efficient use and effective management of radio spectrum resources[24].

[24] As defined in Article 8.2(d) of the Framework Directive

3.3 Comparing the Market Based and Collective Use models

Extensive work has already been undertaken in relation to exclusive assignment of spectrum, which has led to a growing consensus that the market based approach should be favoured for the granting of exclusive spectrum rights for commercial activities. In the longer term we have assumed that access to spectrum for electronic communication services will be achieved either through individual spectrum usage rights or through collective use.

Designating a band as suitable for collective use relaxes some constraints on entry and use but almost invariably introduces new constraints, say on power, and new risks of interference. Hence the costs and benefits of decisions concerning the allocation of spectrum to licensed versus collective use will need to be assessed on a case by case basis. This is because the impact will differ across different frequency bands and for different applications. It follows that there will be some circumstances where there is a clear preference for collective use and some where there is a clear preference for a licensed market based approach.

For example, cellular network operators need to plan their networks on the basis of a projected network capacity and QoS. These parameters are a function of the amount of spectrum available for the network and the amount of base stations. Without exclusive access to spectrum, the only way the network could be reasonably certain of achieving its capacity and QoS objectives would be to over-dimension the network. In other words: to assume that some of the spectrum would not be available because others would be using it, and to provide extra infrastructure to compensate. It would also be difficult for operators to differentiate their service offerings. An example is between a low-price, high volume service and a high quality premium service. This is because the operator offering the high volume service would consume the majority of the available capacity, potentially squeezing out other service offerings, reducing competition and customer choice.

This is a different scenario to “wireless hotspot” providers who concentrate on highly localised service provision, with no requirement for wide area coverage and who can often achieve exclusivity by other means (i.e. such as negotiating an agreement with an airport or chain of coffee shops). The use of short range devices such as WLANs and key fobs by individual consumers is clearly an inappropriate candidate for individual rights of use, since there is a very low risk of interference between these devices and the cost of administering licences would be more than the cost of the devices themselves

In between these two network paradigms there is a substantial “grey area” where both approaches may prove similarly attractive and a hybrid approach combining the two may even be preferred. An example is the recently formed “Unlicensed Mobile Access” (UMA) initiative, which is intended to allow access to GSM and UMTS mobile services over licence-exempt wireless technologies such as Bluetooth and WiFi[25]. UMA will provide seamless handover and roaming between licensed and licence-exempt access networks, enabling network operators to provide additional capacity in traffic hotspots without the necessity to acquire additional exclusive spectrum. Such a development clearly has the potential to affect the balance of demand between licensed and collective use spectrum.

[25] see www.umatechnology.org/

The key attributes of the two approaches are compared in Table 3. Table 4 looks at their implications for the achievement of EU policy objectives:

Table 3: Comparison of Market Based and Collective Use Models

Attribute	Spectrum usage rights (SURs)	Collective Use
Cost of market entry	Potentially high, depending on level of demand for available spectrum.	Low in most cases with no payment required to access spectrum.
Ability to address niche markets	Yes, but possibly in competition for spectrum with those seeking to address a mass market which may increase cost of spectrum access and make niche application uneconomic.	Yes, but QoS may be limited by the presence of interference. Power limits are likely to necessitate significant infrastructure investment to achieve wide area coverage, possibly offsetting saving in cost of spectrum access.
Ability to address mass markets	Yes, depending on nature of SUR (e.g. how much spectrum is available) and if successful in obtaining SUR, e.g. through auction or trading.	Yes, but QoS may be limited by presence of interference. Power limits may increase infrastructure requirements if wide area coverage required, but this is less of an issue with a large user base
Certainty of spectrum access	Uncertain because number of SURs may be limited and demand may exceed supply.	Yes up to a point, but congestion / interference may deny access at certain times or locations.
Frequency co-ordination between users	SUR parameters define frequency and geographic extent of SUR ex-ante, based on successful co-existence between different users – can only be changed by SMA or by negotiation between rights holders.	In most cases no advance co-ordination is undertaken (exception is where spectrum is shared with licensed services and a risk of interference exists). Automatic co-ordination may be possible depending on the technology deployed.
Quality of service	Largely under operator or user control with a known interference environment	Uncertain interference environment. QoS available depends on extent of use by other users.
Speed of access to spectrum	Can be slow if required spectrum has not yet been licensed and there is no provision for spectrum trading. May be faster with trading.	Immediate, providing application is compatible with existing technical constraints on use of spectrum.
Suitable applications	Not generally appropriate for low power, short range applications where risk of interference is low (little additional benefit derived from SURs).	Best suited to applications where risk of interference is small (typically low power, short range) and/or QoS is not critical.
Ability for an SMA to re-farm spectrum for other uses	Depends on licence conditions but in principle easily achieved at end of licence term. Difficult before then unless conditions for revocation are very clear and set out in advance.	Can be difficult if there is a large installed base of devices.
SMA Administration costs	Can be high (auction design and management, enforcement activities etc). However, this is largely dependent on the terms of the licences.	Generally low, though may be costs associated with clearing spectrum (where new spectrum allocated to collective use), and providing information on spectrum availability and conditions of use
Achievement of social obligations	Can be achieved through licence conditions (e.g. coverage / content obligations).	Can support social obligations, e.g. by providing low cost solution to extending broadband access or facilitating independence for elderly or infirm (social alarms)

Table 4: Implications for Broader EU Objectives

	Spectrum usage rights (SUR)	Collective Use
Promoting Innovation	Can support innovation where there is a need for certainty and control over QoS. Limitations on the number of competing players may also stimulate innovation and investment because of the potential for high returns, although if the number of players is too small this could be a disincentive to innovation. Uncertainty of spectrum access may deter opportunistic development of new technologies, favouring established technologies (e.g. UMTS) or emerging global standards (e.g. WiMax).	Certainty of spectrum access can promote opportunistic development of new technologies that can work effectively in a collective use environment (e.g. Bluetooth, WiFi, ZigBee). Can also provide a cost effective way to test the market for innovative new applications.
Promotion of investment (e.g. in infrastructure, product development or service delivery	Good because of legal certainty once an SUR has been acquired and knowledge that will be able to operate in a controlled interference environment.	Good because cost of accessing spectrum is low, time to access is short and there is little or no risk of having access terminated or revoked. However, potential for interference may deter large scale or longer term investment.
Competition	Limitation in number of SURs and/or constraints on the way rights can be used can constrain competition, however negative effects are reduced if rights are flexible (i.e. liberalised) and tradable and SMA releases sufficient spectrum to accommodate several competing operators.	Generally supports competition because of low entry costs and fast access, and even better if conditions of access are liberalised (i.e. not application specific). However, operators selecting areas of high demand could lead to less competition in rural or other low demand areas.
Achieving optimal spectrum use – technical efficiency	Auctions and trading should support efficient spectrum use by encouraging users to maximise the return on their spectrum investment.	Low cost and immediate access to spectrum can stimulate the development of spectrum efficient technologies (e.g. progressive evolution of WiFi standards to support much higher bandwidths and capacity).
Promotion of the internal market	Achieved through harmonised allocations to licensed services that enhance productivity and mobility (e.g. mobile broadband) and foster development of European development, manufacturing and service providers.	Achieved through harmonised allocations to collective use that enhance productivity and mobility (e.g. WiFi, automotive radar, RFIDs) and foster development of European development, manufacturing and service providers.

Note that in some cases the objectives in Table 4 are inter-related. For example, the interplay between competition and innovation has recently been explored by Aghion and Griffith (2005)[26]. They suggest that the impact of competition on innovation depends on the scale of two potentially off-setting effects, namely:

- the impact of competition on profits before innovation occurs; and
- the impact of competition on returns once innovation has occurred.

If the second effect is larger than the first then competition may not lead to innovation and vice versa. Aghion and Griffith also note that innovation is often undertaken to escape competition and so identifying an empirical relationship between the two variables is not straightforward. In particular, it is found that the response to competitive entry depends on how close the incumbent firms are to the production frontier. [27]

3.4 European Regulatory Framework for Collective Use

3.4.1 Background

The last decade has seen progressive changes in radio spectrum management and policy in the European Union (EU) through a series of regulatory measures. These measures have provided the platform for enabling decisions on the availability of radio spectrum for relevant EU policies, providing legal confidence, mechanisms for radio spectrum policy development, transparency on spectrum usage and a consolidated European position in international radio spectrum fora.

The regulatory measures that have enabled the progressive change are:

- The Framework Directive (2002/21/EC), on a common regulatory framework for electronic communications networks and services. Articles 8 and 9 of the Framework Directive lay down principles for the use and management of radio frequencies for electronic communications services. Specifically the Directive refers to encouraging efficient use, harmonisation and effective management of radio frequencies with allocation and assignment based on objective, transparent, non-discriminatory and proportionate criteria.
- The Authorisation Directive (2002/21/EC), which contains a presumption against making the use of radio frequencies subject to the grant of individual rights of use unless harmful interference is likely, limits the conditions that may be attached to rights of use for radio frequencies (Annex B), and defines the procedures for limiting the number of rights of use to be granted for radio frequencies and regulates the imposition of fees for rights of use.
- The Radio Spectrum Decision (2002/676/EC), which creates a regulatory framework that allows the development of a radio spectrum policy for the

[26] P Aghion and R Griffith, Competition and Growth, Reconciling theory and evidence, MIT Press 2005

[27] "The Effects of Entry on Incumbent Innovation and Productivity", P Aghion, R Blundell, R Griffith, P Howitt and S Prantl, October 2005.

European Community in all sectors where radio spectrum is necessary for the establishment and functioning of the internal market i.e. not only in electronic communications but also in sectors such as transport, health and Research & Development. The Decision addresses Committee procedures, measures for harmonising spectrum use in the EU, the availability of information on spectrum use, and the Commission's role in international organisations[28].

- The Radio and Telecommunications Terminal Equipment (R&TTE) Directive (1999/5/EC), which puts into place a framework for placing on the market and putting into service of radio equipment. Article 7 states that Member States may, only as an exception, restrict the putting into service of compliant equipment when justified.

The main objective of EU radio spectrum policy is to optimise the use of spectrum so as to maximise its value for society and to avoid harmful interference.[29] As already described, there are three main methods for managing radio spectrum which can be used exclusively or in combination in some cases to achieve these objectives. Since February 2005, the Commission has issued a number of policy statements aimed at promoting more flexible use of spectrum and greater use of market approaches to spectrum management. The Commission has emphasised the need for "a gradual but systematic liberalisation of radio spectrum use".[30] As part of the i2010 initiative the Commission has presented a strategy for advancing a single market for radio spectrum use in Europe.[31] Most recently, as part of the 2006 review of the Regulatory Framework for Electronic Communications, the Commission has signalled its intention to adopt legally binding instruments to[32]:

- Achieve the introduction of technology and service neutral spectrum use as a default position (through the WAPECs[33] concept);
- Establish a committee process to identify selected bands for use under general authorisation (i.e. for collective use);
- Develop a common framework for spectrum trading in the EU.

This strategy is aimed at ensuring a common approach within the EU to managing spectrum resources that will allow innovators to place new technologies on the EU single market

[28] Including the Radio Spectrum Committee and procedures for issuing mandates to CEPT and harmonising spectrum use within the EU.

[29] The Radio Spectrum Decision also refers to economic, safety, health, public interest, freedom of expression, cultural, scientific, social and technical aspects of Community policies.

[30] European Commission. June 2005. "A forward-looking radio spectrum policy for the European Union: Second Annual Report." COM (2005) 411.

[31] European Commission. 29 September 2005. "Commission proposes advancing single market for radio spectrum use." IP/05/1199.

[32] See "Commission Staff Working Document on the Review of the EU Regulatory Framework – Proposed Changes", 28 June 2006, SEC(2006) 816, available at: http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/staffworkingdocument_final.pdf, and "Commission Staff Working Document on the Review of the EU Regulatory Framework – Impact Assessment", 28 June 2006, SEC(2006) 817, available at: http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/impactassessment_final.pdf

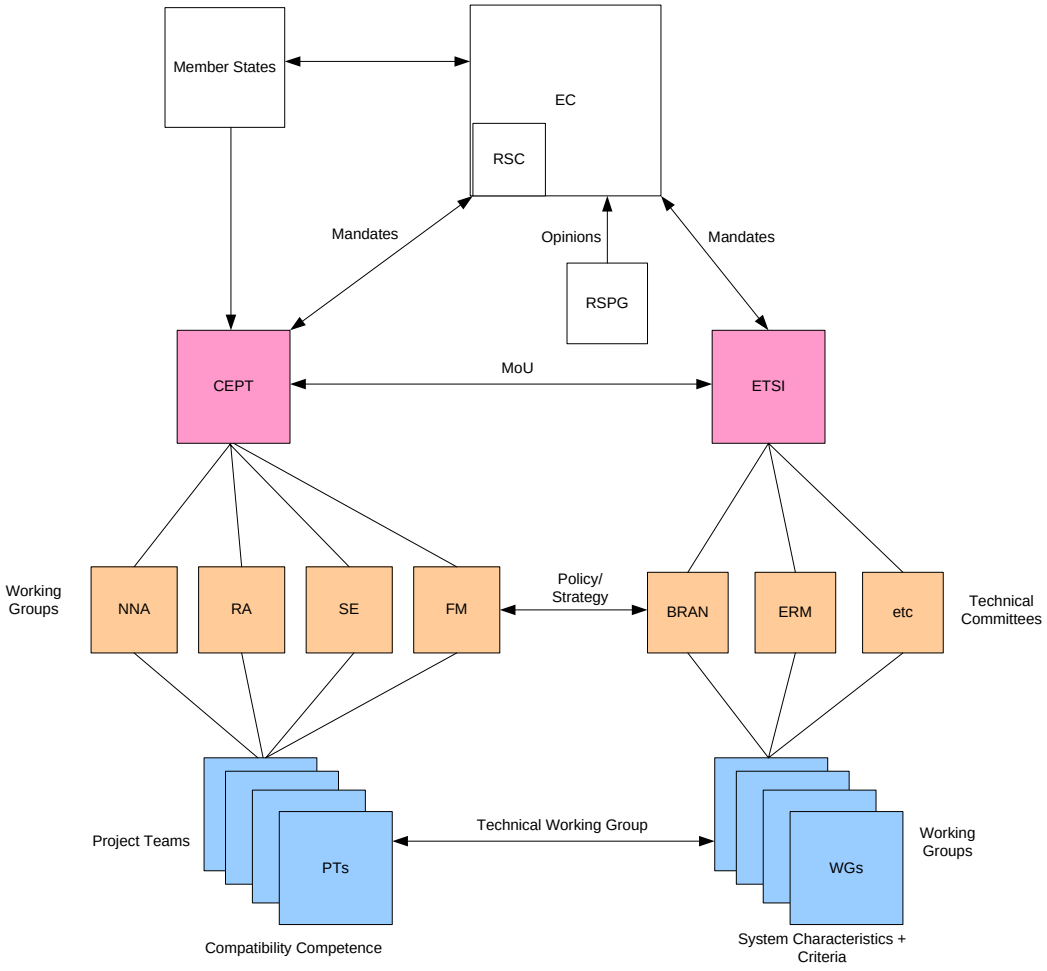
[33] Wireless Access Policy for Electronic Communications Services (WAPECS), RSPG05-102final, RSPG, November 23, 2005

quickly and with legal certainty. By putting in place a common framework across the EU the costs to organsations of acquiring and using spectrum in Europe on a multi-national and possibly a pan-European basis are expected to be reduced.

3.4.2 Organisational Structure

The allocation of spectrum at a national and European level is the responsibility of national regulators operating within the European regulatory framework. The main organisations involved and their inter-relationships are shown in Figure 4. Generally, requirements for spectrum in many cases originate within ETSI[34] as this is where new communications systems/technologies are defined. The competence for radio compatibility studies resides within the CEPT, hence the interaction between these two bodies at various levels. This interaction is usually achieved through liaison statements and System Reference Documents.

Figure 4: European Spectrum Management Organisations



[34] European Telecommunications Standards Institute, www.etsi.org

Although ETSI is cited in Figure 4 as the European Standards Organisation (ESO) there are in fact three organisations - CEN[35], CENELEC[36] and ETSI that are active in the ICT domain. The role and function of these ESOs is currently under review by DG Enterprise as part of its ICT Standardisation Work Programme.[37]

The European Commission issues mandates to the ESOs and CEPT on various spectrum management and ICT issues, on which the Commission receives technical and policy level support from the Radio Spectrum Policy Group (RSPG)[38]. The RSPG provides opinions to assist and advise the Commission on radio spectrum policy issues, on co-ordination of policy approaches and, where appropriate, on harmonised conditions with regard to the availability and efficient use of radio spectrum necessary for the establishment and functioning of the internal market.

The Radio Spectrum Committee (RSC)[39] assists the Commission in the development and adoption of technical implementing measures aimed at ensuring harmonised conditions for the availability and efficient use of radio spectrum, as well as the availability of information related to the use of radio spectrum.

3.4.3 Process for Harmonising Collective Spectrum in Europe

Historically, the approach to harmonising collective spectrum use in Europe has been predominantly on the basis of Recommendations or Decisions issued by the Electronic Communications Committee (ECC) within CEPT. There are certain exceptions, such as the spectrum allocated to DECT cordless phones, which is mandated by an EC Directive. ECC Recommendations are limited in the extent to which they can support harmonisation, as they are entirely voluntary in nature and there is no obligation on individual Member States to implement them. ECC Decisions carry greater weight, in that once Member States have committed to implement the Decision they are obliged to implement them, usually by means of transposition into national legislation or incorporation into the national frequency allocation table. However there is no obligation on Member States to commit to ECC Decisions.

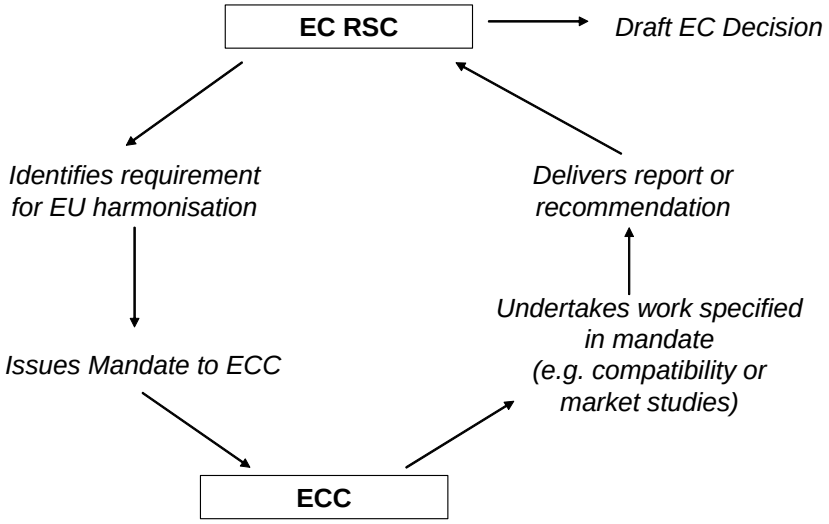
Collective use spectrum is mainly allocated to Short Range Devices (SRDs), which is the generic term for a number of applications and technologies. SRDs are in the main equipment that is compliant with the RTTE Directive (termed Class 1 products)[40] or equipment that is permitted under a European Radio communications Committee (ERC) decision covering licence-exempt use. Currently the spectrum management activities for SRDs are mainly handled by the Short Range Device Maintenance Group (SRD/MG) of CEPT, which

[35] European Committee for Standardisation, www.cenorm.be
[36] European Committee for Electrotechnical Stanadisation, www.cenelec.org
[37] DG Enterprise ICT Standardisation Work Programme
http://ec.europa.eu/enterprise/ict/policy/standards/ict_index_en.htm
[38] RSPG, http://rspg.groups.eu.int/
[39] Radio Spectrum Committee,
http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/index_en.htm
[40] Class 1 refers to equipment compliant with the RTTE DIrective which can be placed on the market and be put into service without restrictions.

maintains the document ERC Recommendation 70-03[41], the principal consolidated source of information concerning SRDs in Europe.

Since the introduction of the new EU regulatory framework a closer working relationship between the European Commission and ECC has been established and there has been a move towards using Commission Decisions to support key harmonisation measures. Typically, the EC's Radio Spectrum Committee identifies a need for harmonisation measures, instructs the ECC to undertake any necessary market or technical studies to inform the harmonisation process and then develops a draft EC Decision reflecting the outcome of the ECC's deliberations. The EC Decision is put to the European Parliament for ratification following a process of internal (EC) and external (public) consultation. The process is illustrated in Figure 5 below:

Figure 5: Harmonisation Process Involving EC and ECC.



An example of such a process has taken place with regard to a range of SRDs. A draft Commission Decision on the harmonisation of the radio spectrum for use by SRDs was issued for public consultation on 8th August 2006. The document as drafted required Member States to make available, on a non-exclusive, non-interference and non-protected basis, a series of frequency bands for short-range devices, subject to the specific conditions and by the implementation deadline, defined in the Annex to the draft Decision. The Decision would be regularly revised to be adapted to technical progress.

The Annex to the draft Decision reflects the content of a number of annexes of the existing ERC Recommendation 70-03, essentially those which have already been implemented in all EU Member States under the existing voluntary arrangements. By inclusion in the draft Decision the specified bands and applications would become mandatory in all Member States. The current draft Decision does not address those bands and applications that have not yet been implemented throughout the EU, and are hence more likely to be of concern to manufacturers and potential users. In this sense the EU's current role in this area appears to be largely a reactive one: it strengthens the status of existing harmonised allocations by

[41] ERC Recommendation 70-03, Relating to the use of Short Range Devices (SRD), http://www.ero.dk/documentation/docs/docfiles.asp?docid=1622&wd=N

incorporating them into EU legislation rather than mandating further harmonisation where this has failed to take place under the existing CEPT arrangements.

The two recent examples below highlight the time taken to gain harmonised spectrum and conditions of use in the EU under the existing voluntary approach.

The first example concerns DMR 446, a digital variant of the already established and highly successful PMR 446 licence-exempt mobile radio standard, operating in the 446 MHz band. DMR 446 was first proposed for additional harmonised spectrum within ETSI in June 2004, leading to an agreed ECC decision in October 2005[42]. However, by July 2006 only two EU Member States had implemented the Decision, with a further five committing to implementation. The majority of Member States, including major markets such as Germany, Italy, Spain and the UK have yet to make clear their intentions, making it difficult for manufacturers to commit to equipment development and denying the benefits of this new product to those countries that have implemented the decision.

(i) Harmonised Spectrum - Digital Mobile Radio (DMR) 446, Systems Reference to ECC Decision Example:

DMR446 provides a simple example of the process of gaining harmonised European spectrum with collective use, which has no complicated compatibility studies. The process from ETSI requesting harmonised spectrum using Systems Reference document, to an ECC decision took 16 months. Some 2 years from the Systems Reference Document only 3 SMAs having implemented this decision. The key dates and documents are noted below:

December 2003, Presentation to FM38 on DMR

June 2004, ETSI TR 102 335-1 V1.1.1 (2004-06) Technical Report Electromagnetic compatibility and Radio spectrum Matters (ERM); System reference document for harmonized use of Digital Mobile Radio (DMR); Part 1: Tier 1 DMR#, expected to be for general authorization with no individual rights operation

October 2004, ETSI TR 102 335-1 V1.1.2 (2004-10) Technical Report Electromagnetic compatibility and Radio spectrum Matters (ERM); System reference document for harmonized use of Digital Mobile Radio (DMR); Part 1: Tier 1 DMR#, expected to be for general authorization with no individual rights operation

October 2005, The ECC Decision (ECC/DEC/(05)12) [43] for the collective use of harmonised licence-exempt spectrum for DMR 446 was published.

The status of this decision as of July 2006 is 3 Administrations have implemented, 3 have committed and 2 are under study.

[42] ECC Decision on harmonised frequencies, technical characteristics, exemption from individual licensing and free carriage and use of digital PMR 446 applications operating in the frequency band 446.1- 446.2 MHz (ECC/DEC/(05)12)

[43] ECC Decision of 28 October 2005 on harmonised frequencies, technical characteristics, exemption from individual licensing and free carriage and use of digital PMR 446 applications operating in the frequency band 446.1- 446.2 MHz, available from: www.ero.dk

The second example relates to the illegal importation of low power FM micro transmitters used to transmit music from portable devices to FM radio receivers. These devices became widely available in the U.S. and Far East, where they could be operated legally under existing provisions catering for ultra low power devices. As no such provisions existed in Europe, use of these devices was illegal but many thousands were imported into the EU, both by returning travellers and on a commercial basis. Studies were undertaken to derive appropriate limits for interference mitigation and steps were taken to include provision for the devices in Recommendation 70-03 and the related ETSI standards. However, many countries have still yet to implement this provision and even when implementation has taken place this has typically taken up to 3 years.

(ii) Compatibility Studies for SRD to Support ERC Recommendations Example:

Micro FM transmitters have been used illegally for many years. However, it was the growth in demand following the introduction of mass storage devices (mp3 Players) that drove SMAs to seriously look at this issue. A joint and coordinated push from both ETSI and CEPT ensued in 2003, with the Swiss Administration the first to suggest driving this forward.

Timeline:

Mid 2003 Ofcom UK commissioned internal compatibility report (Project 811), which was published **March 2005**[44].

Late 2004 CEPT and ETSI took the findings of Project 811 and they study radiated powers between 10 and 250 nW.

Late 2005 CEPT work leads to ERC consultation, ECC report 73[45] and eventual entry into ERC Recommendation 70-03. ETSI published the draft amendment to the EN in late 2005, thus allowing equipment to be placed on the market in EC.

Late 2005/Early 2006 Administrations start to authorise the use in late 2005 early 2006.
July 2006 EN is entered into the EC Official Journal and therefore becomes harmonised in EC.
July 2006 UK published consultation on amending UK Wireless Telegraphy (Exempt) regulations, based on the harmonised standard. The expectation, based on previous experience of bringing forward new regulations is that the regulations will be in force in **November 06**.

The conclusion that can be drawn on the subject of Collective Use spectrum harmonisation is that the harmonisation process is protracted to the detriment of the manufactures and users. However, the recent actions of the Commission in the development of the Draft SRD decision are a step in the right direction.

[44] Band II SRD Compatibility Tests, RTCG Project No.811, Issued 10th March 2005, Available from: http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/rlans/technical/tests/srdtests.pdf
[45] ECC Report 73, Compatibility of SRD in the FM Radio Broadcasting Band, Hradec Kralove, October 2005, available from www.ero.dk

3.5 Global Harmonisation Activities

At a global, level, the ITU-R[46] has also developed a recommendation providing guidance on technical and spectrum requirements for Short Range Devices (SRDs), which includes reference to the current situation in Europe, North America, China, Japan and Korea[47]. The importance of global harmonisation is self-evident for some applications, such as medical implants where a user may travel anywhere in the world and interference could have a potentially catastrophic effect. Global frequency allocations have also been a significant factor in the success of Wi-Fi and RFID applications, allowing global mobility and the production of equipment on a sufficient scale to make it commercially attractive. In some cases market developments have driven moves towards global allocations, as in the FM micro transmitter example previously cited. In recognising the fact that harmonisation is key to the development of collective spectrum use in Europe, it is addressed in greater detail in Chapter 6.

3.6 European Commission Initiatives

The European Commission has had a long and relatively successful involvement in facilitating collective use of spectrum in Europe. Perhaps the biggest single success (in terms of market volume) was the 1991 DECT Directive (91/287/EEC), which mandated the exclusive allocation of spectrum around 1900 MHz for digital cordless phones complying with a new harmonised European standard. This provided manufacturers with the confidence to invest in the new standard, enabling it to succeed where previous similar standards that were not fully harmonised (notably CT2), failed. More recently, the adoption of the R&TTE Directive heralded a move away from national standards and approaches to compliance to a single, harmonised approach based on declarations of conformance. A new category of equipment was defined ("Class 1"), as fully harmonised licence-exempt devices that could be legally sold and deployed anywhere in the EU. This made it far easier for new equipment to be launched into European markets if the equipment conformed to the harmonised standards and frequency allocations.

Since the introduction of the new regulatory framework in 2003, the Commission has taken a more proactive role in spectrum management activities, and is addressing a number of specific issues in relation to collective use of spectrum. In addition to the draft Decision on SRDs already described, the Commission has already issued four Decisions for harmonising frequency allocations for applications involving collective use of spectrum namely:

- Decision 2005/928/EC on the harmonisation of the 169.4-169.815 MHz band for social alarm systems;
- Decision 2005/513/EC on the harmonisation of the 5GHz frequency band for the implementation of Wireless Access Systems including Radio local Area networks (RLANs);
- Decision 2005/50/EC on the harmonisation of the 24 GHz radio spectrum band for time limited use by automotive radar equipment;

[46] International Telecommunication Union – Radiocommunication, http://www.itu.int/ITU-R/
[47] ITU-R Recommendation SM.1538-1

- Decision 2004/545/EC on the harmonisation of the spectrum in the 79 GHz range for automotive radar equipment.

The implementation status of these Decisions can be found on the EC website. [48]

3.6.1 CT2 / DECT Case Study

One example of a market where European harmonisation appears to have been a strong factor is cordless telephones. In the early 1990s there were two competing digital cordless standards in Europe, namely Cordless Telephone 2 (CT2) and Digital Enhanced Cordless Telecommunications (DECT). Both were digital standards offering similar levels of functionality, with CT2 operating in the 865 MHz band and DECT in the 1890 MHz band.

Attempts were made to harmonise CT2 throughout Europe on a voluntary basis, based on a CEPT Recommendation. However in practice only around half of European SMAs implemented the allocation with other SMAs having existing uses of the spectrum that could not be readily moved. DECT on the other hand was backed by an EC Decision that mandated Member States to make the spectrum available exclusively for this application. The subsequent failure of CT2 and continuing success of DECT have been attributed largely to the latter's status as a fully harmonised European allocation. For example, when consulting on a proposal to revoke the allocation to CT2 in 1999, the UK SMA observed that:

"The market for CT2 technology has not been as successful as anticipated. This is largely due to increasing popularity of DECT equipment, which has the advantage of being a harmonised European standard with access to the much larger European market. This has resulted in the under-utilisation of the frequency band 864.1 – 868.1 MHz"[49].

DECT has since extended its reach well beyond Europe and is now deployed in more than 110 countries worldwide[50]. The standard has also been adopted as one of the global IMT-2000 3G mobile standards.

3.7 CEPT Initiatives

Whilst the EU's role has been substantial, historically most of the harmonisation measures in Europe relating to collective spectrum use have emanated from CEPT. The following are the three main CEPT initiatives that affect collective spectrum use

- ERC Recommendation 70-03 contains all allocations, restrictions and status for SRDs;
- The development of an SRD strategy through Project Team FM PT43;
- The provision of information concerning the availability of spectrum for collective use through the European Frequency Information System (EFIS).

[48] Implementation Status of the decisions:
http://europa.eu.int/information_society/policy/radio_spectrum/ref_documents/index_en.htm
[49] "Cordless Telephony: The Future of Analogue and CT2 Cordless Telephony in the United Kingdom", UK Radiocommunications Agency consultation document, November 1999
[50] source: DECT Forum

The status of these initiatives are discussed below.

3.7.1 ERC Recommendation 70-03

ERC Recommendation 70-03 (referred to as ERC 70-03) provides a consolidated set of harmonised frequency bands and applications for short range devices (SRDs) in the CEPT area. It is a lengthy and complex document, comprising in excess of 60 frequency bands and containing 13 separate annexes covering different types of SRD applications. The extent to which each of the recommended bands is harmonised among CEPT countries varies considerably. Information on the extent of harmonisation (i.e. which countries have implemented or committed to implement each frequency allocation identified in the document) is also provided in ERC 70-03. There is a wide variation in the degree of harmonisation, for example whilst the 2.4 GHz and 433 MHz bands are now adopted in all CEPT countries, the non-specific allocation in the 863 – 870 MHz band is only adopted or planned in 7 of the 47 CEPT countries. A summary of the implementation of the specific frequency bands can be seen at Appendix C.

The 13 annexes of ERC 70-03 cover 12 specific applications and a single generic category of "non-specific devices". Most of the application-specific annexes relate to applications where safety or security may be an issue, such as transport (rail and road), alarm systems, medical devices or movement detection. Interference to such applications could have serious consequences, but the characteristics of the systems themselves (e.g. short duty cycle, occasional intermittent operation, very short range) mean that interference between these devices is unlikely to arise. For these applications, unconstrained sharing with other types of SRD may present an unacceptable risk of failure, hence the justification for specific frequency allocations for these applications. Certain other applications, whilst not having the same safety or security issues, may also be unsuitable for unconstrained sharing with other devices. For example, interference to RFID systems could cause significant disruption in retail and warehouse environments and interference to wireless microphones could seriously disrupt major public events where these devices are used. All of these various constraints notwithstanding, applications such as wireless data transmission and wireless audio should in principle coexist well with other SRD applications so long as appropriate sharing protocols are deployed.

ERC 70-03 provides a valuable reference tool for industry, but as it has evolved over the years it has become increasingly complex. Some rationalisation and relaxation of the technical constraints that apply to the various bands, particularly for non-specific applications, would be helpful in clarifying and enhancing the opportunities for collective spectrum use. Possible approaches to this are considered in Chapter 4.

3.7.2 Project Team FM PT43 – SRD Strategy

CEPT's Frequency Management Working Group created a project team Project team (FM PT 43) to produce a report in order to fulfil a Mandate from the Commission to develop a strategy to improve the effectiveness and flexibility of spectrum allocated for Short Range Devices. This mandate was aimed at strengthening the Internal Market for generally

authorised radio communication products in order to provide legal certainty for Class 1 products[51] and improving access to spectrum for innovative products.

The key findings of the report[52] include:

- SRDs are a success in economic terms with an increasing demand, resulting in additional, globally harmonised, spectrum being required particularly in the UHF band;
- Technology developments are enabling greater sharing of spectrum;
- ERC 70-03 is a vital source of information for the industry;
- A balanced decision by regulators on determining additional SRD spectrum and ensuring the most effective use of the radio spectrum resource in general needs to be made. However the potential for using market mechanisms as a tool for designating SRD spectrum is considered to be limited.

These findings have been taken into consideration during our work.

3.7.3 ERO Frequency Information System (EFIS)

EFIS is an on-line database developed by CEPT[53], providing information on European frequency allocations and uses on a country-by-country basis. EFIS enables searches to be undertaken on the basis of user-defined frequency limits, types of radio service / system (these include the various categories of short range device defined in ERC 70-03) or technical standards. The database also includes a searchable version of the European Common Allocation Table.

The facility in its current form appears to be of limited utility for identifying existing harmonised European allocations. For example, a search for allocations to non-specific short range devices in the 863 – 870 MHz band, where a number of harmonised allocations are clearly defined in ERC 70-03, indicates that there are no allocations in the European table and refers to national allocations in only 60% of EU countries. As major countries such as France, Germany, Spain and the UK are among those for whom no information is provided (indeed the UK does not participate in EFIS at all), the information provided by EFIS is unlikely to be useful to potential developers wishing to enter the European market. This is despite the availability of harmonised ETSI standards and clear evidence from chip manufacturers of support for this band as an alternative to the established U.S. 900 MHz ISM band[54].

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[51] Classification of equipment in accordance with the R&TTE Directive (1999/5/EC) http://www.ero.dk/1ea61de3-7b19-45f7-9dad-331e1499d528.W5Doc?mid=BB4994F2-8411-4AA9-A6E5-CE893A0E3E5E&frames=no

[52] Draft Final Report from CEPT in response to the Second EC Mandate to CEPT to develop a strategy to improve the effectiveness and flexibility of spectrum availability for Short Range Devices (SRDs). FM43(06)63 Rev 9

[53] and accessible via its own web site www.efis.dk

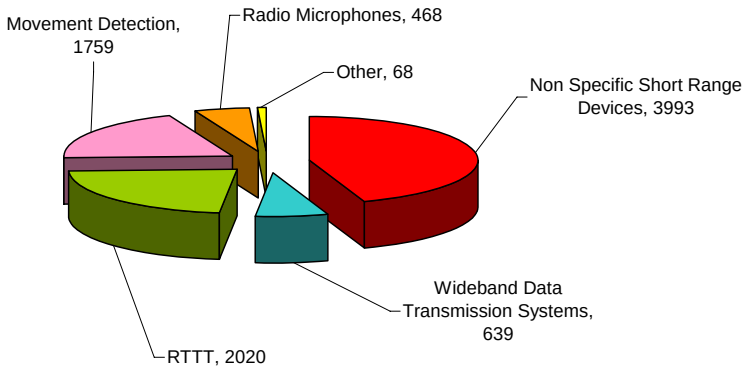
[54] For example see "Wireless Short-Range Devices: Designing a Global Licence-Free System for Frequencies below 1 GHz", by Analog Devices, available online at www.analog.com/library/analogDialogue/archives/40-03/wireless_srd.pdf

The European Commission has issued a mandate to CEPT to assess the feasibility and efforts required to use the EFIS database to provide a minimum set of information specified in the Mandate.[55] In Chapter 3 we discuss extension of this information to include specific information concerning collective use spectrum.

3.8 Amount of Spectrum Allocated to Collective Use

The total amount of available spectrum to all applications in ERC 70-03 is 8553.86MHz[56] which can be seen by specific application at Figure 6 below.

Figure 6 : Spectrum Available to Collective Use Applications (MHz)



Source: Mott MacDonald analysis from ERC Recommendation 70-03

[55] Annex 1, Mandate to CEPT on the use of EFIS for publication and access to spectrum information within the Community, DGINFSO/B4, 8 December 2005

[56] Spectrum allocation may be shared with other SRD/Licence-exempt or licensed services

A further breakdown is provided below in Table 5 by frequency band.

Table 5 : Amount of SRD Spectrum Allocated

Frequency Range	Spectrum Available for Collective Use[57]	Spectrum Available for Non-specific Collective Use[58]
0 – 1GHz	25.51MHz (496.62MHz) 2.55% (49.74%)	9.7MHz (3.756MHz)
1GHz – 3GHz	83.5MHz (98.5MHz) 4.18% (4.93%)	83.5MHz (83.5MHz)
Above 3 GHz	8021.5MHz (8036.5MHz) 3.21%[59]	3.9GHz (150MHz)

Source: Mott MacDonald analysis of ERC 70-03 and Draft SRD Decision

There is further spectrum allocated for collective use in Europe, some of which is harmonised but is not detailed in ERC 70-03. An example is the PMR446 band which is harmonised on the basis of implementation of CEPT Decision (ECC/DEC/(05)12).

A relatively small amount of radio spectrum is currently set aside for collective use, if one disregards the devices that share broadcast spectrum for the broadcast industry (e.g. Wireless Microphones and Audio). For example, around 7.7% of the spectrum below 3 GHz is currently available for collective use in EU countries, compared to 15% allocated to broadcast services alone. Below 1 GHz, the contrast is even starker, with only 2.55% of spectrum allocated to collective use. This is very different from the situation in North America where the availability of the 902 – 928 MHz band means that approximately three times as much spectrum below 1 GHz is available for collective use as is the case in Europe.

The non-specific spectrum below 1GHz for SRDs which is regarded by many as the priority for harmonisation and expansion currently stands at 9.7MHz, with only 3.756MHz of the spectrum currently in the Draft SRD Decision, which will mandate the harmonisation of these bands. The further expansion of the SRD Decision, particularly to cover the 800MHz spectrum for non-specific allocations will be a subject for further debate and discussion within CEPT and is covered later in this study.

[57] Figures in Brackets include Radio Microphones and Wireless Audio (shared broadcasting spectrum).
[58] Figures in brackets represent the amount of non-specific spectrum proposed in the Draft SRD Decision
[59] Spectrum range from 1GHz – 250GHz

3.9 Recent National Regulatory Initiatives in Europe

In addition to the activities going on at European level within ETSI, CEPT and the Commission, many of the European SMAs that we surveyed are actively studying issues related to collective use. Specific initiatives that are either under consideration or under way include:

- Several European SMAs expressed interest in implementation of UWB once there is agreement at the European level (by the CEPT and/or RSC).
- A number of European SMAs are seeking to make the 5.725-5.825 GHz band available at the national level on a collective use basis (either licensed or licence-exempt) for applications such as WiMAX. Interference risks regarding military applications, notably radars, are a significant impediment in some countries.
- In the UK, Ofcom is currently funding a number of studies relating to technical and economic aspects of licence-exempt spectrum use. These will be used to inform the decision making process for allocating spectrum to licence-exempt versus licensed use in the future. Typically Ofcom would expect to undertake a forecast of the economic costs and benefits of various degrees of licensing (including licensed versus licence-exempt use) when considering a new release of spectrum.
- In Finland, Ficora is considering a proposal to expand the 863 - 865 MHz wireless audio band downwards by 1 MHz (to 862 MHz), as the existing band has become crowded.

3.10 Regulatory Approach to Collective Use in Other Regions of the World

3.10.1 Introduction

This section compares the regulatory environment for collective spectrum use in Europe, Japan and the U.S.[60]

There is a fundamental difference between the U.S regulatory approach and approaches used in Europe and Japan. For the majority of the past three decades the Federal Communications Commission (FCC), like other U.S. regulatory agencies, has preferred deregulation and greater reliance on market forces. An early example of this was the 1980 FCC decision to authorise analogue AM stereo broadcasting without selecting a specific technical standard. Since then the FCC has sought to make spectrum available for both licensed and licence-exempt use with the minimum possible regulation so as to allow market forces to function.

[60] In practice, the regulations in Canada are similar to those in the U.S. due to the long common border, *de facto* common market for consumer products, and fundamental common values of the spectrum management authorities in the two countries.

By comparison, SMAs in Europe and Japan have focused more on responding to requirements developed by mainstream users (e.g. major network operators and equipment vendors) and generally supporting interoperability by means of detailed technical standards. Thus the harmonised standards of GSM and DECT are the hallmarks of European spectrum policy, while the lack of a cellular standard for 2G or 3G, and also the lack of an interoperability standard for cordless telephones, are corresponding hallmarks of U.S. spectrum policy. There are proponents who feel that each approach is superior to the other.

The U.S. approach is partly driven by the view that radio regulation has an economic impact beyond the communications industry and that enabling rapid evolution of technology could lead to innovation in other industries that are direct and indirect users of radio technology. Two brief examples follow:

(i) Federal Express Example

Federal Express (FedEx) revolutionised the package delivery business in the U.S. starting in the 1970s. In doing so, it enabled other new business models that used FedEx's delivery services to create more economic growth. But as a new industry, it did not have easy access to spectrum for dispatching and managing its ground delivery fleet as the more traditional industries were "grandfathered" spectrum assignments that met their current needs. U.S. deregulation in making the 800 MHz land mobile band available in the 1970s with minimal technical regulation made it possible for FedEx to partner with IBM to develop an early nationwide digital 2-way messaging service that gave FedEx the capacity and flexibility it needed to manage its ground delivery fleet. The growth of the FedEx delivery service at a reasonable price in turn enabled the creation of other businesses unrelated to either transportation or communications. Thus, the primary economic impact of spectrum policy in this instance was the increase in productivity of transportation services and in the value of the new businesses that used the improved transportation.

(ii) Portable Bar Code Scanner Example

Wi-Fi and Bluetooth have emerged as two of the main users of the licence-exempt 2.4 GHz band. But shortly after the FCC authorised this band for unlicensed use, another unexpected new application developed: wireless bar code scanners. These are handheld devices that have optical barcode scanners that have a wireless link to IT systems maintaining inventory information. Not only did this enable a new type of product, its use in turn revolutionized inventory control in retail stores and warehouses since an operator could quickly inventory stock. Thus, the main economic impact of this technology comprised the efficiency gains that accrued to the retail and wholesale sectors.

It can be argued that the European and Japanese approach to spectrum policy tends to favour known applications that are supported by traditional spectrum users. Where a new innovative or niche application emerges it is often necessary to go through a protracted process to get the new application included within the regulatory framework. Both of the examples described above could be viewed as niche applications when they were initially implemented and consequently would probably have taken longer to come to market in

Europe or Japan than in the U.S. Furthermore, there is anecdotal evidence[61] that today's ubiquitous Wi-Fi technology started as a niche radio local area network system for cash registers. The FCC did not deal with authorising a specific application or set of users, rather focused on whether it could allow unlicensed use of the ISM bands for spread spectrum without causing harm to any third parties. This is probably why collective use has been pioneered more in the U.S. than in Europe or Japan.

The U.S. has a variety of collective use regimes including the following:

- Licence-exempt with few restrictions on usage and technology;
- Licence-exempt with restrictions on usage but few restrictions on technology;
- Licence-exempt with few restrictions on either technology or usage;
- Private commons (and its closely allied regulatory model spectrum trading/secondary markets).

3.10.2 U.S. licence-exempt regulations

The licence-exempt spectrum gave rise to Wi-Fi and has been the most productive in rapidly accommodating new technology and applications that are difficult to accommodate in traditional spectrum planning. Whilst licence-exempt spectrum with few restrictions has proven to be a useful breeding ground for new technology it does have the potential downside of interoperability issues arising from the lack of harmonisation. Traditional radio systems usually have ranges in the kilometre-plus range and have users who overlap each other spatially and often need to intercommunicate. However, many of today's uses are different and have mutually exclusive usage spaces and limited need for interoperability. Thus interoperability is less of an issue in ubiquitous cordless telephones, baby monitors and Personal Area Networks (PANs) than in cellular telephones.

The growth in Bluetooth, an early Personal Area Network (PAN) technology shows the benefit of interoperability standards – being able to buy computer and cell phone accessories that all work together. But in the U.S. environment these are all handled by voluntary standards that do not involve the spectrum management authority at all. ETSI and Japan's Association of Radio Industries and Businesses (ARIB) have much closer relationships to SMAs than U.S. equivalents have with the FCC.

In the 1989 rewrite of "Part 15", the U.S. licence-exemption regulations, a conscious decision was made to try to move away from detailed prescriptive regulation. This involved a move from specific technologies for specific users for dedicated bands because such regulations were very time consuming to administer for new applications. While all the legacy cases were carried into the new rules in 1989, the new concept of "ultra low power" operation was also included. In effect, a *de minimis* limit equal to the existing limit for unintentional emissions from digital devices (such as PCs) was adopted as a limit for intentional emissions in many bands for almost any type of application. While this ultra low power limit has not had a major commercial impact by itself, it set the stage for the 2003 U.S. authorisation of UWB which was a natural extension of the concept.

[61] For example, see http://en.wikipedia.org/wiki/Wi-fi#History

3.10.3 U.S. private commons

The U.S. has created several types of private commons through both explicit actions and implicit spectrum trading/secondary market regulations. Thus 2 GHz Unlicensed Personal Communications Services (S-PCS) was the first U.S. private spectrum commons but had limited success until the technical restrictions[62] were relaxed recently. The 700 MHz "Guardband Managers" band was created in the U.S. as part of its digital dividend plan to serve as a buffer around a new public safety band. The regional licensees of this band have tremendous flexibility, effectively acting as a spectrum management authority in authorising usage of this band subject to interference constraints on the neighbouring public safety band. A major licensee in this band, Access Spectrum[63], has bundled spectrum offerings in this band with offerings in other more conventional bands made available under spectrum trading/secondary market regulations which apply to most non-broadcast bands available to private users.

3.11 Technology Developments Supporting Collective Use of Spectrum

Collective use of spectrum involves a wide variety of technologies. In recent years there have been a number of enhancements in an attempt to maximise the capacity of available spectrum and minimise the risk of interference between devices. The technology used for collective spectrum has evolved to cope with:

- Sharing spectrum with primary (licensed) users;
- Sharing spectrum with other co-primary users.

These two scenarios offer different technology challenges. Where no degradation of services to primary users is permissible, or where a myriad of technologies share in a co-primary scenario and users do not necessarily expect quality to exceed that available on a best-endeavours basis. This environment of sharing has led to innovation in spectrum access methods and mitigation techniques to ensure that the technologies can co-exist and that the user experience is satisfactory in an environment where users are not protected from interference.

3.11.1 Approaches to Interference Management

The areas of technological development and innovation for spectrum and interference management are three dimensional – addressing power, frequency and time dimensions. The three spectrum dimensions can each be used to support interference management as follows:

- **Power** – limiting the power of a transmitting devices reduces the risk of interference to other devices and the separation required between devices to avoid interference

[62] Ironically these restrictions were requested to control mutual inference by the firms originally interested in using this band.
[63] See www.accessspectrum.com

- **Frequency** - separating users by frequency, for example by changing channel, reduces the likelihood of interference;

- **Time** - by occupying the spectrum at a moment in time when it is otherwise vacant, for example by listening to a channel and transmitting only if nobody else is using it at that time.

At the simplest level, interference is managed by limitations on radiated power, both in-band and out-of-band, and/or duty cycle (i.e. the proportion of time during which the system transmits). More advanced interference mitigation techniques, such as listen before talk (LBT) and spread spectrum, are increasingly used where a large number of similar systems are deployed in a specific frequency band. More recently, these concepts have been stretched even further, with the advent of Ultra Wide Band (UWB) technology to the commercial sector (where the signal is spread over a bandwidth of up to several GHz) and cognitive radio (where the transmission frequency responds dynamically to changes in the local interference environment).

Appendix D summarises the main technologies currently in use or under development and their status in terms of market availability. Table 6 below lists the technological developments and relates these technologies to the spectrum dimension in which they operate to provide mitigation and transmission techniques that allow collective use through polite access.

Table 6: Technology Summary

	Power	Frequency	Time
Mitigation techniques	ATPC	AFA, Cognitive Radio	LBT, Cognitive Radio, Duty Cycle limits
Transmission techniques	DSSS, FHSS, UWB	FHSS,	FHSS,

Detail of the technologies is provided in Appendix D. Acronyms have the following meanings:

ATPC – Automatic Transmit Power Control, AFA- Adaptive Frequency Agility, LBT - Listen Before Talk, DSSS – Direct Sequence Spread Spectrum & FHSS – Frequency Hoping Spread Spectrum

3.11.2 Legacy Technologies

Many collective use applications deploy basic analogue or digital technology that dates back many decades. This is particularly the case for consumer devices, where cost is the main driving factor, but also applies to some professional applications where digital technology cannot currently match the performance of analogue systems. This applies particularly to wireless microphones where the current limitation of digital processing introduces an unacceptable time delay in the amplified voice signal (see Appendix E). As the cost of digital technology has fallen, there has been increasing substitution of older analogue devices by digital devices in some sectors, particularly cordless phones where DECT devices have largely displaced older, interference-prone analogue products.

Many low cost consumer products use very simple binary digital modulation techniques such as Amplitude Switch Keying (ASK), sometimes referred to as “On-Off Keying” (OOK). This is adequate for sending short bursts of data at relatively low bit rates, such as might be required for wireless key fobs. Transmission of higher data rates requires the use of more advanced modulation schemes and techniques to mitigate the effect of interference from other devices using the same frequencies. For example DECT, despite having been around for almost two decades, is a relatively advanced technology which incorporates techniques such as dynamic frequency agility.

Historically, SRD standards did not tend to specify receiver characteristics. In consequence many devices had very poor receiver selectivity which has led to problems of interference from high power transmissions in adjacent bands. There have also been examples of non-harmonised SRD allocations that have delayed the implementation of harmonised bands or led to interference between licensed and licence-exempt services. For example, in the UK it was necessary to clear existing bands at 418 MHz and 888 MHz of SRD use before full use could be made of the harmonised TETRA and E-GSM bands.

3.11.3 Implications

A broad array of current and emerging technical innovations offer the possibility of increased sharing of spectrum. To the extent that the use of these new techniques effectively increases the use that can be made of spectrum and provides economic benefits, it represents a very positive development.

At the same time, the use of these techniques is not without cost. Aside from the simple cost of deploying new and more capable equipment, there are the more subtle costs associated with managing a potentially more complex interference environment, and of addressing the operational transition to the new environment.

Key questions for future policymakers include:

- The degree to which these newer forms of collective use should be permitted or supported at a regulatory level;
- Whether these technologies should be selected by the spectrum management authority, by an industry association or standards body, or simply left to the discretion of the user; and
- How to deal with issues associated with legacy equipment.

A promising approach that has been explored to only a very limited extent in the U.S. and elsewhere is the notion of imposing standards on the receiving device (or of offering protection from interference only to devices that meet defined standards of quality). Regulation to date has tended to focus solely on the transmitter. In many instances, small and inexpensive improvements in receiver quality could generate substantial benefits.

3.12 Views of Industry on the Current Regulatory Approach in Europe

As part of our research for the study we sought views of industry and end-users, on the effectiveness of the current regulatory regime in Europe for collective spectrum use (see section 3.1 for details of respondents). Broadly, it was felt that the current approach in Europe compared favourably with other parts of the world, particularly in terms of moving towards harmonisation, although there was also a strong desire to expedite the harmonisation process further. The process of identifying new spectrum for collective use and evaluating this through the SRD Maintenance Group is seen to work well, but there were concerns about the complexity of the current allocations, as contained in ERC 70-03, and that compatibility studies undertaken by ECC Project Team SE24 can take a long time; up to 3 years was cited in the case of RFID spectrum. Time to market is increasingly critical for developers, especially in the consumer sector where product life cycles are as short as 1 – 2 years. It is important that where a new frequency allocation is identified it is made available in the shortest possible time and in as many countries as possible.

3.12.1 Regulatory Regime

Although in general the current European regulatory approach was seen to compare favourably with other regions of the world, there was strong support for greater harmonisation of frequencies and regulatory processes. Of 18 respondents, who expressed a view, 16 said there should be more harmonisation. One respondent observed that CEPT/EU regulations suffered by being administered differently in Member States and by being poorly explained. Another thought that harmonising the regulations in a less constraining way would be beneficial to reduce customer confusion and uncertainty. There was a high degree of awareness of the current regulatory regime. Of 20 respondents 11 claimed to be “very familiar” with the regulations and another 8 were “somewhat familiar”.

There was a mixed response to the issue of flexibility in collective use allocations. Of 11 respondents, who expressed a view, 5 thought there should be fewer constraints on how specific bands are used, 3 thought there should be more constraints and 3 thought the current situation to be about right. One respondent noted that protocol improvements might make regulation less necessary, enabling regulatory constraints to be replaced with technical ones, whilst another thought there should be more liberalised rules regarding transmission power.

The majority of respondents who expressed a view felt that collective use should be one of the options considered when spectrum is being re-farmed from one type of use to another. However, some noted that re-farming of spectrum that has been allocated to collective use can be problematic as it can take many years to clear a band of existing SRD users. For example, for applications such as building automation and industrial SRD systems, devices are installed in phases that could lead to their being in use for 20 years or more. Users thought that acquisition of spectrum through the spectrum trading market for SRD applications was also likely to be problematic due to fragmentation, lack of harmonisation and the predominance of SMEs in the SRD market.

Regarding compatibility of different applications in the same frequency band, a number of examples of this were cited, mainly in the 2.4 GHz band. One respondent from the SRD sector suggested that the onus should be more on industry to be more innovative in how the

spectrum is used, arguing that improved system design should overcome many interference problems. However, there were concerns from others that mixing systems with different power levels could be problematic. For example, there was a concern that RFID growth in the 865 – 868 MHz band could squeeze out other SRD applications as they have four times the power (2W) and that this would lead to pressure for other spectrum for the displaced applications. There was also a similar concern about the increasing deployment of FWA systems at 5.8 GHz which may cause problems for SRD use of the band in the future, because of the disparity in power levels.

Potential improvements to the existing regulations mentioned by the users include: harmonisation at a global level, a total harmonisation at European level, especially for the 5.8 GHz band, and wider adoption of ERC REC 70-03 allocations. National regulators' current approaches to managing collective use of spectrum are satisfactory for most users, but a lack of manpower was mentioned by one respondent, especially for monitoring purposes.

Some respondents felt that the U.S. is more proactive concerning collective use of spectrum and that there are fewer technical constraints in the U.S., compared to Europe. In Japan, the "Radio Vision 2010" sees ubiquitous wireless networks making extensive use of RFID equipment. One major chip manufacturer summarised the regulatory frameworks concerning collective use as follows: "U.S. approach is essentially market driven; Japanese approach is government-driven; EU is squeezed between these two trends".

A range of views was expressed on how UWB technology should be dealt with in Europe. There was broad support for UWB standards but some respondents, (primarily licensed operators, argued that a cautious approach towards UWB should be adopted. There was a polarisation between those who currently have access to licensed spectrum and are concerned about the potential impact of interference from "underlay" operations and those who are keen to exploit the opportunities afforded by this new technology.

3.12.2 Interference and Congestion

Although 9 out of 15 of those who responded had experienced interference or congestion, this was mainly limited to Wi-Fi systems in the 2.4 GHz band and some specialist bands used for telemetry. Illegal use was noted as a source of interference in the case of wireless microphones and PMR 446. Often the source of interference is difficult for the user to identify: for instance, a Wi-Fi user has no indication of the origin of the problem if a connection does not work in a hot-spot, although often simply moving closer to the base station may eliminate the problem. Wi-Fi operators indicate that problems in the 2.4 GHz band have been relieved somewhat by the availability of the 5 GHz band in most countries. There was a good level of satisfaction with existing provisions to protect collective users from interference; 8 of the 10 respondents who expressed a view felt these provisions were adequate.

Potential capacity and quality of service that can be achieved in specific collective spectrum allocations is very difficult to evaluate, for example, the amount of data traffic or number of users/devices in a given area. However, the Open Spectrum Foundation suggested that

further improvements in protocols are likely to increase the capacity of collective use spectrum. [64]

There was limited awareness of monitoring or enforcement activities among the respondents, with only 7 out of 20 being aware of such activities. There was also a low opinion of the effectiveness of such activities among those who expressed a view. One respondent felt that monitoring organised by private users may become increasingly important in the future.

3.12.3 Categories of Collective Use Spectrum

There was strong support for the concept of categories of spectrum based on quality of service; 10 out of 12, who expressed a view, were in favour of this approach. The view was expressed by some in the industry that the current framework defined in Recommendation 70-03 is too fragmented and complex and that this may act as a deterrent to potential market entrants whose product or technology does not fit directly with an existing 70-03 application.

3.12.4 Anticipated Development of Collective Use Spectrum

There was a broad consensus that the need for wireless communications in collective use bands is likely to increase in the future. Much of this demand was felt likely to come from existing applications. For instance, in the 2.4 GHz band there are many new types of wireless equipment available such as laptops, cameras, mobile phones. Users also expect a growing demand for spectrum in future for telemetry, telephony, video services provision and Wi-Fi in the 5 GHz band. RFID needs could be much higher than expected today, particularly if use in a domestic scenario takes off. For example, home automation kits are already commercially available in the U.S. that use RFID tags and readers to monitor the presence or absence of people, pets, vehicles and other articles around the home. Almost half the respondents thought there might be new requirements for wireless communication that could be met by licence-exempt products or applications that are not currently available. One respondent noted that demand for spectrum is difficult to predict, because new applications sometimes emerge only after the underlying capability has appeared.

One respondent observed that ubiquitous availability of broadband access would require more licence-exempt spectrum below 1 GHz, and felt that there should be a much greater emphasis on licence-exempt operation in higher frequency bands above 30 GHz to take advantage of the higher propagation losses and antenna directivity in these bands.

3.12.5 Alternatives to Collective Spectrum Use

If licence-exempt spectrum was not available or if the quality / capacity failed to meet users' requirements, the alternative would be the use of licensed bands in most cases. One wireless internet service provider mentioned a wire line alternative, but this is a very specific solution, limited to hot-spots. Such an alternative would lead to additional costs linked to the cost of the licence and to the cost of the new equipment.

[64] See the extensive comments of Dr. Robert Horvitz at Appendix A to this report.

3.13 Summary of Findings

From our research it is apparent that although there is reasonable satisfaction with the regulatory approach to collective use of spectrum in Europe, there are a number of areas where improvements are felt to be necessary if the full benefits of collective use are to be realised in the future. These particular areas where regulatory attention is felt to be required, are as follows:

- Speeding up and simplifying access to harmonised collective use spectrum;
- Addressing growth in demand for collective use spectrum;
- Furthering harmonisation of collective use allocations.

Our key findings relating to each of these three areas are briefly highlighted in the following paragraphs, and our analysis of what could be done to address the situation is presented in the subsequent chapters of this report.

3.13.1 Speeding Up and Simplifying Spectrum Access

Our findings for speeding up and simplifying spectrum access are as follows:

- Whist ERC 70-03 is felt to be a useful source of information the multiplicity of applications and technology constraints defined therein makes it unduly /unnecessarily complex. It is therefore difficult and time consuming for developers of new products to determine whether they are compliant with existing regulations or whether a new set of regulations is required.
- The process of gaining access to harmonised spectrum for a new application or technology is considered to be too slow, particularly for consumer products, where time to market is critical.
- The classification of licence-exempt spectrum is not sufficiently flexible to support innovation.
- To deploy collective use applications in the EU, innovators require low cost and timely access to accurate information on the status of harmonised collective use bands in the EU.
- The two main Pan-European sources of information for collective spectrum harmonisation, ERC 70-03 and EFIS are inconsistent and in some cases information is incomplete and/or out of date. In addition, EFIS does not give an indication of the implementation of harmonised spectrum.

3.13.2 Addressing Growth in Demand for Collective Use Allocations

Our findings for addressing growth in demand for collective use allocations are as follows:

- There appears to be no clear methodology used by regulators or European bodies for determining whether spectrum should be licensed or licence-

exempt and indeed how much spectrum should be allocated to collective use applications.

- Current requirements for spectrum for collective use can be met by existing allocations, so long as these are implemented by SMAs, but accelerating growth in demand for collective use applications in future could outstrip the available supply and/or lead to degradation of service quality.

- Difficulties in re-farming spectrum once allocated to collective use can act as an impediment to making further collective use allocations.

- Spectrum acquisition through market means for collective spectrum is unlikely to occur in practice. This means that regulator intervention will be required to determine new allocations and the question of whether regulators should require the deployment of new technologies needs to be addressed.

- More market information on trends in the use of licence-exempt applications and monitoring information on the use of and extent of congestion in collective use bands is required to determine whether such bands could become congested in future. This information will also be used as an input to decisions concerning the allocation of additional spectrum for collective use.

3.13.3 Furthering Harmonisation of Collective Use Allocations

Our findings for furthering harmonisation of collective use allocations are as follows:

- The degree of harmonisation of collective spectrum bands across the Member States is mixed and in some cases insufficient to support an EU-wide market.

- Spectrum users and manufacturers we interviewed would like to see greater harmonisation.

- There is insufficient implementation of harmonised frequency allocations under ERC 70-03.

- Global harmonisation of collective use allocations is of increasing importance because of personal/goods mobility.

4 Speeding Up and Simplifying Spectrum Access

4.1 Introduction

This Chapter develops a number of proposals for speeding up and simplifying access to spectrum for collective use. These proposals are aimed at reducing the costs of market entry for innovators and thereby stimulating innovation, and bringing the benefits of new applications to consumers sooner than would otherwise be the case.

There is a presumption built into the EU Regulatory Framework that collective use should be the preferred approach to spectrum allocation where there is a negligible risk of harmful interference. However, in practice the large number of different applications and technical standards referred to in ERC 70-03 acts as a barrier to the introduction of new applications that do not clearly fit into historic allocations. Feedback from industry suggests that gaining approval for new technologies that do not fit conveniently within one of the existing defined categories can take two years or more, particularly where a harmonised allocation is sought. Such delays are not compatible with a rapidly evolving consumer devices market and may act as a deterrent to the development of new, innovative wireless technologies or services.

Improving awareness of market opportunities through the provision of readily available information on the status of collective use in Member States and, where possible, simplifying the conditions attached to using such spectrum should provide an incentive towards the development of innovative new wireless technologies and applications. We consider that an important first step in increasing the awareness of the opportunities for collective use of spectrum is to clarify which spectrum is reserved for particular applications or technologies and which is available on a substantially unconstrained basis for new applications or technologies.

Specific issues addressed in this Chapter are as follows:

- The balance between specific versus non-specific collective use allocations.
- A possible simplified approach to the categorisation of collective spectrum allocations.
- The information on collective spectrum allocations required by application developers and manufacturers.

4.2 Factors Affecting the Balance between Specific versus Non-Specific Spectrum Allocations

The rapid pace of technology and market change has led to moves by some SMAs towards technology service and application neutral designation of spectrum use where this is compatible with avoiding harmful interference; this is often referred to as spectrum liberalisation. This approach facilitates access to spectrum for those wishing to develop or deploy innovative new wireless applications or technologies that do not fit readily within historic spectrum allocations.

In the case of collective spectrum, the benefits of a non-specific approach are clear, in that it enables developers to introduce technology enhancements without the need to gain regulatory approval first. For example, in the U.S. this has led to rapid evolution of the 802.11 series of standards; the basis of WiFi.

There may be cases where it is appropriate to limit the applications or technologies used, for example for safety-critical, health or security applications, so that an acceptable quality of service is maintained. Users of licence-exempt spectrum do not face the price of congestion they impose on others and in consequence the extent of use of these bands may become excessive in the sense that more use than is optimal will occur.[65] This overuse could result in congestion and therefore reduce the quality of service. Where the costs of a reduced quality of service are high as may be the case with health, security and/or safety applications there are good reasons for limiting access to bands used by these types of application.

Where such quality of service considerations do not arise, for example, (e.g. where the consumer costs of a lower quality of service are not high or where there are substitute licensed services), as in the case of many consumer applications or wideband data systems where protocols are specifically engineered to cope with a hostile interference environment, we believe a liberalised approach should be adopted.

In addition to quality of service issues, the choice between specific and non-specific allocations should also take account of the consequent impact on ease of access for new market entrants. To improve awareness and understanding of the opportunities provided by collective spectrum use and facilitate access to spectrum for new market entrants, we believe there is a need for considerable simplification of the current regulations relating to collective spectrum use, as embodied in ERC Recommendation 70-03 and the various Class 1 equipment sub-classes.

We therefore propose that there should be a clear distinction between application or technology-specific allocations and general-purpose allocations[66] that have minimal restrictions. The former should be objectively justified on the basis of service quality and spectrum co-existence requirements. The general-purpose allocations would provide opportunities for immediate spectrum access for innovative new services or technologies that might currently face delays in gaining regulatory approval. Steps should be taken to harmonise spectrum in the latter category throughout Europe, particularly in the bands below 1 GHz where costs are lower and propagation conditions more favourable, to provide developers with ready access to the entire European market in the same way that developers have access to the 902 – 928 MHz band throughout North America.

Our conclusions are as follows:

- A move towards an application and technology neutral approach to the designation of harmonised ‘Collective Use’ frequency bands across the EU would simplify and speed up the process for innovators seeking to launch new

[65] This result is shown informally in “Spectrum licensing and spectrum commons – where to draw the line” W Webb and M Cave, Warwick Business School, papers in Spectrum Trading No 2, September 2003. It is shown formally in “The Economics of Radio Spectrum” S Jones, P Levine and N Rickman, Final Report for Ofcom, March 2004.

[66] General purpose allocations can be interpreted as non-specific SRD (Annex 1 in ERC 70-03)

applications and open up access to applications that are currently not permitted or are subject to unnecessary technical constraints;

- Collective use applications that require a higher level of protection from interference, for example, for health, security or safety reasons, should continue to have access to harmonised bands that are limited to certain specified applications. As far as possible such access should be provided on a technology neutral basis, so long as this does not compromise the necessary quality of service.

4.3 Simplifying Categories of Collective Use Applications

Currently, spectrum allocated to collective use is either application-specific or non-specific. Whilst this situation might seem straightforward it is complicated by the fact that many of the non-specific allocations are still subject to specific technical constraints. For example, very short duty cycle requirements that indirectly limit the applications that might be deployed. Many of these constraints have been applied for good reason, mainly to minimise the risk of interference between SRDs and other services in adjacent bands, which are based on extensive compatibility studies. Whilst recognising the benefits in terms of interference reduction that might result from this approach, we consider that more could be done to promote awareness of spectrum that is not subject to such constraints. Moreover, additional spectrum could be made available on a "minimal constraints" basis to support new, innovative applications.

In section 2.2 we observed that the extent of interference protection required by particular radio applications could be considered to be a "hierarchy", with essentially three levels of protection from interference, namely:

- **Full protection**: Exclusive right of use required; provides legal recourse in the event of harmful interference
- **Partial protection**: Collective use, restricted to specific applications and/or technologies; no legal recourse against interference from other legitimate spectrum users
- **No protection**: Collective use, open to all applications and technologies subject to compliance with certain technical parameters; no legal recourse against interference from other legitimate spectrum users

Applications making collective use of spectrum necessarily fall into the latter two categories, since as the spectrum is shared there can by definition me no exclusivity. Whether partial protection or no protection is appropriate will depend on the nature of the application, for example whether there are health or safety implications. Where there is no clear, objective case for partial protection, the greatest flexibility will be derived by adopting the "no protection" principle and permitting a technology and application neutral approach to spectrum use.

Although the principle of full protection is not applicable to collective use applications, there are circumstances where it may be possible for collective use to take place in the same

spectrum as licensed use, by placing appropriate restrictions on the nature of collective use (e.g. by requiring some form of licensing or geographic co-ordination). In such cases it is important that the interference protection provided by the licensed user's right of use is not degraded by the presence of collective use in the same frequency band.

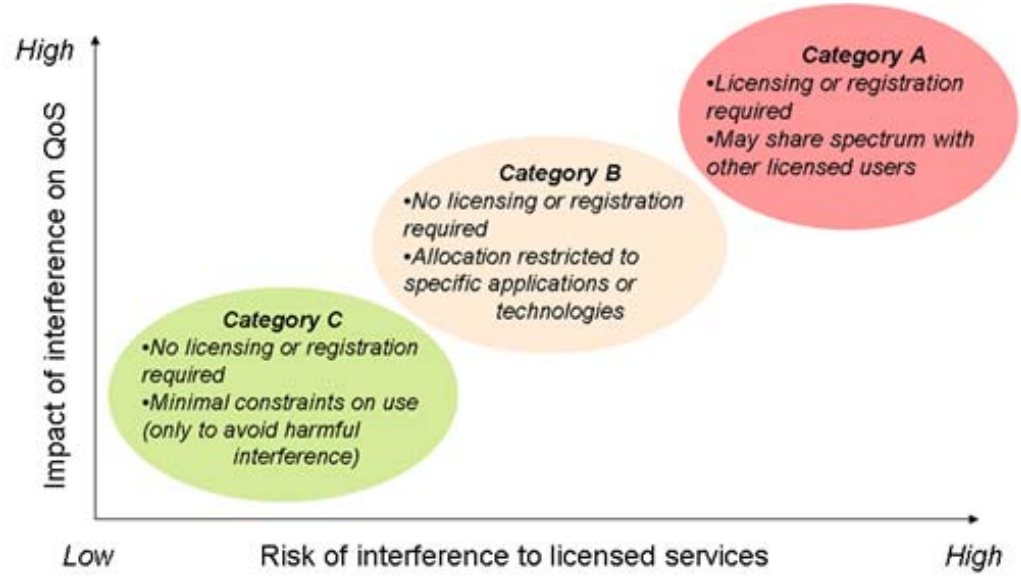
4.3.1 Proposed Approach to Categorisation

We therefore suggest that where radio spectrum is designated for collective use, the designation should fall into one of three broad categories, based on the above hierarchy of interference protection, namely:

- **Category A:** Frequency designations that are suitable for collective use only where licensing or co-ordination are in place to avoid interference to licensed, non-collective use applications, or to facilitate future re-farming.
- **Category B:** Frequency designations that are subject to limitations on the permitted collective use applications or technologies in order to reduce the risk of interference either to the collective use applications concerned or to licensed, non-collective use applications.
- **Category C:** Frequency designations that have no limitation on the applications and where technology limitations are limited to those required to avoid harmful interference.

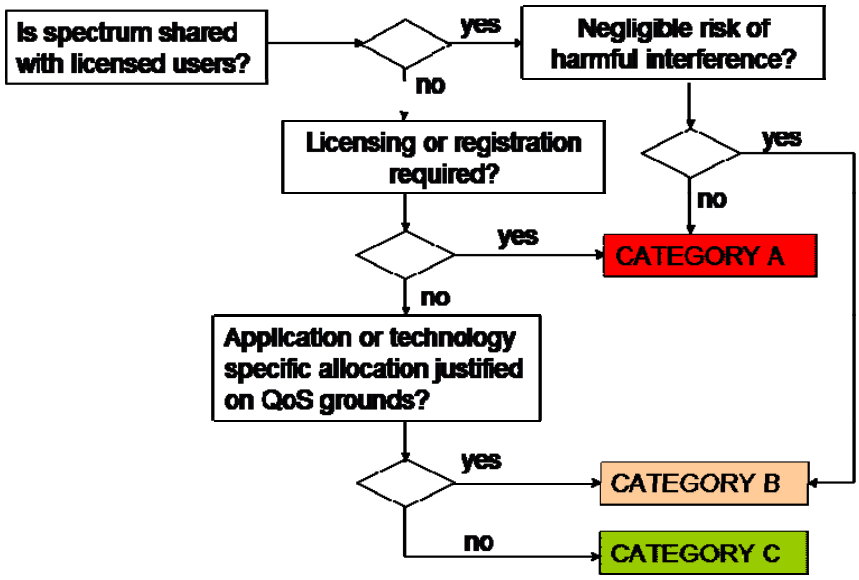
The categories also relate to the quality of service (QoS) required by the application. Applications where QoS is particularly important and where interference would have a severe effect on QoS will fall into category A. Those where QoS is important but the impact of interference is less severe (e.g. because interference mitigation technologies are deployed) will fall into category B. Applications where QoS is not critical will fall into category C. This is illustrated in Figure 7 below:

Figure 7: Collective use categorisation in terms of QoS and interference



The following flow chart at Figure 8 is intended to assist with the categorisation of existing SRD spectrum allocations. We suggest that these are summarised in ERC 70-03 and within the EFIS database so that users can see at a glance which spectrum is available on a "minimal constraints" basis and which is reserved for specific applications / technologies.

Figure 8: Proposed Categorisation of Collective Use Spectrum



The principal benefit of this categorisation is that it readily identifies spectrum that can be used by new applications without the need for specific technical constraints other than those that are required to avoid interference to other users, which is defined as category C. Where constraints are necessary we suggest that these constraints are limited to a maximum in-band power spectral density and an appropriate block edge mask and out of band emission limits to protect adjacent bands.

Considering existing ERC 70-03 allocations, the re-categorisation shown in Table 7 should apply. Note that where categories A or B are indicated, the existing application-specific designation should continue to apply to the allocation. However, where category C is indicated, the application reference should be removed and the allocation should become application and technology neutral.

Table 7: Mapping of Rec 70-03 Annexes to Three Proposed Categories

Rec 70-03 Annex Ref	Application	Proposed Category and justification
1	Non-specific SRDs	C
2	Detection of Avalanche victims	B (health / safety)
3A – 3C	Wideband Data Transmission	C
3D	Wideband Data Transmission[67]	B (co-existence with other services)
4	Railway Applications	B (safety)
5	RTTT	B (safety)
6	Movement detection	B (safety / security)
7	Alarms	B (safety / security)
8	Model Control	B (where spectrum designated for flying models) / C
9	Inductive applications	B (Band L – coexistence with MF / LF broadcast services) / C
10	Radio microphones	A (operational and co-existence requirements – co-ordination needed)
11	RFID	B (operational requirements)
12	Healthcare	B (health / safety)
13 A – C	Wireless Audio	C
13 D	Wireless Audio	B (coexistence with broadcast services)

Source: Aegis Systems Ltd analysis of ERC 70-03

We consider that the three categories we have identified is the minimum feasible set. This is because of the need to provide quality of service for certain applications and because of the need in some circumstances to protect licensed services[68] sharing a collective use band. In

[67] For the 5470 – 5725 MHz band the use of DFS is mandated to facilitate sharing with other services. Hence this allocation would remain technology-specific in this respect but should become application-neutral

[68] We use the term licensed rather generally here to include military and other government use and receive only services that may not be formally licensed but do require interference protection.

order to provide the greatest flexibility and simplicity our recommendation in this area is to adopt this minimum set for both new and existing allocations. However, we recognise that detailed development of these ideas could raise practical problems in respect of existing allocations that may require re-categorising.

Recommendation 1: Simplify categorisation of collective use spectrum

To facilitate understanding and awareness of collective spectrum use, we recommend that frequency allocations for collective use be grouped into three specific categories. This will differentiate clearly between allocations that are constrained to particular applications or technologies on quality of service / co-existence grounds and those that are available for general use with minimal constraints. The three categories should be defined as follows:

Category A: Licensing or co-ordination required to avoid interference to licensed, non-collective use applications, or to facilitate future re-farming.

Category B: Limited to specific applications and/or or technologies in order to reduce the risk of interference and maintain an acceptable quality of service.

Category C: No limitation on the applications or technology other than those required to avoid harmful interference.

4.4 Speeding Up the Harmonisation Processes

Chapter 3 described the decision-making processes and typical timescales for new harmonised spectrum allocations. It can take three years or more for ETSI and then CEPT to develop the necessary System Reference Documents and undertake the associated Compatibility Studies in order to achieve a harmonised allocation. This time period is too long relative to product lifecycles that can be as little as 1-2 years.

The time taken for SMAs to implement new harmonised allocations under the current voluntary arrangements is also too long relative to product lifecycles. This is partly owing to delays in implementing ECC Recommendations or Decisions and partly owing to the need to change national legislation to accommodate the new harmonised spectrum. We have considered the reasons behind these delays and what might be done to improve the situation.

ETSI have examined the Systems Reference Document process themselves and have concluded that the process is adequate. The speed with which the document is produced is mainly governed by the industry representatives involved in developing the Systems Reference Document that will be prioritised accordingly. The other main factor affecting timescales is the frequency of Task Group/Parent body meetings to develop the document, reach consensus and gain approval.

CEPT works on consensus and must gain the approval of Member States to move spectrum policy forwards. Again, the speed at which ECC Decisions are made is governed by the timing of the meetings and the generation of studies and reports to enable ECC Decisions or Recommendations to be made. Policy and technical analysis is undertaken by Working Groups whose members comprise SMA and industry representatives. These representatives

undertake the work on a part-time basis, whereas the time taken could be shortened if work on these matters was undertaken on a full-time basis. There are a number of ways this could be achieved including the following:

- Dedicated resource supplied by SMAs and industry for a specified period of time on projects.
- Creation of a permanent team within ERO to undertake technical analysis; or
- Creation of a fund to procure the technical analysis through competitive tendering processes.

The funding for these alternatives would need to be investigated. Whatever the funding arrangements, the management of the studies would need to remain independent i.e. under the control of CEPT, the Commission or some other neutral body. It is not necessary to expedite the process for all policy decisions, but only certain strategic areas of regulation, policy and spectrum management. Where this decision should be made and the source of funding is beyond the scope of this study.

Recommendation 2: Make provisions for a full-time resource to be available (either permanent or ad-hoc basis) to undertake the necessary market and technical studies to inform decisions on future spectrum allocations

The Commission and CEPT should establish a structure and process that allows more concentrated effort to be applied. This would reduce the time to gain harmonised spectrum allocations for new collective use applications and thereby reduce the time to market. The resource identified should undertake the Regulatory Impact Assessments and Compatibility Studies required in supporting decisions. In addition, prioritisation of effort for strategically important areas of spectrum and regulation needs to be managed by a central body.

4.5 Improving Access to Information

As many collective use applications need large markets to achieve the economies of scale necessary for economic viability, and are also internationally mobile, it can be expected that many equipment suppliers and applications developers will be looking for a European wide market. The size of the potential market for collective use applications in Europe depends on the extent to which individual countries have implemented relevant harmonisation measures. Reliable and up-to-date information on the extent of implementation of CEPT and EC harmonisation measures is therefore of vital importance to equipment developers and vendors. However, we have found that the two main Pan-European sources of information for collective spectrum harmonisation, ERC 70-03 and the European Frequency Information System (EFIS) are inconsistent and in some cases information is incomplete and/or out of date. Although EFIS includes reference to the Common European Allocation Table, this also does not provide a clear indication of where spectrum use is harmonised. This means that in practice developers and manufacturers may need to contact up to 47 SMAs to determine the implementation status of relevant measures. This is clearly a significant barrier to market entry particularly compared with the situation in the U.S. as described in Chapter 3.

The Commission has emphasised the importance of spectrum information for effective decision-making by business in the internal market for products and services and furthering the sustainable growth of the electronic communications industry. The Commission has mandated CEPT to assess the costs of improving EFIS to meet a minimum set of requirements.[69] CEPT's report in response to this mandate sets out the resources and processes required to upgrade EFIS and maintain the data.[70] However, neither the Mandate nor CEPT's report makes explicit mention of spectrum allocated for collective use.

We consider that EFIS should be enhanced to provide a 'one-stop shop' for up-to-date spectrum information on harmonised 'Collective Use'. Harmonised spectrum should also be one of the high level choices when searching the EFIS database. This will require further work collating information on the status of implementation (and any restrictions that may apply) and then regular updating of the information as required. The Commission could assist this process by requiring Member States under Article 5 of the Radio Spectrum Decision to publish the relevant information on the status compliance with EC and CEPT harmonisation measures in their National Frequency Allocation Tables and submit the information to CEPT.

Recommendation 3: A single, definitive, on-line information resource on harmonised collective spectrum in Europe should be established

We recommend that The EC should mandate the CEPT to establish EFIS as the definitive information resource on harmonised collective use spectrum in Europe. Spectrum that is harmonised throughout the EU should be one of the high level choices when searching the EFIS database. In addition, the European Common Frequency Table, as accessed through EFIS, should also be enhanced to show clearly all spectrum where collective use has been harmonised across Europe, by CEPT and/or EC measures, with clear cross references to the relevant technical and regulatory conditions for use of the spectrum. The Commission could assist this process by requiring Member States, Under Article 5 of the Radio Spectrum decision to publish the relevant information on the status compliance with EC and CEPT harmonisation measures in their National Frequency Allocation Tables and submit the information to CEPT at least every six-months.

[69] Mandate to CEPT on the use of EFIS for publication and access to spectrum information within the Community, 8 December 2005.
[70] "EFIS", Final Report in response to mandate to CEPT, ERO, Doc. ECC(0^) 079Rev2 Annex 15, July 2006

5 Addressing Future Spectrum Demand

5.1 Introduction

Our research has indicated that there is not an immediate problem with congestion in existing collective use bands, though rapid growth of the use of some bands (such as the RFID band at 866 MHz) is anticipated and could lead to congestion in the future, driving demand for more spectrum. Decisions about new allocations typically need to be made well in advance of the allocated band being available for use. This is because existing users may need to be migrated, appropriate technical conditions for use of the band developed, and potential alternative uses of the band investigated. If new allocations are to be harmonised across Europe, time also needs to be allowed for administrative processes to achieve such agreements, which can currently take several years.

Demand for licensed radio spectrum is likely to grow to accommodate increasing demands for broadband mobility and to maintain quality of service for public wireless networks. The extent of the demand for spectrum will depend on the extent to which existing spectrum and ongoing technological developments can accommodate the growth in demand for applications. The increasing use of techniques such as Listen Before Talk (LBT) and Adaptable Frequency Agility (AFA) can significantly increase the capacity of available spectrum, especially for applications where the duty cycle is small and delay can be tolerated. However, to realise the full benefit of such techniques it is necessary for all, or at least the large majority of devices operating in a particular band to make use of them. This may not be practical in the short term in bands that are already heavily used by legacy applications and technology.

The availability of new technologies in the future such as Ultra Wide Band (UWB) has the potential to cater for many existing collective use applications as well as new applications such as wireless Universal Serial Bus (USB) connections. This could potentially relieve pressure on some existing collective use bands Nevertheless, the short range device industry has expressed concern that increasing take up by new users will lead to saturation of existing bands unless improved interference avoidance measures and/or additional spectrum is forthcoming.

The case for or against changing allocations for collective spectrum use should take account of likely future demand growth, the potential to use new technologies that may be able to operate satisfactorily in a collective use environment and the implied opportunity cost in terms of spectrum denied to licensed use.

In this chapter we consider three ways of catering for future demand growth for collective use spectrum:

- Finding additional spectrum allocations for collective use.
- Developing ways of sharing spectrum between collective and licensed use.
- Making greater use of existing collective use allocations.

We start by developing some high level projections of future demand for collective use of spectrum, then consider ways in which the balance between licensed and collective use spectrum should be determined. We then apply the concepts that we have developed to identify frequency bands in which collective use of spectrum would appear to have clear advantages over licensed use. Allocation decisions can then be made in situations where the case for collective versus licensed use is less clear cut.

Our starting assumption is that at some point in the future additional spectrum may need to be allocated to collective use. This assumption is also made by most regulators and industry commentators we have spoken to and we note the following estimates of increased requirements for licence-exempt use:

- Ofcom (UK): Increase from 5% to 6% of total available spectrum above 3 GHz.
- Intel: up to 500 MHz additional spectrum required to support high bandwidth mobile applications.
- Low Power Radio Association: Additional spectrum preferably below 1 GHz to support growth in RFID, home automation, etc.

However, there is uncertainty around all of these estimates and we need to consider the possibility that some of the spectrum allocated to collective use might be better used if reallocated to licensed use. We conclude this Chapter with a discussion of mechanisms that could enable re-farming of collective use spectrum.

5.2 Forecasting Future Demand for Collective Use Spectrum

Section 2.5 presented some indicative estimates of the projected market for some collective use applications in 2009. These are by necessity very speculative, since as most collective use of spectrum is licence-exempt, there are few reliable indicators of user numbers. The estimates in section 2.5 suggest the growth in value of collective use applications will be substantial[71] and this is supported by the market volume estimates presented by ECC PT 43 and summarised in Section 2.4. Assuming this level of growth materialises, it is likely that congestion will become apparent in some bands. For example, there is already anecdotal evidence of congestion at 2.4 GHz in urban centres. There is also the possibility that new applications will emerge that will create new demand for licence exempt spectrum, although it may be possible to accommodate some of these and some of the growth in existing applications by use of underlay allocations such as UWB.

Catering for such growth in demand is a challenge for regulators on two fronts. Firstly, because the forecasts themselves are uncertain, and secondly because the relationship between demand for a service or application and the corresponding demand for spectrum is not always clear[72]. Decisions on whether to allocate additional spectrum to collective use are often driven by manufacturers and politics with little information on the extent of current use

[71] Over three-fold over the period 2003 -2009

[72] unlike licensed spectrum use where networks can monitor utilisation and be adapted accordingly, collective spectrum use is largely autonomous and therefore little information is available about cumulative usage and the effect on quality of service

or future demand. In addition, little consideration is given to the collective use model except where licensing would not work; contrary to the Authorisation Directive that sees collective use as the default.

Translating growth in demand for applications into a corresponding growth in demand for spectrum is far from straightforward. Technology developments such as spread spectrum, antenna diversity and dynamic frequency access have made it possible to use existing spectrum far more intensively than even a few years ago. Nevertheless certain clear demand trends do seem to be apparent and these are considered in the following paragraphs.

5.2.1 Frequencies below 1 GHz

Firstly, industry feedback suggests there is a strong demand for additional spectrum below 1 GHz to cater for applications such as building automation and to take advantage of the improved propagation environment, particularly building penetration at these lower frequencies, relative to the 2.4 GHz band. The recent approval by ETSI of spread spectrum standards in the 863 – 870 MHz band will go some way to addressing this demand, so long as the frequency allocations are implemented promptly across Europe. However, the band available is substantially smaller than the corresponding band in the U.S. (902 – 928 MHz) and there is therefore interest in the possibility of widening the current band to provide greater scope for spread spectrum operation.

There is also a consensus emerging within industry that demand for RFID systems will grow significantly over the next decade, and that this will lead to congestion in the existing frequency band 865 – 867 MHz for high power interrogator systems. Since there are also concerns about potential interference from such high power systems, demand for a separate dedicated frequency band is anticipated.

5.2.2 Frequencies above 40 GHz

The other clear trend across the electronic communications sector is that demand for bandwidth is increasing continuously. Existing spectrum in the 5 GHz band will be probably be sufficient in the medium term but in the longer term demand may arise for much greater bandwidths than can be accommodated in the currently available spectrum. Until recently, component costs have been prohibitive in bands above 40 GHz; however developments in monolithic microwave integrated circuit (MMIC) technology have led to significant price reductions in the last few years. For example, a number of developers have been addressing the market for automotive radars in frequency bands above 70 GHz, initially focussing on the luxury car market but extending this to mid-market models as component prices have fallen.

The potential benefits of these high frequencies for data transmission are significant. Fixed wireless equipment developers such as Ceragon and Terabeam are already offering communication links delivering bit rates of 1 Gbps and developers are working on bit rates of up to 10 Gbps. One chip developer, Triquint, has suggested that the market for mm-wave MMICs will grow from US$163 million in 2003 to US$400 in 2007. The relatively high free space attenuation and high antenna directivities available in these bands make sharing much less problematic than in lower frequency bands. There appears therefore to be a good

case for making much of the spectrum above 40 GHz available on a collective use basis, both for short range, very high bandwidth applications and for longer range applications such as multimedia wireless systems (MWS).

5.2.3 Frequencies between 1 and 40 GHz

The recent adoption of 350 MHz of spectrum for various SRD applications in the 5 – 6 GHz band, complementing the established ISM band at 2.4 GHz means that demand for spectrum in this frequency range will largely be met for the foreseeable future. By the time bandwidth requirements grow to the extent that there is insufficient spectrum available in this range, we would expect the cost differential between frequencies above and below 40 GHz to have fallen to the extent that the latter will provide an economically viable solution for short range applications. This would leave the majority of the spectrum below 40 GHz to cater for anticipated growth in demand for wide area broadband mobile services and associated wireless infrastructure links. These will require individual rights of use to ensure the necessary quality of service is achieved.

5.2.4 Demand for Underlay and Overlay Use

Demand for access to existing licensed spectrum may arise from a number of quarters and could be served by appropriately framed underlay or overlay provisions. Underlay operation of ultra low power devices has already been successfully demonstrated with the introduction of low power FM micro-transmitters. In principle this approach could be extended to other frequency bands to enable reception of local content on digital radio or television receivers.

Demand may arise for access to UHF TV spectrum for in-home distribution of TV or other audiovisual content or to facilitate the cost-effective delivery of broadband access to remote areas where higher frequency bands might be uneconomic. Both of these applications might be suitable for an overlay approach, either using “smart” technology that can detect the presence or absence of a local TV service or by using a licensing based approach. The latter would not however constitute collective us in the true sense.

We conclude that specific demand is likely to arise for collective use spectrum in the following frequency bands:

- In the vicinity of the existing 863 – 870 MHz band, to support wider bandwidth spread spectrum systems and growing demand for RFID systems.
- Above 40 GHz to support short range, very high bandwidth systems and multimedia wireless systems.
- Possible demand for underlay or overlay operation, particularly in broadcast bands to facilitate reception of locally generated content on domestic TV and radio receivers.

5.3 The Balance between Licensed and Collective Use Spectrum

The balance of spectrum allocated to licensed versus licence-exempt use has historically been determined by technical requirements, industry demands and political factors. For

example, a European allocation for social alarms allocation at 169 MHz was decided with a view to meeting European social and healthcare objectives. Some licence-exempt bands, such as 2.4 GHz, were originally created not for radio communications but to provide a "public park" for electromagnetic radiation from non-radio communications devices such as microwave ovens.

Recently there has been an active but unresolved policy debate concerning the appropriate balance of spectrum allocations between licensed and collective use. Ting et al (2005) model the choice with a number of stylised assumptions concerning demand and costs but their results are ambiguous.[73] The literature has been reviewed in Webb and Cave (2003)[74] which provided some rules for making allocations to licence-exempt versus licensed use. They conclude that:

- Spectrum should be allocated as licence-exempt where congestion is unlikely. This is because licence-exempt users face weak incentives to economise on their spectrum use (because they do not face a price) and this is required in congested bands in order to maximise output (by avoiding interference). This of course assumes it is possible to make such judgements about where congestion is not likely to occur.

- There is no evidence to suggest that designating spectrum as licence-exempt rather than licensed would remove congestion problems in the 100MHz to 5GHz range.

- Regulatory rules (e.g. politeness protocols, controls on transmit power) can greatly reduce the probability of congestion in licence-exempt bands (although this may of course also reduce the utility of the spectrum for some applications, such as broadcasting or wide-area mobility).

One way of addressing whether more or less spectrum should be allocated to collective use would be to undertake a regulatory impact assessment of frequency specific reallocation proposals. However, the information required for such an assessment is considerable and its collection and analysis could itself prove to be a significant regulatory burden. There is a growing consensus in relation to the management of spectrum for licensed applications that market based approaches are preferable to the traditional "command and control" approach. We therefore consider whether there are circumstances in which market transactions could be used to determine allocations for collective use.

5.3.1 Determining the Balance using Market Mechanisms

As a general matter, where there are competing demands for spectrum an optimal economic outcome will result, if users face the opportunity cost of their spectrum use. This can be achieved through the implementation of spectrum markets (auctions, trading etc)[75] or

[73] "Comparing welfare for spectrum property and spectrum commons governance regimes", Ting, Wildman and Bauer, Telecommunications Policy 29, 2005.
[74] Spectrum licensing and spectrum commons – where to draw the line, W Webb and M Cave, Warwick Business School, September 2003
[75] This assumes no market failure e.g. no monopoly or externality issues arise.

through the regulator setting a price for spectrum based on opportunity cost.[76] Market solutions are simplest to achieve if spectrum use is licensed. Note: such licensing need not preclude collective use, as evidenced by the recent auction in the UK of the DECT guard band spectrum[77].

In the case of collective use, a private commons might provide one way of introducing market forces. A private commons involves an organisation buying spectrum and making it available to others on a collective basis.[78] Private commons are likely to be practical if:

- The entity buying the spectrum obtains significant benefits from collective use by others and will tolerate any free riders[79]; or
- A group of users or manufacturers who club together to pay for the spectrum collectively obtain significant net benefit from this use and the club can tolerate any free riders.[80]

The question we need to address is, 'how often might these circumstances occur?' An analogy to the first circumstance is given by recent proposals from municipalities and private companies to fund some or all of the cost of roll-out of city-wide Wi-Fi networks, to address a mix of economic development and digital divide issues.[81] Only hotspot infrastructure is being funded in these cases because the spectrum is already allocated to licence-exempt use. Alternative spectrum could in principle have been purchased or leased together with the infrastructure. Even so the following issues need to be addressed:

- Would the presence of free riders undermine the viability or quality of the service that is paying for spectrum access? This is likely to depend on the technical limitations placed on access to the band.
- Can market forces take account of the social benefits arising from use of licence-exempt devices? The Wi-Fi example given above illustrates social benefits can be addressed directly by government agencies entering the market to acquire or even provide the services they want. In principle they could also buy or lease the spectrum they require for a given application.
- Would acquisition of spectrum on a national basis be sufficient to support equipment production? Private commons will be created on a national basis so long as licensed use is national. While this could provide a sufficient

[76] Setting such prices can also be informational demanding.

[77] The UK recently auctioned twelve licences for this block of 2 x 3.3 MHz of spectrum at the top of the GSM 1800 MHz, whereby each successful bidder gained the right to use all of the spectrum on a shared basis together with other successful bidders.

[78] The FCC's discussion of the private commons concept sees this as a compliment to licence-exempt bands created under Part 15 that would be suitable for peer to peer communication between devices. The FCC notes that the licensee would not be able to set technical conditions that restrict emission limits of devices to below the level authorised for the band under Part 15 rules for licence-exempt devices. Para 91, FCC 04-167.

[79] This way could be attractive to technology developers but may depend on the availability of internationally harmonised spectrum. In the US, FCC regulations on leasing spectrum permit the creation of private commons, though no such initiatives appear to have been taken so far.

[80] It is assumed any competition issues are dealt with by competition law.

[81] "City of London goes Wi-Fi: City Corporation appoints The Cloud to install Wi-Fi in the Square Mile", New Release, 20 February 2006. www.cityoflondon.gov.uk; "Google aims to track users with Wi-Fi", Financial Times, 6 April 2006. http://www.yegoo.gm/index.php?part=13&spart=5&id_text=3559

market for many devices in the U.S., this seems less likely in Europe (because of the smaller size of national economies) except for applications used by specific markets e.g. telemetry or wireless microphones. Replicating the success of Wi-Fi (based on a global allocation) is unlikely to happen with a country-specific allocation. One way a supplier of a private commons may be able to reduce the costs of gaining access to spectrum on an EU-wide basis would be to collaborate with national licensed users.

Turning next to the "club" idea this is only likely to be feasible if there are a relatively small number of club members undertaking similar activities. We define small as tens or hundreds rather than millions, otherwise negotiation and co-ordination costs become too large and/or the objectives of members too diverse. This points us towards applications used by business not consumers and/or devices produced by a relatively small number of manufacturers. One potential example would be the professional use of wireless microphones. The availability of these frequencies tends to be country specific and in most countries the majority of use is by broadcasters, the main theatre and events groups. We conclude that private commons are likely to play a limited but potentially useful role in meeting demand for collective spectrum use for certain types of user.

An alternative idea involves using the value of collective use as a reserve price in any auction of spectrum. The idea would be that if there was no interest at this reserve price or the reserve was not exceeded in an auction then the spectrum would be allocated to licence-exempt use. The value that would need to be calculated for this purpose would be the profits earned by suppliers/users in excess of a "normal" return (i.e. what economists call producer surplus).[82] This might equal the cost saving from using the licence-exempt as compared with a licensed application or the supernormal profits that could be earned if the device is a big success. This begs the question of how to estimate such values in cases where the future uses of a licence-exempt band are not known at the time the allocation decision is made. A key feature of licence-exempt bands is that they spawn innovation that is by its nature uncertain and so not known *a priori.* Therefore, while attractive in principle, we think this approach is likely to be difficult to implement in practice.

5.3.2 Determining the Balance Administratively

Estimates of future spectrum requirements require numerous assumptions to be made concerning the success of future applications. These include the nature of applications demanded, demand for wireless as compared with wired access and the technical efficiency of the technologies that will deliver services. The risk that assumptions turn out to be wrong are not appraised and nor is the potential impact on the availability of spectrum for licensed services or uses that are unlicensed. To address these issues a regulatory impact assessment (RIA) is required.

The Commission has issued guidance on the conduct of such assessments that involves a six step procedure.[83] Applying this to the issue at hand it involves:

1. **Identify the problem**: Should more/less spectrum be allocated to collective use?

[82] Bidders in an auction will (rationally) only ever bid up to this amount.

[83] "Impact Assessment Guidelines", European Commission, SEC(2005) 791, 15 June 2005

2. **Define the objectives**: The Radio Spectrum Decision refers to the aim of "optimising the use of radio spectrum and of avoiding harmful interference" while taking account of policy priorities in the following areas: economic, safety, health, public interest, freedom of expression, cultural, scientific, social and technical aspects. The weight to be put on these different aspects is not specified which makes interpretation of the objectives problematic and potentially arbitrary. [84] For the purposes of this document we assume that the overall objective of spectrum policy is to promote social and economic welfare.

3. **Develop main policy options:** The options are licensed versus collective use where the latter includes both licence-exempt use and light licensing.

4. **Analyse their impacts**: This involves assessing the direct and indirect environmental, economic and social impacts – both intentional impacts and possible unintended impacts. Next it is necessary to consider who is affected – individuals and businesses and the distribution of costs and benefits amongst them.[85] In this case we are primarily concerned with impacts on individuals and businesses in the EU. The focus should be on the most important impacts, where this determined either qualitatively or quantitatively. This will depend on the likelihood of the impacts occurring, their possible scale and whether they are reversible or not.

5. **Compare the options**: This comparison needs to take into account both qualitative and quantitative aspects and the risks associated with different options. Examples of approaches to quantifying costs and benefits are discussed below.

6. **Outline policy monitoring and evaluation**: This stage is required so that appropriate data is collected to evaluate the policy or regulation when it comes up for review. We note that this is rarely done in respect of spectrum management decisions.

The benefits of adopting RIAs are that they are transparent and, within the constraints of available information, should result in decisions that (*ex ante*) offer the greatest economic and social benefits for European citizens.

It is assumed that when spectrum allocation decisions are made they will need to be justified by taking account of the objectives of spectrum management in Europe. We note that the ECC Draft Report on a strategy for SRDs also stresses the importance of undertaking RIAs when deciding on collective use allocations.[86]

i. Measuring Costs and Benefits in Theory

Economists measure social welfare as the sum of the total benefits to consumers above and beyond the price they pay plus the profit to producers above a normal return. An economic definition of efficiency is a situation in which it is not possible to improve the well-being of

[84] Note the weights given to these various policy objectives should not vary according to the decision being considered, otherwise policy making will become unpredictable and lack transparency. Note however that the scale of economic, safety, health, etc benefits could vary across different policy options.

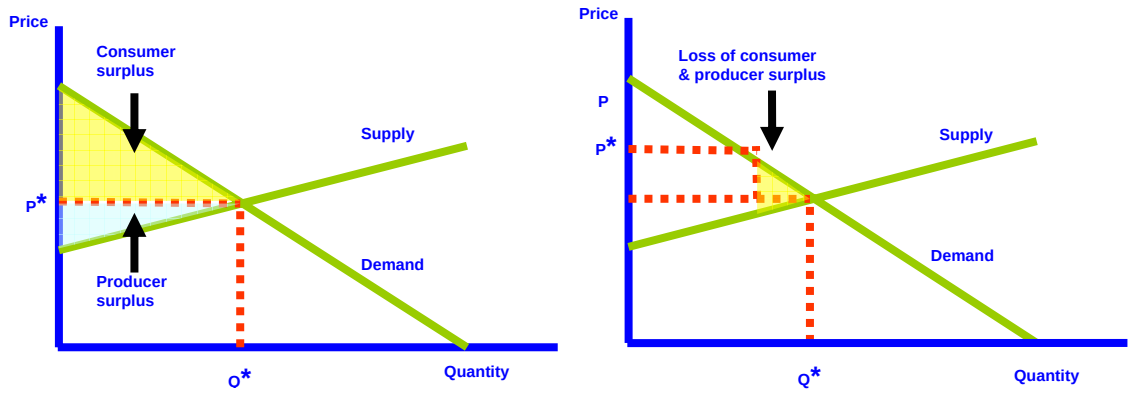
[85] In principle policy makers should make the weightings given to different groups explicit e.g. the UK Treasury publishes weights to be given to different income groups in cost/benefit analysis. http://greenbook.treasury.gov.uk/

[86] Section 7, Draft of 24 March 2006, FM43(06) Rev 9

one individual in the economy without harming the well-being of at least one other individual in the economy – this is known as the Pareto criterion.[87]

In Figure 9 "consumer surplus" is the area below the demand curve, sometimes refered to as consumers willingness to pay, and above price, what they have to pay., Producer surplus is the difference between the supply curve, known as the marginal cost and revenue, calculated by price times quantity.

Figure 9: Consumer and Producer Surplus



The price that maximises the sum of the two areas is P* - the price that corresponds to the marginal cost of production at Q*. This is illustrated in the left hand figure. The right hand figure shows consumer and producer surplus when the price is above P*. In this case, consumer surplus is smaller and producer surplus is larger, but the total area is smaller by the small "missing" triangle just above the intersection of the supply and demand curves.

The potential benefits from licensed or licence-exempt use include the consumer and producer benefits from the new applications that will use the band. The scale of these benefits will depend on:

- The characteristics (service, quality, price) of the new applications and the extent of competition from substitute products and services, which in turn will affect the benefits users enjoy and take-up rates.
- The differential impact of the licensing arrangements on service/application innovation and the timing of investment to deliver the service/application.
- The timescales over which benefits are to be enjoyed and the discount rate applied to future benefits.

[87] The Pareto criterion means that economic outcomes (sometimes called states) can be compared without recourse to interpersonal comparisons of utility. Hence it is possible to compare two outcomes without comparing individuals' utilities.

- The size of the potential market addressed by the spectrum allocation decision – certain applications may not be developed unless there is a regional or global market because R&D costs are high and so low (average) production costs can only be achieved with high sales volumes.

- In the case of an occupied licensed band, whether incumbent licensed users are displaced or not by the designation of the band for licence-exempt use.

- The wider impact of the new applications on competition and, assuming this is positive, the consumer benefits from enhanced productivity and lower prices, improved service quality in other services.

- Externalities generated by the services or the spectrum use. This includes interference effects and any positive or negative environmental, economic or social externalities. Possible examples of the latter include any inclusion/democracy benefits from wider broadband deployment and changes in road congestion, accidents and pollution caused by automotive radar.

In addition to these benefits the following costs need to be considered:

- The administrative costs associated with making the allocations and any on-going administrative costs associated with managing the band.

- The costs of reversing the allocation decision should it turn out to be wrong.

- The costs of dealing with any increase in congestion in licensed and licence-exempt bands caused by the denial of for licensed and licence-exempt use respectively. For example, installing additional infrastructure or using more interference resistant handsets.

ii. Examples of the Costs and Benefits of Collective versus Licensed Use

Estimates of the net economic benefits collective use for a number of applications have been produced in a study for the UK regulator Ofcom[88]. Initial results indicate that the net present value of these benefits over the next 20 years for the EU[89] could be as follows

- Home data networking: €36bn (this includes avoided costs of using wired systems and the benefits arising from the stimulus to broadband take-up).
- Public WiFi: €590bn (this includes the cost savings from not using cellular services for mobile internet access and the benefits from greater use of mobility services).
- Automotive radar: €220bn (this includes the benefits arising from reductions in the number of accidents).
- RFIDs: €200bn (this includes the efficiency benefits to the retail sector alone).

[88] "Value of Licence Exempt Spectrum, Indepen, Aegis and Ovum for Ofcom. Forthcoming.

[89] Results for the UK have been grossed up to an EU level by multiplying by the ratio of UK to EU GDP.

The main challenge in undertaking any assessment of costs and benefits is that they mainly occur in the future and so are necessarily uncertain. This means the likelihood of possible outcomes occurring needs to be assessed. This might be done with reference to analogous past situations and gathering views from industry participants and potential consumers.

The first task however is to have a clear idea of the types of benefits those licence-exempt applications can offer. Specific estimates of "benefit" have been produced for selected applications. For example:

- The global airline industry estimates that use of RFID in baggage handing could reduce the costs of dealing with stolen and misdirected baggage by up to €2bn p.a.[90].
- The economic benefits of tele-care technology, which includes community service alarms and infra-red movement sensors, and home safety devices such as smoke, flood and CO2 detectors have been estimated by the University of Stirling to realise gross cost savings for local authorities of around €18,000 per person if they occupy their own home rather than residential care houses.[91]
- Ofcom estimates that the benefits to the UK from the deployment of automotive radar will comprise a reduction in casualties and vehicle damage with a net present value of €200-400m.
- The Arts Council of the UK estimates the impact on theatres, many of which use professional radio microphones, in terms of the expenditures of theatre goers and payments to theatre employees as around €3.6bn annually. [92] We note however, that these values represent the value associated with theatres and do not give any indication of what might happen if theatres no longer existed. In practice it would be expected that much of the expenditure would be redirected to other goods and services.

At a European level it also necessary to take account of the contribution of licensed and collective use applications to the internal market and other EU objectives such as those articulated by the i2010 initiative. In this regard the following benefits are likely to be particularly important:

- The contribution to reducing the costs of trade within the EU and thereby promoting the internal market. For example, RFIDs will generally reduce trading costs and automotive applications, such as automotive radar and electronic road tolling, should reduce the level of road congestion and hence the costs of transporting goods within Europe.
- The contribution in reducing the "cost" of personal mobility within Europe, for example through the use of licence-exempt equipment/applications throughout the EU.
- The contribution to increasing productivity, for example by enabling more flexible use of buildings, through wireless building automation systems, and

[90] Chip to end lost luggage, By David Millward, Transport Correspondent, Daily Telegraph, Filed: 08/05/2006)
[91] http://www.tunstall.co.uk/detail.asp?ID=255
[92] Economic impact study of UK Theatre, D Shellard, University of Sheffield, Arts Council, April 2004

allowing individuals to have seamless access to broadband communications services at low cost when on the move. We note that licensed applications could also offer these benefits, though possibly at higher cost.

- The contribution of relatively low cost licence exempt broadband access services to help foster economic development and the provision of e-government in areas of low population density.[93]

iii. Example of 1800-1805 MHz

In 1992 the ERC adopted Decision (ERC/DEC/(92)01) which allocated the frequency bands 1670-1675 MHz and 1800-1805 MHz for the Terrestrial Flight Telecommunications System (TFTS). The TFTS would allow public phone calls to be made from aeroplanes to ground based networks. There was little commercial interest in the service and in 2002 the CEPT withdrew the identification of the two bands for TFTS by adopting ERC Decision (02)7. The 1670-1675 MHz has since been reallocated to the Mobile Satellite Service but decisions about the 1800 MHz band have not yet been made.

In May 2004 the European Commission gave CEPT a mandate to investigate possible future harmonised uses of the band. This investigation found that[94] :

- The band is generally available for use in Europe but that the UK and Ireland have indicated that they plan to license use of the band on a technology and application neutral basis.[95]
- While the majority of administrations wish to continue with the designation of the band for harmonised use band there is no consensus on what this use might be.
- Possible licensed services that were mentioned by industry/regulators are: UMTS, wireless broadband systems, mobile broadband, back-haul links for GSM from planes, radio microphones, helicopter communications and medical telemetry.
- There is no common use of the band outside Europe (i.e. in the U.S. and/or Asia).
- It was suggested by the ECC that potential use of the band for licensed and licence exempt applications should be further investigated. At the end of 2005, the ERC sent out a second questionnaire concerning the future use of the band and most administrations expressed a preference for flexible use of the band. Given this the EC has tentatively proposed two follow-up scenarios for comment[96.]

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[93] "Bridging the Broadband Gap", Communication from the Commission, 20 March 2006, COM(2006) 129 final

[94] Radio Spectrum Committee Working Document, Final CEPT Report in Response to EC Mandate on TFTS Bands, RSCOM-46, 21 September 2005. http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/index_en.htm

[95] It is planned to license the use of the band from 1785-1805 MHz for these services in Eire and Northern Ireland. "Award of available spectrum: 1785-1805 MHz", Ofcom and Comreg, December 2005; http://www.comreg.ie/publications/default.asp?S=&NavID=&ctype=5&NID=102224

[96] RSCOM06-42, 23 June 2006, http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/index_en.htm

- Unlicensed usage should be on a technology and application neutral basis;
- Licensed usage should be based on the WAPECS approach.

In Table 8 we illustrate how the decision as to whether to allocate the 1800-1805 MHz band to licensed versus collective use might be made using the six step process given by the EC's Impact Appraisal Guidelines.

Table 8: Applying the Regulatory Impact Guidelines: an Outline for the 1800-1805 MHz Band

Step	Outline of approach
Identify the problem	The future allocated use of the 1800-1805 MHz band?
Define the objectives	The overall objective of spectrum policy is to promote social and economic welfare.
Develop main policy options	The options are: ▪ Wait and see (i.e. do nothing); ▪ Licensed (using WAPECs concept); ▪ Light licensing/licence exempt use. It is assumed that the existing technical constraints on the band would continue.
Analyse the impacts	Key factors that would need to be analysed for each option are as follows: **Wait and see**: Potential benefits of waiting mainly comprise the resolution of uncertainty concerning technical, regulatory and market factors. The main costs are the costs of delay in consumer and producer benefits from use of the resource. **Licensed use**: Identify potential applications and then forecast potential use and the net consumer and producer benefits from that use.[97] Impacts on competition and achievement of specific policy objectives should be identified and valued where possible. Any costs, for example, an increased risk of interference should be assessed and the costs of licensing the service. **Light licensed/licence exempt use**: Go through same process as for licensed use.
Compare the options	This would involve calculation of the net benefits of the licensed and licence exempt options compared with the wait and see base case.
Outline policy monitoring and evaluation	This would involve defining the process for monitoring implementation of a revised harmonisation measure and periodically (say every 5 years) monitoring actual use of the band based on market data and possibly also technical monitoring information.

5.3.3 Findings

The key question is: should the band be licensed or collective use? We conclude that, in general decisions about the balance between licensed and collective use spectrum will need to be made administratively. While private commons offer the possibility of using the market to determine the balance between licensed and collective use spectrum their role in Europe

[97] Transfers of revenue and profit between organisations should be identified and netted out.

is likely to be rather limited. However, when developing regimes for spectrum trading in Europe the Commission/SMAs should not preclude the possibility of private commons.

We conclude that, in general decisions about the balance between licensed and licence exempt spectrum will need to be made administratively. While private commons offer the possibility of using the market to determine the balance between licensed and licence exempt spectrum their role in Europe is likely to be rather limited. However, when developing regimes for spectrum trading in Europe the Commission/SMAs should not preclude the possibility of private commons.

For applications where licensing is not practical or needed because interference between devices is unlikely or licensing is not cost effective because the costs of administering and enforcing a licensing regime would be high, access to licence exempt spectrum is likely to be necessary. Provision for these applications will need to be made for this either within existing or new spectrum bands. Licence exemption provides a means of corralling such uses into a given band and ensuring that other bands are not unduly affected by illegal use. Equipment specifications can be used to control the level of interference and regulatory bodies need to make decisions about the appropriate technical parameters to impose. This involves economic as well as technical trade-offs, as more onerous technical requirements typically imply an increased equipment cost.

Finally, the possibility of making the former Terrestrial Flight Telecommunications System (TFTS) downlink spectrum (1800 – 1805 MHz) available for collective use was mooted during the study. Although some interest was expressed in collective use of this band by the Low Power Radio Association, there was a preference for spectrum below 1 GHz. However there was a strong preference for keeping the band harmonised across Europe but not necessarily on a collective use basis. The band would therefore seem to be a suitable candidate for applying the decision making process described in section 5.3.2.

However, the adoption of impact assessments can be a costly exercise, so we caution the Commission in adopting rigorous impact assessments for all frequency bands. Instead a simple and quick exercise could firstly be run through such as the example at Table 8 which would identify whether the exercise is worth pursuing in more depth.

Recommendation 4: Establish a transparent, objective methodology for deciding whether to allocate spectrum for collective use

Decisions about the balance between licensed and licence exempt spectrum should be made in a transparent manner considering all feasible options and using all available information on the costs and benefits of these options. The EC's regulatory impact guidelines provide a template for making such assessments and we recommend that this is adopted by the Commission and CEPT when considering potential candidates for collective spectrum use in the future. The analysis should be based on information such as the following:

i) The extent of use of collective use spectrum, gathering through monitoring activities undertaken by SMAs or possibly industry.

ii) Trends in the deployment of collective use applications/equipment. This will need to be supplied by industry or possibly collected through consumer surveys conducted by SMAs or national statistics organisations.

iii) International trends in collective use applications gathered from industry and other SMAs.

It is recommended that the Commission develops ways in which this information can be gathered on a systematic basis through co-operation with industry and SMAs.

5.4 Finding Additional Spectrum Allocations for Collective Use

Whilst technology evolution has the potential to expand capacity in existing bands for existing applications, this may not in itself be sufficient to cater for all the growth in demand, nor cater for new applications that may not be compatible with existing users of these bands. If innovation is to be encouraged, provision may need to be made for access to spectrum for new wireless technologies and applications.

In considering which frequency bands might be suitable for collective use, regulators need to trade-off the costs, benefits and risks of this option as compared with designating the bands for possible licensed applications. If in the absence of regulatory controls there are no competing demands for spectrum now or in future (i.e. use by one user would not cause harmful interference or denial of spectrum access to another) then there is a strong case for allocating the spectrum to collective use. The reason for this is that there are costs associated with licensing the spectrum such as administrative costs and possible delays in spectrum access and, in some cases, no benefits in terms of avoiding harmful interference. Circumstances in which licensing might possibly be justified are where government wishes to impose social obligations on users (e.g. coverage obligations) though such obligations generally only apply in the case of high powered wide area systems which typically need to be licensed to avoid harmful interference.

In practice, the conditions of no interference in the absence of any regulatory controls will rarely, if ever, occur. The exception is possibly in very remote locations and at certain high frequencies where atmospheric absorption is particularly high, notably around 60 GHz. Furthermore, one rarely has certainty that no competing demands will arise in future which in turn suggests that blanket designation of certain bands for collective use is a risky strategy (see also the discussion of re-farming below).

However, in practice competing demands for spectrum are less likely to occur in the following bands:

- High frequency bands, say above 40 GHz, because at these frequencies propagation distances are relatively short, and the available bandwidth is large.
- Low frequency bands, say below 70 MHz, whose utility for licensed applications is diminished by high levels of noise, an uncertain propagation environment and the need for large, cumbersome aerials if wide area coverage is sought.
- Rural or remote areas because the density of use is low.

Each of these circumstances is therefore a clear candidate for collective use, though some controls on transmission power and possibly other technical parameters are likely to be required. Below we refer to these bands as "low cost" allocations for collective spectrum use. As a general rule we suggest that frequency bands that have proved unattractive for licensed applications either owing to large antenna size, high levels of noise or limited operational range should be made available for collective use on a minimal constraints basis

We also consider alternative "high cost" allocations that are attractive to both licensed and licence-exempt use because of the lower equipment costs, good propagation characteristics and high density of demand (in urban areas).

5.4.1 Potentially "Low Cost" Allocations for Collective Spectrum Use

i. Below 30 MHz

This part of the spectrum is suited to inductive applications and general SRD use. Demand for broadcast applications in the LF, MF and HF bands is declining but this trend may be reversed if digital technology such as Digital Radio Mondiale is successful. The possibility of further spectrum around 27 MHz to complement existing allocations may be worth exploring, although alternative bands at higher frequencies may be more attractive in terms of smaller components and aerial size. The longer-term introduction of digital broadcasting technology in the existing broadcast bands may lend itself to collective use by ultra low power transmitters similar to those currently used in the FM broadcast band. There are already "underlay" allocations for inductive applications in the bands below 1,600 kHz. However, our research has not indicated any specific interest in further collective use of these frequencies.

ii. 30 – 300 MHz

This frequency range is suitable for long-range communication, although relatively large aerials are required. The cessation of broadcast services in Band I (47 – 68 MHz) upon digital switchover raises the possibility of a harmonised band that could be used on a collective basis. Previous attempts to introduce licensed services in this band have been unsuccessful, owing in part to the large aerials required for wide area mobile use, high levels of background noise and the susceptibility to periodic interference from distant high power broadcast transmitters. The latter will no longer be an issue when broadcasting ceases and for short-range applications noise and aerial size are of less concern. The relatively large bandwidth available would lend itself to technologies such as spread spectrum; this is already deployed by some military systems at similar frequencies. The band could be used to enable longer-range licence-exempt communication for telemetry applications.

In the European Common Allocation Table the band is a primary land mobile allocation with a secondary amateur allocation in the band 50 – 52 MHz. There is already some collective use of the band. For example, wireless microphones and non-specific SRDs operate on a shared basis in some countries. Current allocations within the band in each country are detailed in Table 9. We therefore propose that some or the entire 47-68 MHz band is made available on a collective use basis, with minimal constraints on technologies or applications.

Table 9: Applications in the 50-52 MHz Band

Country	Broadcasting	Defence	Microphones	Land Mobile	Wind Profilers	SRDs	Fixed
Austria	X	X		X			
Belgium	X	X					
Cyprus		X		X	X	X	
Czech Rep	X		X	X			
Denmark	X				X		
Estonia	X	X		X			
Finland	X	X					
France	X						
Germany	X	X			X		
Hungary	X	X					X
Iceland	X			X	X		
Ireland	X						
Italy	X			X	X		
Lithuania	X	X			X		
Netherlands	X			X			
Poland		X		X	X		
Portugal	X	X					
Slovakia		X				X	
Spain	X						
Sweden	X						
UK			X	X	X		

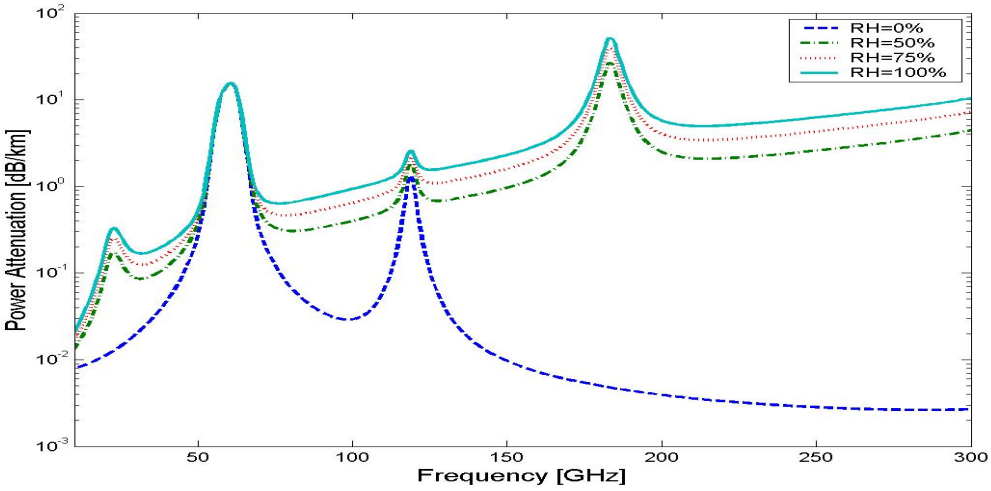
The recent decision to include FM micro transmitters in Band II raises the question of whether a similar approach might be feasible in Band III in the longer term, for example to provide reception on DAB equipment operating in the band. However we are not aware of any immediate demand.

iii. 40 GHz Upwards

Frequencies above 40 GHz are attractive for collective use for a number of reasons, including the following:

- Relatively high free space / atmospheric attenuation, particularly in the vicinity of 60 GHz where absorption by atmospheric gases increases attenuation by up to 20 dB / km (see Figure 10)
- Very small aerial and component sizes, reflecting the very short wavelengths at these frequencies.
- Relatively little use by licensed services.

Figure 10: Power Attenuation at 60 GHz. [98]



The principal disadvantage with these frequencies is that historically costs of components have been substantially higher than those for lower frequencies; due largely to the difficulty of producing reliable, surface mounted integrated circuits. However, significant progress has been made in relation to the development of components in the 77 GHz automotive radar band, to the extent that monolithic mm-wave integrated circuits can deliver acceptable quality at an affordable price, at least for this relatively high-end application. The expectation is that prices will continue to be driven down and that technology will not be a barrier to low cost consumer devices at 40 GHz and above, should the 77 GHz automotive radar be successful.

One further characteristic of these frequencies is that they are generally unsuitable for non-line of sight applications, due to high levels of absorption by building materials. Whilst this would be a clear disadvantage for mobile applications it provides distinct benefits for short range line of sight applications, since the probability of interference from other nearby devices is significantly reduced. The size and cost of producing relatively high gain

[98] Source: Y. Pinhasi, A. Yahalom, O. Harpaz, G. Vilner, "Spectral Characteristics of Gaseous Media and their Effects on Propagation of Ultra-Wideband Millimetre Wave Radiation", *Journal of Non-Crystalline Solids* 351 (2005) 2925–2928, available at: www.yosh.ac.il/research/mmt/WS2003/Papers/182-197.doc.

directional aerials is also reduced at these frequencies, making them particularly suitable for point to point transmission links or mesh-based networks.

ECC Decision (99)15 designates the 40 GHz band for MWS, however, there is currently no use of this band and so it is a potential candidate for collective use applications. MWS are defined as providing fixed wireless access direct to the end user for multimedia services, including converged broadcast and telecommunication services and providing capacities equivalent to several TV channels per subscriber. To date there have been few commercial developments of such systems although research is being undertaken[99]. The increasing take up of higher bit rate broadband services and the development of new bandwidth heavy services, such as HDTV and ipTV, suggest that higher capacity systems could become commercially viable. Hence any designation of the band for collective use applications would need to be justified by a thorough regulatory impact assessment.

We believe that there would be benefits in making much of the spectrum above 40 GHz exempt from licensing, with the possible exception of those bands already identified for specific licensed applications, such as the fixed link band at 55 GHz, or where there are other services such as radio astronomy that may require protection at certain locations. In particular, the 40.5 – 42.5 GHz band harmonised for MWS should be considered as an early potential candidate for collective use, in view of the absence of any current interest in the use of this spectrum for licensed system deployment.

5.4.2 Potential "High Cost" Allocations to Collective Spectrum Use: 300 MHz - 40 GHz

i. 300 MHz – 1 GHz

This frequency range offers an optimal combination of range, building penetration and component / aerial size and is thus well suited to a variety of collective use applications. Existing SRD allocations at 433 MHz and 863 – 870 MHz are already heavily used and there is anecdotal evidence that congestion occasionally arises at 433 MHz. This frequency range is also very sought after for licensed use, such as broadcasting and mobile services, and by government and military users, for the same reasons. The scope for additional collective use spectrum is therefore limited and most interest is likely to focus on expanding existing bands, since it would be relatively easy to extend the operational bandwidth of existing products in these bands. However, the imminent switchover to digital TV and the possibility of a "digital dividend" raises the question of whether some of this released spectrum could be used on a collective basis, either in the form of specific frequency allocations or by the introduction of overlay or underlay technologies.

According to the LPRA, there could be significant problems in the longer term if additional spectrum is not found in the lower (VHF/UHF) frequency bands, as demand for RFID, home automation, social / medical applications etc increases. There is currently no harmonised VHF spectrum in Europe, which increases pressure on the limited amount of spectrum at 433 and 868 MHz. Higher bands like 2.4 GHz and 5 GHz are good for data transmission, but lower bands (below 1GHz) are preferred for other types of SRD application.

[99] The EC 6th Framework project, BroadWAN, includes investigation of new generation, high capacity 40 GHz point to multipoint systems.

The 800 MHz band is of particular interest for generic applications as an ETSI standard has recently been ratified for spread spectrum modulation in the band and a number of chip manufacturers have already developed products for the band. If the band is to develop its potential as a European alternative to the North American 900 MHz ISM band, which has been a significant spur to innovation in that region, then harmonisation of this band is of particular importance.

ii. Expanding Existing Collective Use Bands

The 433 MHz band currently extends from 433.05 - 434.79 MHz, which is allocated as an ISM band throughout ITU Region 1[100]. Spectrum either side of this band (430 – 440 MHz) is currently allocated to Radiolocation and Amateur services on a co-primary basis. A range of airborne, ship-borne and airborne radars operate in the band alongside amateur repeater stations, many of which operate within the existing ISM band. The band has been available for SRD use for many years and consequently has become established as the main band for low cost consumer devices such as car key fobs. The band is available globally, although power is more constrained in the U.S. and Canada and slightly lower frequency allocations are available in Japan and China. Voice, audio and continuous data transmissions are generally not permitted in the band.

Although most equipment in this band uses traditional narrow band technology, more recently products such as wireless credit card readers have incorporated spread spectrum technology. Although such applications can also be accommodated in the 2.4 GHz band, continuing growth in Wi-Fi traffic in this band is likely to result in localised congestion. There may therefore be a case for considering the wider deployment of SRDs in the 430 – 440 MHz band, subject to mandatory use of interference mitigation techniques, to cater for low duty cycle, high data rate applications such as electronic point of sale equipment. The deployment of wide band spread spectrum systems in the band for applications such as vehicle or asset tracking could also be considered. The impact on amateur services may be a limitation in this band, however, as this is a widely used global allocation.

Our research has indicated that there is greater interest currently in developing use of the 863 – 870 MHz band than 433 MHz, as this is close to the North American ISM band and mostly unencumbered by other services. The bandwidth available for collective use within this band has progressively increased over the years, due in part to the demise of the CT2 cordless telephone standard that was originally allocated spectrum in the 864 – 868 MHz band. The proximity of this band to the North American 900 MHz ISM band (902 – 928 MHz) has enabled the development of devices that can operate in both the European and American bands, such as RFID tags. There is increasing use of interference mitigation techniques such as LBT and AFA in the band. The latest version of the European standard for SRDs below 1 GHz, EN 300 220, includes provision for both Direct Sequence and Frequency Hopping spread spectrum systems in the 863 – 870 MHz band and there are signs of interest from hardware developers in the opportunities this presents. However, the available bandwidth is substantially less than that available in the 900 MHz band (8 MHz compared to 26 MHz) and industry representatives have indicated that this has been a constraint on the adoption of spread spectrum techniques in the band. Nevertheless, a

[100] ITU Radio Regulations Footnote 5 .138

number of manufacturers are offering 868 MHz chipsets alongside their 900 MHz and 2.4 GHz offerings, at prices from around €50.

The band is located between the top end of the UHF TV bands (470 – 862 MHz) and the lower end of the land mobile band (870 – 960 MHz), however the immediately adjacent frequencies remain largely unused in many EU countries. This is partly due to the need for guard bands to protect TV receivers and other uses below 862 MHz, and the requirement for separation between the mobile transmit band (870 – 915 MHz) and the base station transmit band (915 – 960 MHz). Figure 11 illustrates the current national allocations in the band 862 – 872 MHz, based on information from EFIS:

Figure 11: European and National Allocations 862 – 872 MHz

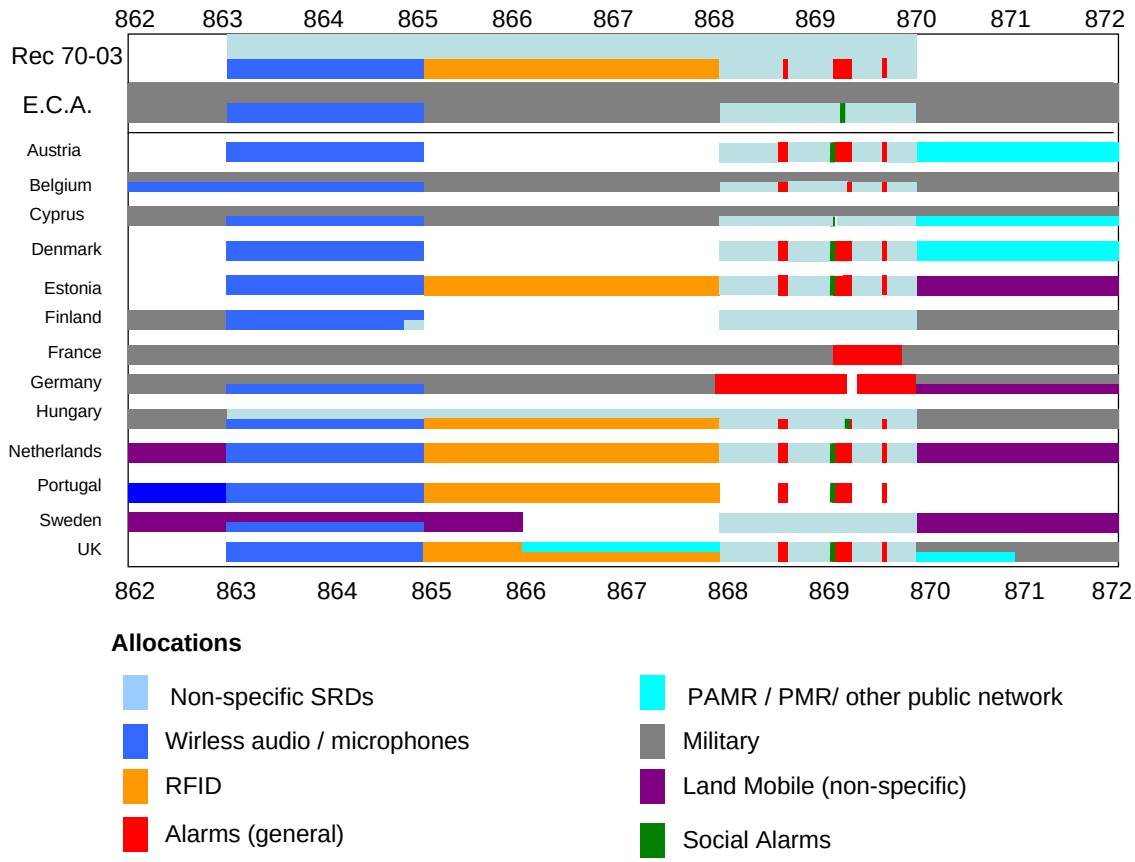


Figure 11 shows that the most common use of the 862 – 863 MHz band is for military applications, although in some countries the spectrum is allocated to land mobile services and there is some use for wireless microphones. Military use is also prominent in the 870 – 872 MHz band but this band is more commonly allocated to land mobile use. However, as noted above, the ability to use frequencies below 872 MHz for wide area mobile applications is constrained by the need to avoid interference to GSM base station receivers adjacent to the paired 915 – 917 MHz band. Since there are already successful examples of sharing between military use and SRDs in the existing 863 – 870 MHz band we consider that there is a good case for extending this band to cover the full 862 – 872 MHz band. This would be particularly attractive for spread spectrum applications, increasing the available bandwidth by almost 50%, but could also be used for narrow band applications, subject to consideration of

any guard band requirements to protect adjacent band services. According to ERC Report 98[101], which addressed compatibility between SRDs and TETRA services in the adjacent frequency band, the probability of interference to TETRA from SRDs close to the TETRA band edge is considered to be low and narrow band (25 kHz) SRD systems are able to operate immediately adjacent to the TETRA allocations. Wider bandwidth systems would however require a frequency separation of 500 kHz.

iii. Catering for RFID Expansion

We have already noted the anticipated rapid growth in demand for RFID applications in the 900 MHz region over the next decade, and the fact that RFID tags are capable of operation over the entire 860 – 960 MHz band. Demand growth may lead to congestion in the existing 2 MHz that is allocated to high power RFID applications, but extending this application within the existing 862 – 870 MHz band may prejudice co-existence with other, lower power applications in the band, particularly social alarms with health and safety implications and wireless audio devices which are particularly prone to interference due to their continuous duty cycle operation. However, we believe there is scope for the deployment of RFID interrogators in the 915 – 917 MHz band, particularly at indoor or enclosed locations where the risk of interference to GSM base stations in the adjacent bands will be minimal. Since the tags are designed to be wideband, in order to support the various international allocations to RFID in the range 860 – 960 MHz, an allocation at this frequency would be compatible with existing RFID tags.

iv. Implications of Digital TV Switchover and the "Digital Dividend"

The imminent transition to digital television brings the possibility that some spectrum could be released from the UHF bands (470 – 862 MHz) for other applications. In principle, these applications could include collective use. However, given the likely high value of this band for licensed applications, either existing broadcast services and potential new services such as mobile TV or fixed wireless services, it seems unlikely that any economic case could be made for an exclusive allocation within this band for collective use. There is clearly potential for shared use of the band, as already shown by the widespread deployment of wireless microphones. In addition there is interest in the use of the UHF band for low power in-home distribution of DTV signals on a licence-exempt basis, using Dynamic Frequency Selection and Transmit Power Control via the signalling path[102].

We anticipate that instead these frequencies will be allocated either to broadcasting services through largely administrative processes or through market mechanisms to new licensed services as suggested in the Commission's stated policy in the recently released 2006 Framework Review. We see merit in the suggestion of one of our questionnaire respondents that if the band failed to meet its reserve price then it should be considered for collective use.

[101] "Compatibility of SRDs at 900 MHz with adjacent services", February 1999

[102] see http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/responses/dtg

v. 1 GHz – 40 GHz

This part of the spectrum is best suited to high bandwidth, short range transmission, a good example of which is Wi-Fi. The availability of substantial spectrum around 5 GHz is likely to meet requirements for the foreseeable future, although it has been suggested that longer term (10 years or more) requirements for very high bandwidth mobile services (100 Mbit/s upwards) may necessitate up to a further 500 MHz below 5 GHz. Whether such spectrum would be best used collectively, on a licensed basis, or using a combination of the two is unclear at this stage. Further detailed impact analysis of the type outlined in section 5.3 is required before coming to a decision in this area.

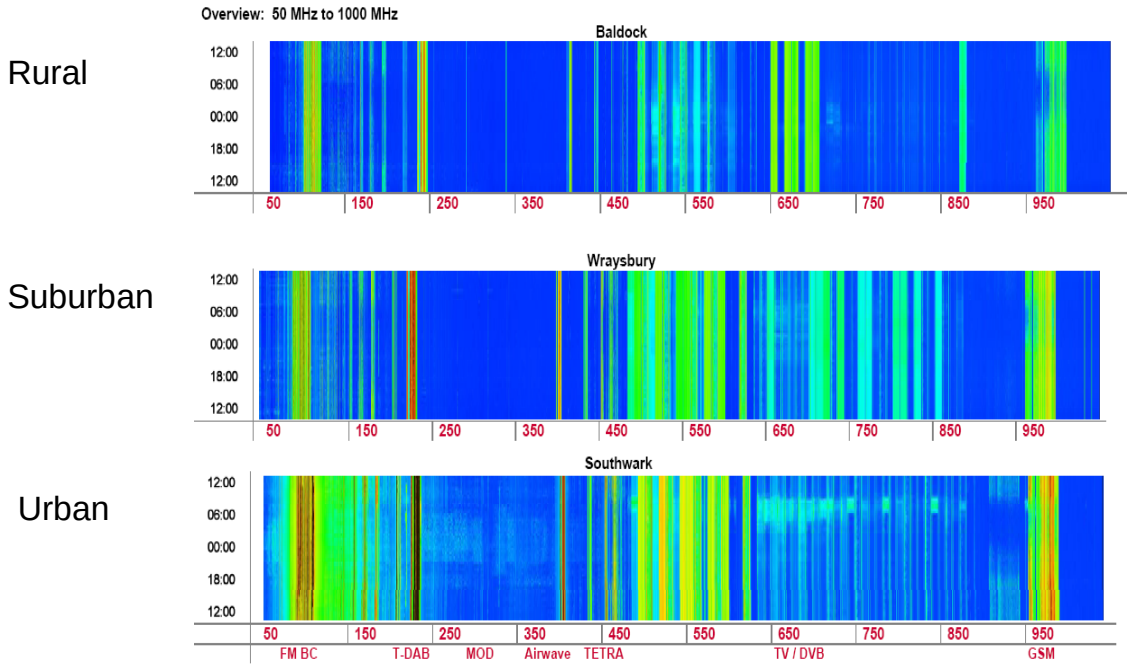
Recommendation 5: The following frequency bands should be considered as potential future candidates fro collective spectrum use and analysed in accordance with Recommendation 4:

Band	Category	Comments
47-68 MHz	C	Will no longer be required for broadcasting following digital switchover and is unsuitable for other licensed use due to the risk of interference arising from anomalous long-distance propagation effects. This band could be attractive for longer range, higher powered collective use applications.
862–872 MHz	C	This entire band should be made available on an application neutral basis subject to the use of spread spectrum technology to minimise the risk of interference to existing users of the band. This would provide a European alternative to the established and successful 900 MHz ISM band in North America. This extended band would make use of spectrum on either side of the existing 863 – 870 MHz collective use band that is currently allocated to other services in some Member States but is very underused in practice
915–917 MHz	B	Consideration should be given to the introduction of RFID interrogation systems in this band, to cater for growing demand for these devices. Compatibility studies should be undertaken to investigate the potential impact of such systems in a variety of deployment scenarios on GSM and UMTS base station receivers operating immediately below 915 MHz.
40.5–42.5 GHz	C	This band, currently harmonised for Multimedia Wireless Systems should be considered as an early potential candidate for collective use, in view of the absence of any current interest in the use of this spectrum for licensed system deployment. In the longer term, consideration should be given to making most of the spectrum above 40 GHz available for collective use, with the possible exception of those bands already identified for specific licensed applications, such as the fixed link band at 55 GHz, or where there are other services such as radio astronomy that may require protection at certain locations.

5.5 Sharing Spectrum between Collective and Licensed Use

It has been observed by the FCC's Spectrum Policy Task Force (2002) and Ofcom's Spectrum Framework Review (2004) that spectrum use over time in licensed bands is in general low. Figure 12 shows UK data from a 24 hour monitoring period and clearly in most of the bands monitored there is relatively little use, as indicated by the blue areas. This observation has led some commentators to conclude that anticipated increased demand for spectrum could be accommodated by increased sharing.[103] It is important to note at the outset that this view takes no account of the economic benefit a licensee may gain from having the option to use spectrum in future even if it is not used today.

Figure 12: UK Radio Spectrum Monitoring Charts



Key: Black/red= high use, yellow/green = moderate use, light blue = low use, dark blue = zero use

Increased sharing in licensed bands by collective use applications could be achieved through either an underlay or an overlay approach (as defined in Chapter 2). In both cases there is intended to be no increase in the risk of interference to the licensed user as a result of the sharing, though in practice certain proposals for underlays and overlays have involved an increased risk of interference that is sometimes justified with reference to the benefits from the collective use application.

Technology advances will address some of these problems allowing much greater sharing of spectrum in future; potentially without increased interference. The increased technical sophistication necessary to ensure no increase in the risk of interference is likely to require up to 10 years of further development to reach maturity.

[103] See papers in "How free is the radio spectrum?", Eds Bohlin, Preissel and Weber, info, Vol 8, no 2, 2006

5.5.1 Implications of Sharing for Incumbent Licensed Users

Licensed users today often object to having to share spectrum to which they had an expectation of exclusive access. It is instructive to consider the reasons for this and how they might be addressed in order to give licensed users an incentive to share their spectrum access. We suggest that licensed users might have the following objections to sharing with collective use applications:

- Actual and perceived risks of interference which could have negative direct impacts on service quality and viability and negative indirect impacts on future investment and innovation, as the certainty of returns declines. The real question here is: Are mitigation techniques good enough to make these impacts minimal?

- Loss of future flexibility in spectrum use. The licensed user may lose options to reconfigure their systems in future because this may cause interference to the collective use applications. While the licence-exempt applications might be allowed into the band on the proviso that they accept any future interference from the licensed system, in practice we doubt that that such interference would be permitted to occur by the regulator if it caused disruption to many consumers and/or affected applications that affect safety of life services such as alarms, automotive radars, or sensors. At this point politics would probably intervene.[104]

- The cost of loss of flexibility is compounded by the difficulty of re-farming licence-exempt use of a band without applying a registration scheme.

- The prospect of increased competition from the new collective use applications.

The first three concerns should be taken into account by SMAs when deciding whether to permit collective use allocations in licensed bands. In respect of competition issues, a policy judgement is required as to whether the benefits of such increased competition outweigh any costs. These include those that may arise if the licensed but not the licence-exempt application has onerous social obligations; social objectives may not be met such as coverage obligations.

These issues mean that there is a risk that proposals for increased sharing between licensed and licence-exempt sharing could conflict with EU proposals for policies aimed at increasing the flexibility of licensed spectrum use and spectrum trading.[105] The risk of SMAs requiring sharing in licensed bands by collective use could reduce their value for licensed use and thereby inhibit trading. In addition, collective use could constrain the extent to which licensees will have flexibility to change their current spectrum use because a change of use

[104] We note that in a similar vein the US PCS operators did not lease spectrum to rural broadband suppliers for fear they would never get it back even once the leases had expired. This is discussed in "Implications of International Regulation and technical considerations on market mechanisms for spectrum management" Aegis and Indepen for the Independent Spectrum Management Review, November 2001, http://www.indepen.co.uk/panda.html

[105] European Commission. 29 September 2005. "Commission proposes advancing single market for radio spectrum use." IP/05/1199.

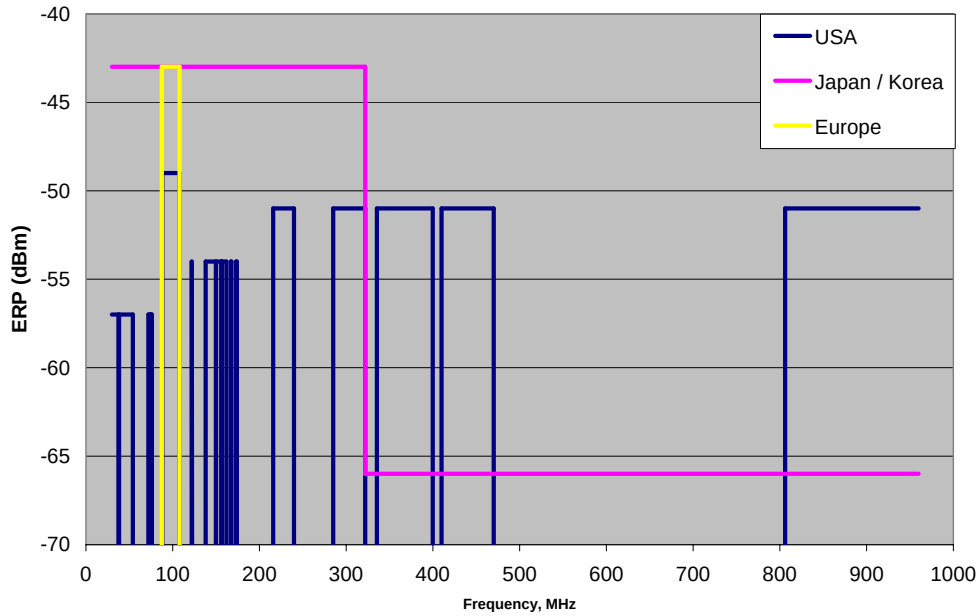
could cause interference to collective users. It will be necessary to proceed cautiously in this regard as many new interference mitigation technologies are still at a rudimentary stage.

5.5.2 Underlay Operation of Ultra-Low Power Devices

Spectrum management arrangements in the U.S., Japan and Korea permit the use of devices within many bands, even to the extent that they are otherwise exclusively licensed, provided that transmission is at such low power as to be scarcely distinguishable from background noise. This is an innovation that merits consideration by the Commission.

We noted in section 3.10 that one of the fundamental differences between regulation of collective use in Europe and in the U.S. is the provision under Part 15 of CFR 47[106] in the U.S. for "ultra low power" devices that operate at a power level below the limit defined for unintentional radiators like personal computers. Although there has been relatively little take up of services under this ruling, there is an argument that it provides additional flexibility for wireless device manufacturers and, with the advent of UWB technology in higher frequency bands, there is the potential to deploy relatively wideband, ultra-low power devices in lower frequency bands at power spectral density levels that would not interfere with existing services. A similar provision to the U.S. Part 15 provision also applies in Japan and Korea (see Figure 13).

Figure 13: Emission Limits for Ultra-Low Power Devices in Europe, U.S.A, Japan and Korea



The technical description of harmful interference for specific frequency bands would enable an underlay mask akin to FCC part 15 to be developed across the EU. However, the interpretation of several terms of art in U.S. regulation, including "safety services", "seriously degrades", and "obstructs or repeatedly interrupts" would need to be clearly defined. This

[106] Code of Federal Regulations, Title 47, Volume 1

would clearly require a balanced view of technical modelling and economic impact assessment for incumbent services. Even though technology neutrality is the order of the day, the practical implementation of underlay spectral masks has been demonstrated with the near introduction of UWB in Europe. Therefore, if we are to move forward with underlay technology, any newly assigned frequency bands must have the underlay spectral mask defined at the outset.

Recommendation 6: Provision should be made for operation of ultra-low power devices in licensed spectrum, akin to the provisions already in place in North America and Japan

The Commission should mandate CEPT to develop appropriate spectral masks for ultra-low power underlay operation in specific licensed bands, using recent work relating to FM micro transmitters and UWB as templates for this work. This would give certainty to licensed users concerning the potential underlay operations in their bands and create opportunities for new innovative applications and devices. The choice of bands for such operation should be undertaken cautiously as in some cases underlay operation may limit the licensed users' flexibility and may necessitate more advanced interference mitigation techniques than are currently available.

5.6 Making Greater Use of Existing Collective Use Allocations

Feedback from industry and regulators indicates that congestion in most existing collective use spectrum allocations is not perceived as a major problem, although very little has been done to verify this through monitoring. [107] Interference mitigation technologies like LBT / AFA and spread spectrum have significantly increased the capacity of existing bands and it would seem sensible to encourage the wider adoption of these techniques in the future. This may mean applying technology constraints to particular bands or sub-bands, such as the various duty cycle limits applied to parts of the 864 – 870 MHz band, to maximise capacity and minimise interference where demand for spectrum is particularly high. Ideally these constraints would be developed by industry and there is a trade-off here with the costs of such constraints which industry is best placed to make. We note that certain mitigation techniques are not technology neutral and that in these cases this principle may need to be sacrificed in order to achieve more efficient spectrum use.

One issue that has come to light from our research is the lack of harmonised spectrum for wideband spread spectrum systems below 1 GHz. Although an allocation to such systems in the 863 – 870 MHz band is included in ERC Recommendation 70-03 and harmonised standards have recently been approved within ETSI, very few Member States have yet implemented this allocation or expressed an intention to do so. Consequently, technology developers in Europe are denied the opportunity to take advantage of the propagation benefits arising from frequencies below 1 GHz. Given the similarity of the new ETSI standards to the protocols defined under existing FCC rules for the 900 MHz band, and the close proximity of the U.S. and European frequency allocations, there is considerable scope for Europe to benefit quickly from the introduction of low cost spread spectrum devices in the 863 – 870 MHz band, but only if a vigorous harmonisation process for this band is followed.

[107] Notably, since users of licence exempt spectrum are not entitled to protection, spectrum management authorities tend to feel that monitoring is not cost-justified.

This conclusion reinforces our earlier recommendation that CEPT addresses the expansion of the existing 863 – 870 MHz band to cover the range 862 – 872 MHz.

5.6.1 The Requirement for Interference Mitigation and the Implications for Regulation

Article 8.1 of the Framework Directive requires "*Member States to ensure that national regulatory authorities take the utmost account of the desirability of making regulation technologically neutral, that is to say that it neither imposes nor discriminates in favour of the use of a particular type of technology, does not preclude the taking of proportionate steps to promote certain specific services where this is justified, for example digital television as a means for increasing spectrum efficiency*".

Some have argued that the mandatory use of mitigation techniques through regulation goes against the technology neutrality requirement of the Framework Directive.

Part of the counter argument comes from the R&TTE Directive in which Article 3.2 addresses essential requirements. One of these is that "*radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communication and orbital resources so as to avoid harmful interference*".

At this point we need to distinguish between mitigating interference into primary, or licensed, users of the spectrum as opposed to mitigating interference into other licence-exempt users of the same type or any other type. In using the term licence-exempt users we are not intending to include mobile handsets and other wireless network terminals which in themselves are licence-exempt but whose operation is managed by the mobile network operator and whose spectrum use is in effect covered by the network operator's right of use. The discussion is directed at licence-exemption in terms of collective use of spectrum where there is no overall control of individual devices.

In the first instance, if licence-exempt devices are to operate in the same frequency band as licensed services it is quite legitimate to mandate mitigation techniques in order to prevent harmful interference. This is in line with the R&TTE Directive and a good example of this situation is the use of the bands 5150 – 5350 MHz and 5470 – 5725 MHz by RLANs where they are required to use Dynamic Frequency Selection (DFS), Transmit Power Control (TPC) and random channel access across a minimum operating bandwidth in order to avoid interfering with radars and satellite systems[108]. Without these mitigating techniques long term access to the spectrum by RLANs would never have been obtained. However, the question remains as to the level of detail that should be used in specifying the mitigation techniques to maintain technology neutrality as far as possible. It is considered that specifying the mitigation technique itself in extensive technical detail could be seen as compromising technology neutrality as this might imply a single implementation. In these circumstances it would be more appropriate to specify the mitigation requirement in terms of the signals/systems that have to be protected along with supplementary information regarding timing for example. This would allow for multiple implementations and not compromise technology neutrality.

[108] Noting that there are interim arrangements to allow some limited use of devices not having these mitigating technologies.

The case of licence-exempt devices interfering with one another is a rather different situation in that the general authorisation covering the licence-exempt devices is generally granted on "a non-interference, no protection" basis. In this case there are two interrelated questions:

- Should mitigation techniques (e.g. Listen Before Talk – LBT) be mandated or should the extent of regulation be limited to a spectral power mask with industry standardising on a mitigation technique if desired?

- What justification is there for mandating mitigation techniques to prevent interference between licence-exempt devices as this appears to run counter to the technology neutrality sentiment of Article 8.1 of the Framework Directive?

Given that these licence-exempt devices are operating on a "non-protection" basis it is not appropriate to rely on the requirements of the R&TTE Directive regarding harmful interference to answer these questions. However, Article 8.2 of the Framework Directive states that "*national regulatory authorities shall promote competition in the provision of electronic communications networks, electronic communications services and associated facilities and services by inter alia*[109]*: (d) encouraging efficient use and ensuring the effective management of radio frequencies and numbering resources*". Mitigation techniques directly lead to more efficient use of the spectrum[110] and it can therefore be argued that this clause in the Framework Directive would support mandatory mitigation techniques.

Revisiting the issue of how mitigation techniques should be specified, previously discussed in relation to known licensed services, it is not clear that the same logic applies in a situation where all the systems in a frequency band are licence-exempt. In fact there are two different cases to consider here. Firstly, situations where the licence-exempt systems are all of the same type such as application specific allocations such as those defined in Annexes 2 – 13 of ERC Recommendation 70-03 and secondly situations where different types of system are allowed (i.e. non-specific allocations). Further explanation is as follows:

- **Application Specific Allocations** In this case the characteristics of the systems will be known and it would therefore be possible to implement mitigation techniques.

- **Non-Specific Allocations** In this case, and by definition, the characteristics of the systems are not necessarily known a priori and it is therefore not possible to any significant degree to implement mitigation techniques between different types of system. It is of course possible to implement mitigation techniques within a given community (i.e. the same type of system) operating in a non-specific band and RLANs in the 2.4 GHz band is a good example of this. This example is based on industry standardising on a mitigation technique rather than the technique being mandated.

In the case of application specific allocations it is possible to implement mitigation techniques as noted above. It can be argued that such mitigation techniques can be mandated as they

[109] (a) to (c) omitted as not being relevant to the discussion.

[110] Listen Before Talk (LBT), for example, improves Quality of Service (QoS) by avoiding collisions. For the same QoS therefore an increased number of users can be accommodated.

increase QoS and hence spectrum efficiency. At the same time it can be argued that industry might in any event standardise on mitigation techniques in order to achieve some form of operational efficiency given that licence-exempt spectrum is generally in short supply. Both are valid arguments and a bias towards technology neutrality would favour the latter. Under what circumstances would it be appropriate to mandate mitigation techniques and sacrifice a degree of technology neutrality? It is considered that when a more reliable level of QoS is required for instance for applications that may have a safety element to them, it would be appropriate to mandate mitigation techniques otherwise it should be left to industry to arrive at some voluntary standard. In those situations where it is deemed appropriate to mandate mitigation techniques in an application specific allocation, the mitigation techniques should be non-exclusive (e.g. LBT or duty cycle limitation) in order to minimise technology constraints and therefore maintain a significant degree of technology neutrality.

In the case of non-specific applications it is clear that given the lack of knowledge of potential systems it is not sensible to mandate mitigation techniques. It should be left to industry to standardise on mitigation techniques within and possibly between given communities should industry decide it appropriate.

Concerning mitigation techniques in the context of 'Collective Use' we conclude the following:

- It is considered appropriate and legitimate within the current regulatory framework to mandate mitigation techniques for licence-exempt services when these are sharing a frequency band with a primary (i.e. licensed) user of the band. This would be on the basis of preventing harmful interference.

- Mandating mitigation techniques for licence-exempt services operating in specific allocations can be justified on the grounds of spectrum efficiency although technology neutrality is likely to be compromised. There is an argument that it might be expected that industry would in any event standardise on suitable mitigation techniques if an operational gain can be achieved, as in the case below. However, there may be situations where a quality of service is needed in which case mandated mitigation techniques could be appropriate.

- Mandating mitigation techniques in non-specific bands is not considered to be appropriate. Industry will standardise on such techniques where an operational gain can be achieved.

We conclude that mitigation techniques should only be mandated for licence-exempt services with respect to primary users, and exceptionally in specific allocations where a case can be made for a required quality of service such as for applications where an element of safety might apply. The mandating of mitigation techniques therefore moves away from technology neutrality but only to meet the needs of safety critical services.

5.7 Re-farming Issues

The relative value of different spectrum uses may change over time in which case reallocations may be justified. For example, there have been many reallocations from fixed to mobile use in bands below 3GHz over the last 20 years. In addition, allocation decisions can turn out to be wrong and in which case a means of reversing them is required.

In the case of licensed spectrum, the SMA may have the right to revoke licences with a due notice period or possibly after making compensation payments. If not, then licences can usually be revoked at the end of the licence term.

In the case of licence exempt spectrum use the situation is more problematic. Users could in principle be put on notice that the band is to be reallocated at a certain time and so their licence exempt status terminates, but the regulator has no easy means of evicting users that continue to occupy the band after the end of the notice period as they cannot be identified. Indeed it was suggested to us during the course of this study that harmonised collective use allocations should be time limited and that there should be a formal review process to determine whether the allocation should continue in force. However, this process is of little value unless licence-exempt users can be moved when the allocation is changed.

If any new licensed use of the band is not affected by the remaining licence-exempt users when the band is re-farmed then this should not be of concern.[111] However, if the new use suffers interference from the remaining licence-exempt users then a means of evicting the latter is required. Possible options include:

- Banning all equipment sales – free trade requirements and international mobility of people and equipment will make this difficult to enforce.
- Taxing all equipment sales after a certain point – this does not deal with legacy equipment and the mobility of devices.
- Requiring all licence-exempt equipment to have a renewal date written into its software. This assumes licence-exempt applications are based on software defined radio which may not always be the case.
- Introducing a system of registration for some licence exempt applications, where registration involves the user registering the location of its use on a computerised database. This allows co-ordination between users and the regulator to identify users more readily than under a licence exempt regime.

Of these options the last two seem likely to be the most fruitful but they do not deal with legacy equipment. In the near term software defined radio may not be economic for certain applications in which case a more practical approach may be to apply a light licensing regime, which allows the regulator to identify registered users and to prosecute them if they continue operations after the end of the notice period. Alternatively if light licensing is not practical, say for certain consumer applications such as garage door openers, then a

[111] Incumbent illegal licence exempt users may suffer interference from the licensed use. In principle this should not be of concern to the regulator though in practice it may be politically difficult to sustain such a situation.

conservative view to making licence exempt allocations recognising the irreversibility of the decision should be taken.

If a light licensing approach is adopted then the following issues need to be considered:

- The information that has to be provided on registration.
- The availability of this information to other users.
- The degree of interference protection from other users offered/obligations to co-ordinate.
- Whether fees are levied or not, say to cover the costs of the registration scheme.
- The mechanism for applying for and getting the “licence”.

In some countries, some PMR frequencies are used collectively on a licensed basis and a light licensing regime applies in the 5.8 GHz FWA band and in some millimetre wave fixed link bands (70 – 80 GHz). In the latter cases the users have access to a central database of all the links using the band and can choose their frequencies accordingly. This provides a better quality of service than would otherwise be the case in a license exempt band.

6 Furthering Harmonisation of Collective Use Allocations

In Chapter 3 we identified two issues related to harmonisation of collective use allocations and the associated technical limits, at both a European and a global level. The first issue concerns compliance with existing harmonisation measures, while the second concerns industry requirements for increased harmonisation in the future. This Chapter addresses these issues. We start with a general discussion of the meaning of the term "harmonisation", and of the potential benefits and costs of harmonisation in the context of collective use spectrum allocations.

6.1 Nature of Harmonisation

We use the term harmonisation in respect of collective spectrum to cover two different meanings:

- the common designation of frequency bands for collective use across countries; and
- the designation of common minimum requirements to avoid harmful interference (e.g. transmitter power).

It is important to note that neither of these points includes adoption of common standards or technologies for collective use bands.

Harmonisation of frequency bands does not necessarily require the same frequencies to be used in each country or region. Multiple or overlapping bands can often be supported economically using current technology. There is, of course, a limit to the degree of customisation to local conditions that is possible, because additional development and chip set costs are incurred. To be affordable, these additional costs need to be spread over a relatively large market; European rather than national markets may be required. For example, while global harmonisation is particularly attractive for high volume, cost-critical applications like RFID, finding suitable frequencies that are available globally is not a trivial task and may involve having to re-farm spectrum from other applications. This has been overcome at 900 MHz by ensuring that tags have sufficiently wide bandwidth to accommodate all the global frequency variants.

The 2.4 GHz band represents a good example of a somewhat fragmented frequency allocation that, in practice, does not cause any significant harmonisation issues. In the U.S., the ISM band occupies 2400 – 2483.5 MHz, whereas in Europe it is generally 2400 – 2500. The U.S. military had existing applications in the upper end of the band, and was unwilling to relinquish it. Base stations that are sold for use in the U.S. are expected to restrict themselves to the U.S. portion of the band, and to signal that restriction. Interfaces for mobile devices, for example Wi-Fi PMCIA cards, are expected to respond by limiting themselves to the U.S. portion of the band. Incompatibilities are not absolutely precluded, but in practice they are rare and generally do not cause harmful interference because of the short range and low power of the equipment.

In respect of the minimum requirements needed to avoid harmful interference, multiple approaches can also be accommodated at a global level if the radio system includes a microprocessor that can choose the appropriate mode of operation for the local environment, in which case there is no need for user intervention.

Similar issues regarding minimum requirements to avoid harmful interference have arisen in the case of UWB. In the U.S., the FCC defined the spectral mask for UWB in 2002. Indoor and outdoor masks were mandated for any future UWB technology at a level of -41.3dBm/MHz (e.i.r.p. mean spectral density) within the frequency range 3.1 to 10.6 GHz. Industry began developing UWB technology to operate with these parameters. In order to ensure that the devices could be exported and used around the globe, a campaign began to harmonise the spectrum and technical conditions for UWB, in particular the Spectral Mask. In Europe, the Commission mandated CEPT to develop harmonised technical requirements for UWB. The currently proposed technical conditions for UWB in Europe[112] differ from those set by the FCC because use of the affected frequency range differs between the U.S. and Europe. Moreover, the FCC generally takes a more relaxed approach to interference issues as compared with European regulators partly reflecting differences in density of radio use. The Commission has nonetheless signalled its intent to seek a relaxation of the conditions proposed by CEPT.[113] In any event, it is likely that manufacturers of UWB equipment will need to build either regional variations of UWB devices or build intelligence into the device so that it automatically adapt to local regulations.

6.2 Benefits and Costs of Harmonisation

Harmonisation is concerned with the allocation of services to specific frequency bands on a European or a global basis. The main benefits for doing this are as follows:

- To reduce the likelihood of harmful interference between services operating in different countries, particularly in border areas, and thereby increase the available spectrum for each country.
- To create a European-wide market for equipment and services thereby reducing manufacturers' risks and allowing them to take advantage of scale economies.
- To reduce equipment costs by limiting the number of frequency bands for which equipment must be made.
- To create the possibility for international roaming.[114]
- To provide greater certainty (protection) to users of spectrum that the spectrum will not be reallocated to other potential uses.

[112] See ECC Decision (06)04 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz, 24 March 2006. http://www.ero.dk/documentation/docs/doc98/official/pdf/ECCDEC0604.PDF

[113] Radio Spectrum Committee paper RSCOM06-52, 20 June 2006. http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/meetings_2006/index_en.htm

[114] This will also require standardisation for interoperability between consumer equipment and different networks.

The main costs of European frequency harmonisation are those associated with the loss of flexibility at a national level, such as the loss of flexibility in:

- matching spectrum supply to demand.
- allowing spectrum to be re-farmed or traded so that high value uses replace low value uses.

Service demands will differ between countries for many reasons, including income, geography, demographics and the provision of competing wired services (e.g. cable TV). Frequency harmonisation could mean that, for any given service, spectrum will remain idle in some countries while insufficient spectrum will be allocated in others, resulting in higher prices and reduced consumer benefits.

Band sharing between different services is often permitted so that countries have some flexibility in matching band use to demand. For example collective use could be accommodated with some national restrictions to protect existing legacy uses. Table 10 summarises the costs and benefits of frequency harmonisation.

Table 10: Benefits and Costs of Frequency Harmonisation

Benefits of Frequency Harmonisation	Costs of Frequency Harmonisation
Avoidance of harmful interference and thereby promotion of efficient use of spectrum, thus increasing spectrum use and competition.	Restrictions on use (or trade) of underused or unused spectrum for alternative uses.
Promotes international mobility (of terminals).	Restrictions on ability to re-farm spectrum for new services.
Reduction of equipment costs by reducing the number of bands equipment needs to operate in.	Insufficient spectrum allocated to some uses.
Creates large equipment markets.	Delays caused by the time needed to agree harmonisation measures.
Promotes competition between equipment suppliers and choice for the consumer.	

Source: Indepen analysis

Harmonisation of frequency bands and technical conditions is most important for equipment that is internationally mobile, and where there are significant scale economies in production. Unlike many licensed applications, harmonisation for collective use is not required for reasons of spectral efficiency because most such applications are relatively low powered; consequently, international co-ordination issues are negligible.

International harmonisation offers significant benefits in the case of applications embedded in the following:

- Portable devices such as computers and mobile phones (e.g. Bluetooth, WiFi).
- Vehicles e.g. road tolling and automotive radar;
- Traded goods (e.g. RFID).
- Individuals (e.g. medical implants).

The benefits of harmonisation are less in the case of fixed applications where equipment can be economically made for national markets (e.g. telemetry, building alarms).

Even where equipment may only be used locally, the international availability of consumer devices can cause problems. For example, national allocations have historically existed for devices such as cordless telephones, and this has led to problems associated with "grey imports", whereby equipment designed to work in other countries has been illegally imported, either deliberately for resale or unintentionally by consumers who have bought equipment abroad and are unaware of the differing national rules.[115] European harmonisation has undoubtedly brought benefits in this area, with the multiplicity of national analogue cordless phone standards almost completely superseded by the harmonised DECT standard; however there continues to be some illegal use of phones imported from the Far East or U.S. that are not compatible with European frequencies. Similar problems arise with licence-exempt PMR equipment, particularly at major international events like the Olympics.

[115] For example, an American who moves to Europe might bring a cordless telephone with him, without ever considering whether operating the phone in a European country might conflict with the national frequency plan and thus cause harmful interference.

We have estimated the net benefits of EU wide harmonisation of collective use allocations using the approach given in Table 11. The details of the calculations are given in Appendix A.

Table 11: Overall approach to estimating the costs and benefits of EU wide harmonisation

Step	Description
1	Identify collective use applications which generate major economic benefits
2	Make projections of these benefits and calculate their net present value (NPV)
3	Consider the impact of EU harmonisation of spectrum on the NPV of the net economic benefits from these applications when compared with a counterfactual in which harmonisation takes place on a voluntary basis
4	Assess the costs of harmonisation
5	Gross up from the incremental benefits of the three selected collective use applications to collective use applications in general

We estimate that the NPV to the EU of harmonising collective use spectrum lies between €463 billion and €898 billion. Such benefits are substantial. For example: the higher NPV of €898 billion is equivalent to a perpetual annual net benefit of €36 billion, or 0.35% of the EU's current GDP, if discounted at 4% per year. For the lower estimate it represents €19 billion, or 0.17% of the EU's current GDP.

Our estimates are clearly uncertain. On balance we believe that they are likely to represent an under estimate rather than an over estimate because:

- They are built up from an estimate of the benefits of harmonisation for a small number of applications.
- Our estimates of the benefits of harmonisation for all future collective use applications are only about 40% more than the incremental benefits of harmonisation for the three known applications – WiFi, RFIDs and SRRs. Harmonised spectrum for future use of RFIDs in sectors other than the retail sector alone could generate benefits of the same order as those for the use of RFIDs in the retail sector.
- Although we have not counted the costs of harmonisation our qualitative analysis suggests that these costs are modest.

6.3 Deficiencies of the Current Harmonisation Arrangements

6.3.1 Improving the European Harmonisation Process

In Chapter 3 we concluded that there has been insufficient progress towards implementation of harmonised frequency allocations as defined in ERC 70-03 and that this is detrimental to

developing a single market for collective use applications. For example, it can be seen from Figure 11 on page 94, that very few administrations have implemented the ERC 70-03 non-specific SRD allocation covering the 863 – 870 MHz band. We also identified strong interest from industry in achieving greater harmonisation of frequency allocations and the regulatory conditions attached to these allocations. There is provision under the Radio Spectrum Decision for the Commission to adopt binding measures to achieve necessary harmonisation. Furthermore, the Commission has recently stated its intention to apply decision mechanisms that yield binding results to be commonly applied by all Member States in respect of unlicensed bands, where the use of spectrum should be made subject to general authorisations, and where conditions applicable to the use of spectrum in those bands would be co-ordinated.[116]

As noted in section 3.6, the Commission has recently issued a draft Decision relating to a number of SRD allocations which have already been implemented in EU Member States. However the Decision does not address recent developments such as the publication of harmonised standards for spread spectrum devices in the 863 – 870 MHz band or the introduction of high power RFID devices in the 866 – 868 MHz band. If the EC is to achieve its goal of expediting access to spectrum for new applications and technologies, it is important that the EC Decision process is applied not just to initiatives that have already been widely adopted in Member States but to those where progress has been slow under the existing regime.

Recommendation 7: Replace existing voluntary approach to collective use harmonisation with mandatory EU-wide allocations backed by an expanded EC Decision

The existing ERC Recommendation 70-03 allocations should be reviewed, re-categorised in line with Recommendation 1 and incorporated into a revised and expanded EC Decision covering all harmonised collective use allocations.

6.3.2 Improving Global Harmonisation

As many new collective use applications are embedded in portable or mobile entities, international harmonisation has become of increasing importance for collective use applications. Indeed, regulators often have little choice but to follow decisions made elsewhere in the world; thus, global harmonisation effectively results from market and political pressure. If the rules fail to keep pace with market developments, the devices will tend to be used illegally (either intentionally or inadvertently). This is often not sustainable politically, as is shown by the FM micro transmitter example referred to in section 3.4.3

This example suggests that it is not possible to effectively block the use of SRDs that consumers find valuable, and that do no real harm. Similar issues could very well arise in the context of UWB if European harmonisation measures are not agreed in a timely manner, as devices equipped with UWB are expected to enter the U.S. market in 2006. Those devices are likely to find their way to Europe; moreover, if consumers find them useful, they will tend

[116] "Review of the EU Regulatory Framework for electronic communications networks and services", Commission Staff Working Document, COM(2006) 334 final, 28 June 2006.

to be used, whether they are authorised or not. *De facto* global harmonisation will occur, forcing the need for *de jure* harmonisation.

All of this implies the need for the European spectrum management community to be more proactive in anticipating and responding to developments from other parts of the world that are like to make their way to Europe.

Recommendation 8: Greater Liaison with other International Spectrum Policy Makers

This should include periodic dialogue between the EC and SMAs in other regions and jurisdictions to identify future opportunities for global harmonisation of collective spectrum use. This would also provide an opportunity to promote European spectrum allocation initiatives at a global level, to the potential advantage of European industry.

6.4 Future Requirements for Harmonised Bands

There is a broad consensus across industry, SMAs and spectrum users that the market for collective use applications will continue to grow for the foreseeable future. A number of factors are likely to drive future growth in demand for collective use of spectrum. These include:

- demand for greater efficiencies in distribution and retailing (driving demand for RFID devices);
- an aging and more affluent society (driving demand for social / medical applications and for consumer devices);
- an increasing emphasis on road safety (driving demand for automotive and transport related applications);
- Increasing expectations of high speed mobile connectivity (driving demand for wireless data transmission).

In most of these cases, there will be a requirement for harmonised allocations. In this section, we consider which bands are likely to be most attractive to cater for future demand growth and whether those bands will need to be harmonised or not.

Table 12 below summarises the future needs identified for some of the main existing applications of the collective use spectrum, based on feedback received from users. We anticipate that most if not all of these applications will require harmonised allocations.

Table 12: Applications and Future Spectrum Needs

Application	Future needs
High data rate systems	A need by around 2015 for data rates of 100 Mbps (up to 1 Gbps) – estimated requirement for up to five channels of 100 MHz each, ideally in bands below 5 GHz (e.g. for fixed use in city locations or downloading movies at railway stations prior to boarding a train).
Home automation and entertainment systems	More need for spectrum around 860 MHz. Home automation applications include alarms, telemetry and closed circuit TV. Interest has been expressed in the use of UHF TV channels to provide in-home distribution of TV signals, using low power DVB-T transmissions that can be received by a conventional DVB-T receiver.
RFID	Current spectrum seems to be sufficient for existing professional applications however there is concern about impact on other, lower power users of the band and the impact of future growth. In a domestic scenario, new spectrum would be needed – note there is an overlap here with home automation so again the 860 MHz region would be preferred
Short Range Voice Communications	PMR446 has now been augmented with 100kHz of spectrum adjacent to PMR446 spectrum for digital short range voice communications. [117] This is expected to meet the future demand for spectrum for such services.
Telemetry	More needs are anticipated in some countries. A number of existing national (non-harmonised) allocations exist – there may be benefit from greater harmonisation
Telephony on Wi-Fi	More needs are anticipated: VoIP over Wi-Fi (2.4 GHz) is developing and could increasingly replace calls made over cellular networks.
Video services provision	More needs area anticipated as continued co-existence with Wi-Fi in the 2.4 GHz band is questioned. The advent of high definition services will increase bandwidth requirements. Interest has been expressed in the development of video transmission systems in the 5.8 GHz band.
Wi-Fi	Development in the 5 GHz band will provide additional capacity to the 2.4 GHz band. MIC, Japan estimates: in 2010, a bandwidth of approximately 480 MHz maximum will be reserved for wireless LANs, mainly in the 5 GHz band, to respond to the spectrum demand. In 2010-2015, a bandwidth of approximately 740 MHz maximum shall be reserved, mainly in the 5 GHz band to respond to the frequency demand.
WiMAX	Use of the 5.8 GHz band is of interest for licence-exempt applications
Wireless microphones	There may be a future requirement if digital TV reduces allocations in the UHF TV bands. Advances in digital processing technology are reducing the demand for spectrum in this area; however, in the shorter term, the delay problems associated with compressed digital audio will mean continuing demand for analogue frequencies.

The future demand for collective use of spectrum may also grow in response to any increase in the cost or complexity of gaining access to licensed bands. Most of the interest in additional spectrum identified by users is for spectrum below 1 GHz, with the exception of

[117] (ECC/DEC/(05)12) - ECC Decision of 28 October 2005 on harmonised frequencies, technical characteristics, exemption from individual licensing and free carriage and use of digital PMR 446 applications operating in the frequency band 446.1- 446.2MHz.

very high data rate systems where spectrum up to 5 GHz would be suitable. Some users expect congestion problems in the longer term if additional spectrum is not found in the lower (VHF/UHF) frequency bands (which are valued because of their propagation characteristics and the relatively low cost of equipment), as demand for RFID, home automation, social / medical applications, and a broad array of other applications increases.

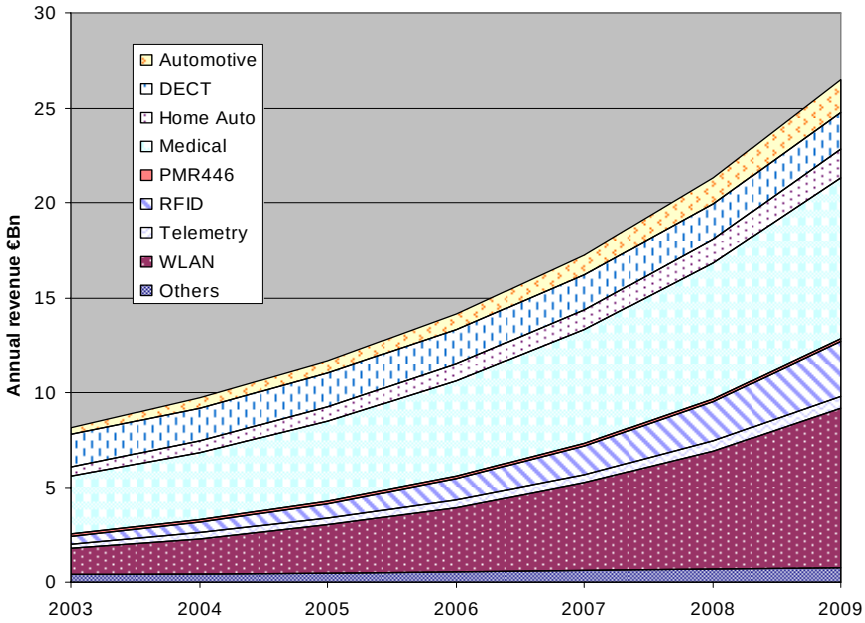
There is currently very little harmonised VHF spectrum in Europe, and this tends to be reserved for particular applications (as in the recently allocated spectrum around 169 MHz for social alarms and hearing aids), which increases pressure on the limited amount of UHF spectrum at 433 and 868 MHz. In addition, we note that there is a lack of harmonised collective use spectrum for non-specific applications at frequencies below 1 GHz, particularly if compared with the U.S. where the availability of the 902 – 928 MHz has stimulated many innovative applications.

7 Recommendations to the Commission on Collective Use of Spectrum

7.1 Introduction

In this chapter we present a summary of our key conclusions and the recommendations that have emerged from our study on Collective Use of Spectrum (CUS)[118].

CUS underpins a multitude of wireless applications including wireless computer networks, consumer devices, medical devices, industrial equipment and intelligent transport systems. The size of the market for these devices is difficult to quantify; however our initial estimates suggest the European market for products and services dependent on collective use of spectrum is likely to be in excess of €20 billion by 2009.



CUS is an essential requirement for a large number of wireless applications that impact upon many aspects of day to day life. The benefits of collective use to individuals, businesses and to the public sector are substantial, although not always straightforward to quantify. This is partly because collective use is generally undertaken on a licence-exempt basis and therefore precise records of the number of users do not exist and partly because the benefits are often indirect or long-term. For example, it is difficult to quantify the efficiency benefits to businesses and consumers of devices such as wireless car key fobs or door openers. Similarly, the benefits derived from wireless medical implants, such as glucose monitors for diabetics, may not become apparent for many years (in the form of extended longevity or improved long term health).

[118] all spectrum management approaches allowing more than one user to occupy the same range of frequencies at the same time, obviating the need for individual (exclusive) licensing

CUS is one of three main approaches to the management of radio spectrum, the other two being the administrative model, whereby individual users are granted exclusive rights to use spectrum on an administrative basis by national regulatory authorities, and the market-based' model whereby exclusive rights are acquired by market mechanisms such as auctions or spectrum trading. Whereas the administrative and market based models generally provide users with a degree of statutory protection from interference from other authorised users, this is not the case for collective use. Depending on the application, interference may be moderated by restricting specific frequencies for specific applications, or by appropriate choice of technology, as evidenced by the recent rapid growth in applications such as "WiFi", which depend entirely on collective use of spectrum.

Designating a band as suitable for collective use relaxes some constraints on entry and use but almost invariably introduces new constraints, say on power, and new risks of interference. Hence the costs and benefits of decisions concerning the allocation of spectrum to licensed versus collective use will need to be assessed on a case by case basis. This is because the impact will differ across different frequency bands and for different applications.

The overall objectives of the study are to provide innovators and application developers with quick low cost access to spectrum for collective use on a European-wide basis. In doing this we have made recommendations aimed at:

- **Lowering barriers to access** spectrum, by offering users greater flexibility in the use of collective spectrum;
- **Optimising the use** of spectrum by improving the extent of harmonisation in practice within existing allocations;
- increasing (modestly) the amount of spectrum available for collective use in anticipation of **future growth** in demand and taking account of the importance of harmonised allocations;
- **reducing the regulatory burden** on spectrum users by encouraging the use of spectrum on a licence exempt or lightly licensed basis where there is no "cost" (in interference terms) to this policy; and
- providing **more transparent mechanisms** and better informed decisions over whether and where to allocate additional spectrum to collective versus licensed use.

The conclusions and recommendations are structured as follows to address the three key areas:

- Simplifying and speeding up the harmonisation of collective use allocations;
- Addressing future demand for spectrum for collective use;
- Furthering harmonisation of collective spectrum use.

7.2 Summary of Conclusions

The principal conclusions from the study, on which our recommendations are based, are summarised in the following sections.

7.2.1 Simplifying and Speeding Up the Harmonisation of Collective Use Allocations

- The existing provisions for harmonised collective use are unduly complex and fragmented. Although there is a presumption under the EU Regulatory Framework that CUS should be the preferred approach to spectrum allocation where there is a negligible risk of harmful interference, we believe that in practice the large number of different applications and technical standards referred to in ERC 70-03 acts as a barrier to the introduction of new applications that do not clearly fit into historic allocations.

- The time taken for SMAs to develop and implement new harmonised allocations under the current voluntary arrangements is too long relative to product lifecycles. This is due to a number of factors including the time taken to undertake any necessary market or technical studies, delays in national implementation of ECC Recommendations or Decisions and the need to change national legislation to accommodate the new harmonised spectrum. Feedback from industry suggests that gaining approval for new technologies that do not fit conveniently within one of the existing defined categories can take two years or more, particularly where a harmonised allocation is sought. Such delays are not compatible with a rapidly evolving consumer devices market and may act as a deterrent to the development of new, innovative wireless technologies or services.

- There is no single definitive information source on harmonised European collective use spectrum allocations. Information is available from various sources including EFIS, ERC 70-03, the European Common Allocation Table and individual SMAs. However, none of these provide clear guidance on which spectrum is fully harmonised throughout Europe and much of the information that is available is inconsistent, incomplete or out of date. Lack of information on harmonised spectrum is likely to delay market entry as manufacturers wishing to address the European market may have to deal with up to 47 individual SMAs.

7.2.2 Addressing Future Demand for Spectrum for Collective Use

- Although the existing spectrum allocations are generally felt to be adequate, so long as these are fully implemented, significant growth in demand for collective use applications may lead to congestion in existing bands and a requirement for further spectrum allocations.

- In general decisions about the balance between licensed and licence exempt spectrum will need to be made administratively, although there may be some limited scope for the use of “private commons”, e.g. to cater for specialist user groups with common interests.

- There is scope for greater sharing of spectrum between licensed and licence-exempt users based on underlay and overlay techniques.

- Given the similarity of the new ETSI standards to the protocols defined under existing FCC rules for the 900 MHz band, and the close proximity of the U.S. and European frequency allocations, there is considerable scope for Europe to benefit quickly from the introduction of low cost spread spectrum devices in the 863 – 870 MHz band, but only if a vigorous harmonisation process for this band is followed.

- Interference mitigation techniques should only be mandated for licence-exempt services with respect to primary users, and exceptionally in specific allocations where a case can be made for a required quality of service (e.g. for applications where an element of safety might apply).

7.2.3 Furthering Harmonisation of Collective Spectrum Use

- Harmonisation of frequency bands and technical conditions is most important for equipment that is internationally mobile, and where there are significant economies of scale. Unlike many licensed applications, harmonisation of collective use is not required for reasons of spectral efficiency because most such applications are relatively low powered; consequently, international co-ordination issues are negligible.

- Under the existing voluntary arrangements many harmonised allocation proposals have been implemented gradually by individual Member States, resulting in continued fragmentation of national frequency allocations and creating a barrier to the development of new wireless technologies and applications for the European market.

- There is evidence that Europe sometimes takes a reactive approach to global wireless developments, such as the recent introduction of low power FM micro-transmitters. This can be detrimental to consumers who are denied the benefits of new products that are available elsewhere in the world and presents enforcement problems.

7.3 Recommendations for Speeding up and Simplifying Spectrum Access

Relative to the approach used in the U.S., the classification of licence-exempt spectrum in Europe appears inflexible and this may in part explain why the U.S. has pioneered more innovation in licence-exempt bands.

The existing categorisation of collective use allocations, as reflected in ERC Recommendation 70-03 and the current draft EC Decision on Short Range Devices (SRDs) is complex, unwieldy, and inconsistent with broader moves in the EU towards technology and application neutrality in spectrum management. In order to provide maximum flexibility of spectrum use and to facilitate innovation in the wireless market, constraints on the collective use of spectrum should be kept to the minimum required to ensure an adequate quality of service and to avoid harmful interference to other spectrum users. Application or

technology specific allocations for collective use should be retained only where these can be objectively justified, e.g. in terms of safety or quality of service requirements. Elsewhere, constraints on collective use bands should be limited to those required to avoid harmful interference.

Many of the existing SRD applications defined in ERC Recommendation 70-03 have particular requirements in relation to health, safety, security or other operational considerations that necessitated a higher quality of service than other SRD applications and there is therefore justification for application or technology specific applications to apply in these cases. In other cases, notably non-specific SRDs, wireless data transmission and wireless audio, we do not believe such constraints are justified and recommend that these allocations should become technology and application neutral, subject only to appropriate limits of in-band and out-of-band emissions to avoid harmful interference to other users.

Recommendation 1: Simplify categorisation of collective use spectrum

To facilitate understanding and awareness of collective spectrum use, we recommend that frequency allocations for collective use be grouped into three specific categories. This will differentiate clearly between allocations that are constrained to particular applications or technologies on quality of service / co-existence grounds and those that are available for general use with minimal constraints. The three categories should be defined as follows:

Category A: Licensing or co-ordination required to avoid interference to licensed, non-collective use applications, or to facilitate future re-farming.

Category B: Limited to specific applications and/or or technologies in order to reduce the risk of interference and maintain an acceptable quality of service.

Category C: No limitation on the applications or technology other than those required to avoid harmful interference.

A substantial cause of delay in the introduction of new allocations for collective spectrum use is the time taken to undertake technical compatibility studies We therefore believe that the Commission and CEPT should establish a structure and process that allows a more concentrated effort to be applied in order to reduce the time to gain harmonised spectrum allocations for new collective use applications and thereby reduce the time to market. The resource identified should undertake the Regulatory Impact Assessments and Compatibility Studies required in supporting EC Decisions. In addition, prioritisation of effort for strategically important areas of spectrum and regulation needs to be managed by a central body.

Recommendation 2: Make provisions for a full-time resource to be available (either permanent or ad-hoc basis) to undertake the necessary market and technical studies to inform decisions on future spectrum allocations

The Commission and CEPT should establish a structure and process that allows more concentrated effort to be applied. This would reduce the time to gain harmonised spectrum allocations for new collective use applications and thereby reduce the time to market. The resource identified should undertake the Regulatory Impact Assessments and Compatibility Studies required in supporting decisions. In addition, prioritisation of effort for strategically important areas of spectrum and regulation needs to be managed by a central body.

Information on the availability of spectrum for collective use in Europe is currently available from a number of sources, including SMAs, EFIS and ERC Recommendation 70-03. We also note that information on collective use is not included within the European Common Allocation Table. We believe that in order to maximise the potential benefits from collective use of spectrum it is essential to have a single, reliable, readily accessible source of information on the availability of spectrum, both for specific applications or technologies and for use on an application and technology neutral basis. As the EFIS database already attracts a high level of awareness and use by European industry, this is probably the most appropriate vehicle to provide such a resource. However, it is important that the information presented in EFIS is comprehensive and up-to-date, and that the information is fully reflected in SMA information documents and the European Allocation Table.

Recommendation 3: A single, definitive, on-line information resource on harmonised collective spectrum in Europe should be established

We recommend that the EC should mandate the CEPT to establish EFIS as the definitive information resource on harmonised collective use spectrum in Europe. Spectrum that is harmonised throughout the EU should be one of the high level choices when searching the EFIS database. In addition, the European Common Frequency Table, as accessed through EFIS, should also be enhanced to show clearly all spectrum where collective use has been harmonised across Europe, by CEPT and/or EC measures, with clear cross references to the relevant technical and regulatory conditions for use of the spectrum. The Commission could assist this process by requiring Member States, under Article 5 of the Radio Spectrum Decision to publish the relevant information on the status compliance with EC and CEPT harmonisation measures in their National Frequency Allocation Tables and submit the information to CEPT at least every six-months.

7.4 Recommendations for Addressing Future Spectrum Demand

Feedback from industry suggests existing harmonised allocations as defined in ERC Recommendation 70-03 are probably sufficient to meet current demand, proving these are implemented in a timely manner across the EU. However, demand for spectrum for collective use applications is expected to grow over the next 10 years. Scarcity of radio spectrum means that it is not a forgone conclusion that requirements for additional collective

use spectrum can or should be met. We have made a number of recommendations aimed at addressing the following issues associated with catering for future demand growth:

- There is no clear means of determining how to decide how much additional spectrum to allocate to exclusive (licensed) versus collective spectrum use.
- Current requirements for spectrum for collective use can be met by existing allocations (so long as these are implemented by Member States) but accelerating growth in demand for collective use applications in future could outstrip the available supply and/or lead to degradation of service quality.
- Difficulties in re-farming spectrum once allocated to collective use act as an impediment to making further collective use allocations.
- Spectrum acquisition through market means for collective spectrum is unlikely to occur. This means that SMA or EU intervention will be required to determine new allocations at a national or European level, and the question of whether regulators should require the deployment of new technologies needs to be addressed.
- There is a lack of market information on collective use of spectrum and the extent of use of existing collective use bands.
- More market information on trends in collective use of spectrum and monitoring information on the use of and extent of congestion in collective use bands is required to determine whether such bands could become congested in future and as an input to decisions concerning the allocation of additional spectrum for collective use.

Our recommendations cover three specific areas, namely the decision making process for allocating new spectrum for collective use, provision for ultra-low power device operation in licensed radio spectrum and potential candidate bands for future collective use allocations.

Recommendation 4: Establish a transparent, objective methodology for deciding whether to allocate spectrum for collective use

Decisions about the balance between licensed and licence exempt spectrum should be made in a transparent manner considering all feasible options and using all available information on the costs and benefits of these options. The EC's regulatory impact guidelines provide a template for making such assessments and we recommend that this is adopted by the Commission and CEPT when considering potential candidates for collective spectrum use in the future. The analysis should be based on information such as the following:

i) The extent of use of collective use spectrum, gathering through monitoring activities undertaken by SMAs or possibly industry.

ii) Trends in the deployment of collective use applications/equipment. This will need to be supplied by industry or possibly collected through consumer surveys conducted by SMAs or national statistics organisations.

iii) International trends in collective use applications gathered from industry and other SMAs.

It is recommended that the Commission develops ways in which this information can be gathered on a systematic basis through co-operation with industry and SMAs.

Recommendation 5: The following frequency bands should be considered as potential future candidates fro collective spectrum use and analysed in accordance with Recommendation 4:		
Band	Category	Comments
47-68 MHz	C	Will no longer be required for broadcasting following digital switchover and is unsuitable for other licensed use due to the risk of interference arising from anomalous long-distance propagation effects. This band could be attractive for longer range, higher powered collective use applications.
862–872 MHz	C	This entire band should be made available on an application neutral basis subject to the use of spread spectrum technology to minimise the risk of interference to existing users of the band. This would provide a European alternative to the established and successful 900 MHz ISM band in North America. This extended band would make use of spectrum on either side of the existing 863 – 870 MHz collective use band that is currently allocated to other services in some Member States but is very underused in practice
915–917 MHz	B	Consideration should be given to the introduction of RFID interrogation systems in this band, to cater for growing demand for these devices. Compatibility studies should be undertaken to investigate the potential impact of such systems in a variety of deployment scenarios on GSM and UMTS base station receivers operating immediately below 915 MHz.
40.5–42.5 GHz	C	This band, currently harmonised for Multimedia Wireless Systems should be considered as an early potential candidate for collective use, in view of the absence of any current interest in the use of this spectrum for licensed system deployment. In the longer term, consideration should be given to making most of the spectrum above 40 GHz available for collective use, with the possible exception of those bands already identified for specific licensed applications, such as the fixed link band at 55 GHz, or where there are other services such as radio astronomy that may require protection at certain locations.

Recommendation 6: Provision should be made for operation of ultra-low power devices in licensed spectrum, akin to the provisions already in place in North America and Japan

The Commission should mandate CEPT to develop appropriate spectral mask for ultra-low power underlay operation in specific licensed bands, using recent work relating to FM micro transmitters and UWB as templates for this work. This would give certainty to licensed users concerning the potential underlay operations in their bands and create opportunities for new innovative applications and devices. The choice of bands for such operation should be undertaken cautiously as in some cases underlay operation may limit the licensed users' flexibility and may necessitate more advanced interference mitigation techniques than are currently available.

7.5 Recommendations for Furthering Harmonisation of Collective Use Allocations

Our research has shown a very strong desire for greater harmonisation across Europe of both frequency allocations and the usage conditions attached to spectrum allocations associated with collective use. This is particularly important at frequencies below 1 GHz, where relatively few of the allocations that are identified in ERC Recommendation 70-03 are harmonised throughout Europe. The lack of harmonisation is a particular problem in relation to non-specific SRD allocations as it is these that lend themselves most too innovative new applications.

We therefore feel that a more proactive stance needs to be taken by the Commission in relation to furthering the harmonisation of spectrum allocations across the EU. The current draft Decision on SRDs appears to be a step in this direction, however we note that the scope of this is currently limited to allocations where harmonisation has already taken place (albeit following lengthy delays in some cases) under the existing voluntary arrangements.

The current voluntary approach to harmonization of spectrum in Europe, as embodied in ERC Recommendation 70-03, has been successful in some cases, but due to the fragmented nature of spectrum use in EU Member States long delays have occurred in the implementation of harmonisation measures. A number of important harmonisation initiatives, for example relating to RFID devices, digital PMR and the deployment of spread spectrum equipment below 1 GHz, have failed to progress due to delayed implementation by individual Member States. We therefore feel that greater use should be made of mandatory EU harmonisation powers, to provide greater regulatory certainty for manufacturers and users.

The existing Recommendation 70-03 allocations are based on extensive technical compatibility studies and we therefore consider these to be a sound basis for harmonised collective use of spectrum in the EU, subject to the removal of any technology or application specific constraints that cannot be objectively justified, in line with Recommendation 1 above.

We estimate that the NPV to the EU of harmonising collective use spectrum lies between €463 billion and €898 billion. Such benefits are substantial. For example: the higher NPV of €898 billion is equivalent to a perpetual annual net benefit of €36 billion, or 0.35% of the

EU's current GDP, if discounted at 4% per year. For the lower estimate it represents €19 billion, or 0.17% of the EU's current GDP.

Our estimates are uncertain, however on balance we believe that they are likely to represent an under estimate rather than an over estimate.

Recommendation 7: Replace existing voluntary approach to collective use harmonisation with mandatory EU-wide allocations backed by an expanded EC Decision

The existing ERC Recommendation 70-03 allocations should be reviewed, re-categorised in line with Recommendation 1 and incorporated into a revised and expanded EC Decision covering all harmonised collective use allocations.

Our research has shown that international developments in collective spectrum use, particularly those where collective use is particularly well established such as the U.S, Japan and Korea, need to be monitored more closely. The EU therefore needs to be more proactive in identifying new international developments in collective spectrum use, and more flexible in accommodating them under existing regulations.

Recommendation 8: Establish greater liaison with other international spectrum Policy makers, to extend EU influence on global spectrum harmonisation.

This should include periodic dialogue between the EC and SMAs in other regions and jurisdictions to identify future opportunities for global harmonisation of collective spectrum use. This would also provide an opportunity to promote European spectrum allocation initiatives at a global level, to the potential advantage of European industry.

8 Glossary

3G	Third Generation
AFA	Adaptive Frequency Agility
AIP	Administrative Incentive Pricing
ATPC	Automatic Transmitter Power Control
CCR	Co-operative Cognitive Radio
CEPT	European Conference of Post and Telecommunications Administrations
CISPR	Special International Committee on Radio Interference
DECT	Digital Enhanced Cordless Telephone
DFS	Dynamic Frequency Selection
DSSS	Direct Sequence Spread Spectrum
DVB	Digital Video Broadcasting
ECC	European Communications Committee
EFIS	European Frequency Information System
EIRP	Effective Isotropically-Radiated Power
EPOS	Electronic Point of Sales
ERMES	European Radio Messaging System (former pan-European paging standard)
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
FWA	Fixed Wireless Access
GHz	Gigahertz (frequency of one thousand million Hertz)
GPS	Global Positioning System

GSM	Global System for Mobile Communications
HDTV	High Definition Television
HIPERLANs	High Performance Radio Local Area Network
IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISM	Industrial Scientific and Medical
ITS	Intelligent Transport System
ITU	International Telecommunications Union
KHz	Kilohertz (frequency of one thousand Hertz)
LAN	Local Area Network
LBT	Listen Before Transmit
LPRA	Low Power Radio Association
MHz	Megahertz (frequency of one million Hertz)
MIC	Ministry of Information and Communication
MIMO	Multiple Input Multiple Output
MWS	Multimedia Wireless Systems
NFPG	National Frequency Planning Group
OFCOM	Office of Communications
OFDM	Orthogonal frequency-division multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OOK	On Off Keying
PMR446	Personal Mobile Radio using the 446MHz part of the UHF range which is open without licensing for personal usage in most countries.
PT43	ECC Project Team 43
QoS	Quality of Service
RA	Radio Communications Agency

RFID	Radio Frequency Identification Device
RIA	Regulatory Impact Assessment
RSA	Recognised Spectrum Access
RSC	Radio Spectrum Committee
RSPU	Radio Spectrum Policy Unit
RSS	Radio Standards Specifications
RTTT	Road Transport and Traffic Telematics
SARA	Short Range Automotive Radar Frequency Allocation
SDR	Software Defined Radio
SMA	Spectrum Management Authority
SNR	Signal to noise ration
SRD	Short Range Device
SRDoc	Systems Reference Document
TD-CDMA	Time Division Code Division Multiple Access
TFTS	Terrestrial Flight Telephone System
UHF	Ultra High Frequency (300 MHz – 3 GHz)
UKSSC	UK Spectrum Strategy Committee
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wideband
VHF	Very High Frequency (30 – 300 MHz)
WiFi	Wireless fidelity a term for certain wireless local area networks that use specifications conforming to IEEE 802.11b.
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WRC	World Radio Conference

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Study on Legal, Economic & Technical Aspects of 'Collective Use' of Spectrum in the European Community

Appendices

November 2006

The opinions expressed in this study are those of the authors and do not necessarily reflect the views of the European Commission

Mott MacDonald

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This report was prepared by Mott MacDonald Ltd, Aegis Systems Limited, IDATE, Indepen Ltd and Wik Consult for the Radio Spectrum Policy Unit (RSPU) of the Information Society Directorate-General of the European Commission. Mott MacDonald, Aegis Systems, IDATE, Indepen and Wik Consult wish to thank the RSPU for their assistance and for providing expert comments on the draft. We also wish to thank national spectrum management authorities and stakeholder representatives who participated in our interviews, questionnaire and workshop.

This report represents the work of Mott MacDonald Ltd, Aegis Systems Ltd, IDATE, Indepen Ltd and Wik Consult GmbH and does not necessarily represent the views of the Radio Spectrum Policy Unit or any other group.

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1 Introduction

This document contains the supporting information in the form of Appendices for the main report of the same title[1].

The Appendices were prepared by Mott MacDonald Ltd, Aegis Systems Limited, IDATE, Indepen Ltd and Wik Consult for the Radio Spectrum Policy Unit (RSPU) of the Information Society Directorate-General of the European Commission[2]. Mott Macdonald, Aegis Systems, IDATE, Indepen and Wik Consult wish to thank the RSPU for their assistance and for providing expert comments on the draft. We also wish to thank national spectrum management authorities and stakeholder representatives who participated in our interviews, questionnaire and workshop.

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2 Appendix A: Quantifying the costs and benefits of harmonising collective use spectrum across the EU

2.1 Introduction

Should the European Commission introduce measures which compel harmonisation of the collective use of spectrum? Such measures would compel member states to allocate common frequency ranges for collective use. They would speed up the process of harmonisation and generate both economic benefits and costs. What is the scale of the net benefits which result? To answer this question we have implemented the five step approach specified in Figure 1. We describe each step in the remainder of this paper.

Figure 1 Overall approach to estimating the costs and benefits of EU wide harmonisation

Step	Description
1	Identify LE applications which generate major economic benefits
2	Make projections of these benefits and calculate their net present value (NPV)
3	Consider the impact of EU harmonisation of spectrum on the NPV of the net economic benefits from these applications when compared with a counterfactual in which harmonisation takes place on a voluntary basis
4	Assess the costs of harmonisation
5	Gross up from the incremental benefits of the three selected LE applications to LE applications in general

2.1.1 Step 1: identify licence exempt applications which generate significant benefits

It is clear that many licence exempt applications generate relatively modest net benefits. But some are of fundamental importance to the EU's economy. In a parallel study for Ofcom to consider this issue[3] we have assessed the economic value of 10 selected LE applications and identified three which generate major benefits and where harmonisation is important because economies of scale in production and international portability of devices are significant:

- The use of short range radars in cars to reduce accidents
- The use of RFIDs in the retail sector to reduce inventory management and in-store labour costs. Note this excludes use of RFIDs in other sectors e.g. transport, medical etc.

[3] The economic value of licence exempt applications, Indepen, Aegis and Ovum for Ofcom, June to November 2006

- The use of public access WiFi service to provide nomadic communications services. This application complements fixed line broadband and 3G mobile services. Potentially it both substitutes for higher cost mobile technologies and stimulates use of broadband on a nomadic basis.

2.1.2 Step 2: make projections of the net benefit of these applications

Drawing on the Ofcom study we have made projections for the net benefits generated by these three applications as shown in Figure 2 and Figure 3

Figure 2 The net benefits from the three applications in the EU

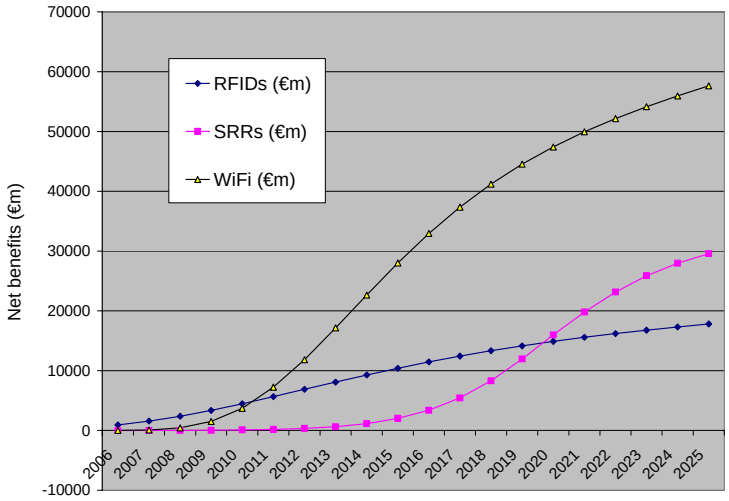


Figure 3 The NPVs of the three applications for the EU with full harmonisation

Application	NPV (€bn)
RFIDs in retail	204
Short range radar to reduce collisions	223
WiFi public access services	587

These projections:

- Are based on UK projections. To gross up to the EU as a whole we multiply by 6.0. This is the ratio of the GDP of the EU to that of the UK*4*

- Represent the most likely projections of the value of each application.*5*

4 Data is from epp.eurostat.ec.portal

5 The study for Ofcom also makes low and high demand projections.

- Assume that demand is unconstrained by spectrum scarcity or by limitations on economies of scale in the production of the necessary devices. In other words these projections assume EU harmonisation of all of the spectrum required by the three applications.

2.1.3 Step 3: consider the impact of EU harmonisation on the net benefits

The net benefits shown in Figures 2 and 3 assume full EU harmonisation. What happens to these values if there is no harmonisation or if harmonisation occurs only slowly, as is likely to happen if harmonisation is voluntary for member states? We model two possible outcomes:

- Scenario 1: the benefits of Figure 2 are delayed. We assume a 5 year delay in modelling such a possibility

- Scenario 2: long term demand is substantially reduced. All three of the applications involve mass markets of highly portable devices and two of the markets are likely to be particularly price sensitive (RFIDs and WiFi). Without harmonisation economies of scale in production are limited, device prices are significantly higher, and so the viability of the application is limited as illustrated in Figure 4. We assume that demand is reduced by 70% without harmonisation under Scenario 2 for RFIDS and WiFi and is the same as Scenario 1 for SRRs (i.e. benefits are delayed 5 years).

Figure 4 shows the impact of these two scenarios on the net present value of the three applications.

Figure 4: The possible impact of voluntary harmonisation

Application	Possible impact of voluntary harmonisation
Short range radars (SRRs)	Device prices remain high (currently €50 each) Demand for SRRs is limited to luxury cars in the short term Impact on injuries, deaths and damage to cars is correspondingly reduced SRR benefits are delayed but not reduced in the long term
RFIDs in the retail sector	Price of RFID tags remains at several € cents RFID tagging of individual items is not justified in most cases RFIDs are limited to “back of store” applications This reduces benefits by 85% (1)
Public access WiFi services (2)	Requirement for frequency agile chips raises prices significantly Installation of WiFi chips in basic laptops and mobile terminals substantially delayed Take up of WiFi public access services correspondingly delayed

(1) Wal-Mart estimates that 85% of cost savings from use of RFIDs comes from “in-store” applications”

(2) This scenario has not occurred. But it may well have done if WiFi spectrum had not been harmonised on a global basis

Figure 5: The impact of harmonisation – NPV of net benefits in €bn

Application	*NPV of net benefits (€bn)*			*Incremental benefits of harmonisation (€bn)*	
	Full harmonisation	*Scenario 1*	*Scenario 2*	*Scenario 1*	*Scenario 2*
RFIDs	204	148	61	57	143
SRRs	223	134	134	89	89
WiFi	587	401	176	186	411
Total				332	643
Average				111	214

2.1.4 Step 4: Assess the costs of harmonisation

Harmonisation generates costs as well as benefits in terms of:

- The cost of clearing existing users from the spectrum designated for harmonisation
- The cost of less efficient use of spectrum because of variations in demand across countries. This could lead to some countries, where demand is low, to allocate too much harmonised spectrum and others, when demand is abnormally high, to allocate too little.

To assess the scale of these costs we consider the position of the three selected applications against these two measures below.

In addition to these two costs there is also a cost associated with the EU specifying frequencies for harmonisation which are out of line with market developments in North America and East Asia(see Chapter 3). It is clearly important for the EU to minimise this cost by considering such developments before reaching any harmonisation decision.

2.2 Short range radars

Short range radars use harmonised spectrum at 24 and 77 GHz with strict limits on the density of use of the 24 GHz allocation[6]. There were no clearance costs at 77 GHz and the costs of less efficient use of this spectrum because of harmonisation are insignificant given that:

- Short range radar used very high frequencies for which other uses are limited.
- The short range and directional use of this spectrum by short range radars means that there are opportunities for its use to be shared with other, as yet unidentified, applications.

[6] Which is also designated in the USA for the same purpose

2.3 RFIDs

RFIDs are designed to respond to interrogators in the frequency range 860 to 960 MHz. So there is a wide range of options for harmonised bands to use with the tags[7]. The EU has proposed harmonised use of RFIDs in the 865 to 868 MHz band. But so far member state implementation of this recommendation is poor[8].

Clearance costs for the recommended harmonisation are low. There may be military applications in some countries and there are a few old CT2 devices using the band. More spectrum is required if interrogators are to work at the densities implied by our net benefit projections. Possible expansion bands include 915 to 917 MHz and 870 to 877 MHz. Again clearance costs should be low.

RFIDs can be used across a wide range of frequencies. So member states have considerable freedom to adjust national allocations to meet national demand patterns. This should minimise the inflexibility costs introduced by harmonisation.

2.4 WiFi

Spectrum for WiFi is already harmonised. WiFi uses 83.5 MHz of spectrum at 2.4 GHz where it co-exists with other unlicensed users such as microwave ovens, wireless audio links and outside broadcasts. It also uses 300 MHz of spectrum at 5 GHz where it co-exists with use by devices such as radars.

In both cases the ability of WiFi, with its listen before talk functionality and use of spread spectrum techniques to minimise the impacts of interference, to co-exist with established applications means that the need to clear existing applications from the harmonised spectrum is limited.

It is more difficult to assess the inflexibility costs of the WiFi spectrum allocation. But again we believe that they are likely to be modest given that:

- There is a wide range of applications which are likely to use WIFI (public access telecommunications, home data networks, home entertainment, wireless building automation and home automation)
- The universal appeal of these applications should mean that national variations in demand for this spectrum are limited.

[7] It is also desirable to harmonise the frequency used by the interrogators to much narrower bands. But it is mass production of the tags which will ultimately drive RFID prices down and determine what applications are viable

[8] See for example the latest version of ERC Recommendation 70-03

2.5 Conclusions

Based on the analysis of the three individual applications set out above we conclude that:

- The costs of clearing spectrum for harmonisation are likely to be modest given that these LE applications can often co-exist with other applications and use frequency agility techniques to find otherwise unused spectrum
- The inflexibility in spectrum use introduced by harmonisation is modest in practice
- Overall the costs of harmonisation are likely to be small compared with the benefits. We therefore do not attempt to quantify them.

2.5.1 Step 5: gross up for other applications

Based on the analysis so far we estimate (in Figure 5) that the NPV of the net benefits of harmonisation are worth between €332 billion and €643 billion, depending on whether we consider Scenario 1 or Scenario 2. These estimates reflect the impact of the three selected applications alone.

In practice it is highly likely that in future other LE applications, where harmonisation is equally important for maximising economic benefits, will emerge. Looking to the future we take the average benefits for the three applications examined as an indicator of the benefits of harmonisation for major new applications (which increasingly have the characteristics of being mobile and requiring scale economies to be economic). In particular we assume that:

- Applications where harmonisation is important emerge every five years for the next 30 years. This period reflects the fact that WiFi, short range radar, and RFID applications are projected to generate net benefits which exceed 0.1% of GDP within a six year period (ie three years between important applications). This may be a rather conservative estimate. The steady improvements in battery technology combined with the falling costs of transceiver chips means that other, as yet unidentified, major LE applications are likely to become viable over the next two decades. This could shorten the interval between major applications emerging
- The incremental value of harmonisation for each such application has a net present value of €111 billion (Scenario 1) or €270 billion (Scenario 2). The NPV used is the average of the individual applications of Figure 3
- The NPV of each application is then discounted back to 2006 using a real discount rate of 4%[9].

With these assumptions we estimate that the NPV to the EU of harmonising LE spectrum lies between €463 billion and €898 billion. Such benefits are substantial. For example the higher NPV of €898 billion is equivalent to a perpetual annual net benefit of €36 billion, or

[9] The rate recommended by the Europe an Commission in its impact assessment guidelines, SEC(2005)791, June 2005

0.35% of the EU's current GDP, if discounted at 4% per year. For the lower estimate it represents €19 billion, or 0.17% of the EU's current GDP.

Our estimates are clearly uncertain. On balance we believe that they are likely to represent an under estimate rather than an over estimate because:

- They are built up from an estimate of the benefits of harmonisation for a small number of applications.
- Our estimates of the benefits of harmonisation for all future collective use applications are only about 40% more than the incremental benefits of harmonisation for the three known applications – WiFi, RFIDs and SRRs. Harmonised spectrum for future use of RFIDs in sectors other than the retail sector alone could generate benefits of the same order as those for the use of RFIDs in the retail sector.
- Although we have not counted the costs of harmonisation our qualitative analysis suggests that these costs are modest

3 Appendix B: Survey of spectrum regulatory authorities and spectrum users

3.1 Methodology

Our survey comprised two interrelated methodologies:

- A series of interviews, conducted during the early phases of the study;
- Responses to a web-based questionnaire.

The two were both driven from a common set of questions. Moreover, the interviewer would transcribe the interview results into the questionnaire. Thus, the two processes were used to generate a single, integrated database.

There were two different versions of the questions: one for spectrum regulatory authorities, and one for spectrum users.

Access to the questionnaire was mediated by a requirement for a user id and password.

The web-based questionnaire required the respondent to indicate how the data could be used: whether solely for statistical purposes or quotation without attribution. We strove to respect any user desire for privacy or anonymity.

We feel that the survey has generated useful results and insights, but we would caution that the respondents can not be viewed as being a statistically random or a representative sample. Those respondents who came forward on their own may reflect self-selection bias; those respondents whom the study team pressed to respond may reflect a bias in the sense that the team itself considered their responses to be important. Also, the sample size is a small population. The results are indicative and suggestive, but they can not be assumed to be fully representative of the community of interest, however defined.

3.1.1 Sample characteristics

Our sample comprises 12 spectrum management authorities and 21 users. 10 of the spectrum management authorities are from Member States of the European Union; 2 of the regulatory authorities are North American.

In this Appendix, we sometimes refer to spectrum management authorities for brevity as regulators; however, the reader should recognise that spectrum management authority sometimes rests, not with the regulatory authority, but rather with the government (i.e. the ministry).

3.2 Detailed responses –Spectrum Management Authorities

We present the responses module by module, where each module represents a sequence of interrelated questions. This section, Section A.3, summarizes the responses provided by *spectrum management authorities*. Spectrum *users* saw a significantly different set of questions.

3.2.1 Spectrum currently available for "collective use"

A.i We request detailed information about the five most commercially significant spectrum bands in which your country currently practices collective use.

All of the European spectrum management authorities who explicitly responded indicated support for the 2.4-2.4835 GHz band (and the North American regulators indicated support for harmonisation of the 2.4 GHz band at the North American level). Some impose technical conditions, while others impose notification requirements, but only one indicated that an individual right of use was required. Support for the 5.15 – 5.35 GHz band seemed also to be widespread. The 2.4 band is largely used for wireless LANs, various SRDs, RFID, equipment for detecting movement, and for various amateur applications, while the 5.15-5.35 band is viewed more in terms of wideband data transmission. Both of these bands are harmonised at the European level.

The 5.725-5.825 GHz band is a more complicated story. Several spectrum management authorities noted the lack of harmonisation for wideband data transmission, and a number indicated specific challenges in their respective countries due to conflicts with pre-existing systems, notably with military radars. One spectrum management authority noted that the band is largely used for wireless cameras.

Many included RFID in 865-868 MHz, 1.880-1.900 GHz (DECT) among the five most important bands, noting that these were harmonised allocations in Europe.

A number of authorities referred to 433.05-434.79 MHz (non-specific SRDs, such as key fobs, animal tracking devices, social alarms, and remote control). European harmonisation was viewed as very important in this band, and indeed in the collective use bands in general.

Several authorities mentioned bands in the general range of 863-870 MHz, where each had a slightly different emphasis on their use. One mentioned 863-865 MHz for wireless audio (headphones and microphones). One spoke of 864-865 MHz (cordless audio devices). A third spoke of 863-870 MHz (non-specific SRDs, RFID, and social alarms).

Other European spectrum management authorities provided insights about the collective use allocations that they viewed as most significant in light of their respective national circumstances. One referred to 37-39.5 GHz, 57.1-57.8 GHz and 58.6-58.9 GHz (fixed radio systems), and 21.65-26.65 GHz (SRDs and Road Transport and Traffic Telematics). Another referred to 26.957-27.283 MHz (non-specific SRDs and inductive applications).

One spoke of 446-446.1 MHz for mobile – known as PMR446 (except aeronautical mobile);

North American respondents spoke of the 5.47-5.725 GHz band (also mentioned by a European respondent as a wireless LAN band) and the 902-928 MHz bands, both of which are largely harmonised on a North American basis. 3.65.3.7 GHZ and 24.05-24.25 GHz were also mentioned in North America.

A.ii What is the total amount (in MHz) of spectrum allocated to common use in your country?

Responses were of a very uneven quality. Since we defaulted the first three bands to the 2.4 GHz, 5.8 GHz and 5.1 GHz bands, all spectrum management authorities would automatically show these in their totals if they did nothing else. One European regulator indicated 100 MHz of additional collective use bands; another indicated roughly 30 MHz of additional collective use spectrum; and yet another, 13.5 MHz of additional collective use spectrum.

A.iii Types of collective use: Does your country make use of licence-exempt spectrum commons? Does your country make use of spectrum underlays? Does your country make use of spectrum overlays?

Nearly all spectrum management authorities answered that their country made use of licence-exempt spectrum commons (although one indicated that the term had no legal meaning in their system).

Among European regulators, three responded that their country uses neither overlay nor underlay. Three indicated some use of underlay in their respective countries, with one of these indicating that, while UWB would be the first “pure” use of underlay, elements of this exist in many bands.

Only one European spectrum management authority said that overlays were in use in their country, namely accommodation of wireless LANs in the 5.4 GHz band by dynamically adapting to pre-existing military use by selecting a vacant channel and adjusting power.

A.iv Is any spectrum set aside on a collective use basis for experimental, test or development applications?

The European regulators who responded to this question all indicated that no collective use spectrum is set aside for these purposes. Instead, such requests were accommodated on a case by case basis, using spectrum that happens to be available at the time. One explicitly noted that the test/trials may not cause undue interference to other radio services. See, however, section A.viii below, where one spectrum management authority noted that they make 100 KHz available between 30 and 470 MHz for experimental and/or temporary uses.

A.v Are there examples of different licence-exempt systems co-existing within a given spectrum allocation (for example, in the 2.4 GHz or 5.8 GHz bands)?

Several spectrum management authorities pointed to the coexistence of applications such as WiFi, Bluetooth, wireless keyboards, RFID, non-specific SRDs in the 2.4 GHz band, and a few mentioned a subset of these in the 5.8 GHz band.

A.vi Where can information on the availability of spectrum for collective use in your country be found?

The following examples of information provided by NRAs on collective use spectrum were provided. Typically these take the form of tables listing harmonised (European) and national allocations.

- Belgium: www.bipt.be provides a table of frequencies, indicating permissible applications and whether a licence is required.
- Canada: Radio Standards Specification (RSS) - 210 at the following Internet address:
  http://strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/en/sf01320e.html
- Denmark: This information is to be found in 3 different documents:
  1- The interactive frequency plan:
  http://frekvensplan.itst.dk/frekvensuk/asp/band.asp
  2- Executive Order No. 1266 of 10 December 2004 regarding use of frequencies without an individual license (in Danish):
  http://www.itst.dk/image.asp?page=image&objno=164107372
- Finland: Regulation FICORA 15 are available at www.ficora.fi
- Hungary: 1. Decree of the Government No. 346/2004. (XII.22.) Korm. as modified with decrees of the Government No. 167/2005. (VIII.24.) Korm, No. 19/2006. (I. 31.) Korm. and No. 59/2006. (III. 21.) Korm. on establishment of national allocation of frequency bands.
  2.Decree of the Minister of Informatics and Communications No. 35/2004. (XII. 28) IHM as modified.
- Ireland: National Table of Frequency Allocations:
  http://www.comreg.ie/_fileupload/publications/ComReg0477.pdf
- Spain: The National Table of Frequency Allocations (CNAF), published in the Spanish Official Gazette (BOE) on June 28th 2005.

A.vii What percentage of collective use spectrum is based on harmonised European allocations?

Most NRAs did not provide a specific response, however one spectrum management authority asserted that some 94% were harmonised at the European level. Another emphasised that 90% of collective use allowances were based on harmonised European allocations, and that 10% (primarily SRDs) were based on national allocations. A third asserted some 98%.

A.viii For bands other than those described in response to question 1, are there collective use bands that are primarily used for specific applications or devices?

One respondent said that between 30-470 MHz, 100 kHz was set aside for experimental and/or temporary uses. Another mentioned several bands between 59.75 kHz and 135 kHz that are used for inductive applications. A third referred to the PR27 citizens band allocation (26.96-27.410 MHz) and to motion detection and alerts (9.2-9.975 GHz). A fourth noted that they try not to allocate spectrum for specific applications – they strive instead for technological neutrality.

3.2.2 Planned future development with regard to collective use

A.i Are there any new requirements for collective spectrum beyond what is currently available?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	6	50,0	54,5	54,5
	No	4	33,3	36,4	90,9
	No Answer	1	8,3	9,1	100,0
	Total	11	91,7	100,0	
Missing		1	8,3		
Total		12	100,0		

Most regulators noted a general increase in overall demand for spectrum, but they did not explicitly link this to an increase in the proportion allocated to Collective Use. At least two are actively studying demand. Two spoke of future WiMAX requirements in the 5.725-5.825 GHz band (where interference with military radar poses risks). One regulator noted the following potential demands:

- Radiofrequency Identification Systems (RFID) operating in the 865-868 MHz band, technical features according to European harmonization following ETSI regulation EN 302 208 and maximum authorised power of 2 W.
- Low-power UWB devices operating under 10 GHz. These devices are being studied and followed up by the possible CEPT ECC/DEC(06)xy. A Decision on the harmonisation of their conditions, as well as by other possible Decisions under study at the Radio Spectrum Committee (RSC) of the European Union Commission.

Very low-power voice transmission equipment in the 87.5-108 MHz band, as well as other uses in different frequency bands, harmonised through a Decision on SRDs currently under study at the Radio Spectrum Committee (RSC) of the European Union Commission.

Digital PMR 446 system, operating in 446.1-446.2 MHz band, is currently under study and consideration.

A.ii If so, what steps are being taken to accommodate these?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Allocate new license-exempt bands	1	8,3	20,0	20,0
	no actions are planned	1	8,3	20,0	40,0
	other	3	25,0	60,0	100,0
	Total	5	41,7	100,0	
Missing		7	58,3		
Total		12	100,0		

A.iii Are there any plans to change the conditions attached to current collective use spectrum bands?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	1	8,3	10,0	10,0
	No	7	58,3	70,0	80,0
	No answer	2	16,7	20,0	100,0
	Total	10	83,3	100,0	
Missing		2	16,7		
Total		12	100,0		

Most regulators either responded in the negative or else provided no answer. One noted the need to conform to ongoing changes in Recommendation 70-03 (which deals with Short Range Devices (SRDs). Two mentioned possible future implementation of UWB. One mentioned possible future requirements for the use of “politeness protocols” in some bands.

The FCC (USA) noted that their rules already permit private commons. Proceedings on underlays and on the use of the interference temperature are formally open, but it is not clear in what time frame they will close, if at all.

A.iv What is your perception of the future market demand for devices and applications requiring collective use of spectrum? How this is likely to impact on future spectrum requirements?

Some respondents felt that they had limited data available; those who expressed an opinion said that overall demand for spectrum would increase, and that demand for Collective Use spectrum would increase. Some spoke of migration from wired to wireless transmission as a driver, one spoke of RFID as a potential important driver, while others spoke of broadband wireless Internet access.

One expressed concerns about SRDs reducing the economic value of the spectrum to subsequent licensees. Several saw cognitive radio as representing the best opportunity to enable Collective Use in bands already allocated.

3.2.3 Regulatory aspects - Management model of the frequency bands for "collective use"

A.i Are there any new requirements for collective spectrum beyond what is currently available?

Most respondents spoke of underlay (including UWB), and several spoke of overlay (possibly including LBT and DFS).

Most respondents spoke of the concerns that existing licence holders have about possible interference caused by underlay and overlay systems. Several felt that technical rules (such as DFS) in conjunction with power limits could contain this risk. Three noted that higher power is permitted at higher frequencies (e.g. 1 W eirp at 5GHz and above).

A.ii Are there any legal or regulatory impediments to introducing certain kinds of collective use, e.g. restrictions on the provision of services to third parties?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	4	33,3	44,4	44,4
	No	4	33,3	44,4	88,9
	No answer	1	8,3	11,1	100,0
	Total	9	75,0	100,0	
Missing		3	25,0		
Total		12	100,0		

A number of respondents identified technical, market or competitive impediments, but no respondent identified a legal impediment to liberalisation of regulation. (These have been reflected in the responses above). One respondent observed that its national transposition of the European framework actually required it to allocate on a Collective Use basis wherever doing so would not cause harmful interference or service disruption. Another noted that it is unlawful to cause harmful interference to any licensed service.

A.iii What is the decision making process for allowing licence exempt or "light licensing" use in bands - e.g. is there any use of cost / benefit analysis or consideration of innovation gains versus displacement of other services.

Many users spoke of a process including in its early phases consideration of relevant CEPT recommendations, coupled with technical assessments; followed by some sort of regulatory impact assessment by a Decision (in some cases signed off by the Minister or some senior decision-maker).

Only one regulator spoke of economic cost/benefit analysis. This regulator indicated at length that they are considering using the auction mechanism to allocate spectrum bands to licence-exempt of "light licensing" allocation – where a band fails to fetch the reserve price at auction, they would consider allocating the band to some form of Collective Use. The choice between licensed versus licence-exempt use would in that case reflect a forward-looking prediction of revenue.

A.iv Do you think it is reasonable that licensed use of spectrum should attract a fee whilst licence-exempt use does not?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	11	91,7	91,7	91,7
	No	1	8,3	8,3	100,0
	Total	12	100,0	100,0	
Total		12	100,0		

No spectrum management authority identified this as a significant concern. Most respondents specifically commented that both kinds of spectrum users understand and accept the arrangement. Most also noted that exclusive licensees typically feel that they are paying for protection from interference. Two respondents noted that it would in any case be difficult to collect a fee from licence-exempt users (unless perhaps it was assessed at the time of sale of the associated equipment).

A.v How are the costs associated with managing licence-exempt spectrum recovered?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Licence fees	1	8,3	12,5	12,5
	General revenues	2	16,7	25,0	37,5
	Other	1	8,3	12,5	50,0
	No answer	4	33,3	50,0	100,0
	Total	8	66,7	100,0	
Missing		4	33,3		
Total		12	100,0		

Many respondents indicated that these costs were not specifically broken out. In effect, this would appear to imply that funding comes from general revenues in the absence of a specific commitment to fund from licence fees. One respondent indicated that they assess regulatory fees that are independent of licence fees.

A.vi What is your policy concerning: (1) Ultra Wideband Technologies? (2) Short Range Devices (SRDs); (3) Radio LANs (for public and private use); (4) Unlicensed PMR?

For UWB, no European regulator said that they currently permit it, but most indicated that they intend to as soon as agreement is finalised at a European level. For SRDs, most respondents explicitly expressed broad support for CEPT 70-03 (with minor national exceptions in a few cases). One noted that only PMR446 is licence-exempt.

A few national authorities included pointers to their respective rules, including Canada (RSS-210, with particular reference in the 5 GHz band to http://strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/en/sf01158e.html and Ireland http://www.comreg.ie/_fileupload/publications/odtr0271.pdf

A.vii Is collective use one of the options considered when developing spectrum refarming policy?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	7	58,3	70,0	70,0
	No	3	25,0	30,0	100,0
	Total	10	83,3	100,0	
Missing		2	16,7		
Total		12	100,0		

A.viii Comparing the total amounts of licensed and licence-exempt spectrum in your country, do you think that the amount of license-exempt spectrum is too much, too little, or about right?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	About the right amount of licence-exempt spectrum	7	58,3	87,5	87,5
	No answer	1	8,3	12,5	100,0
	Total	8	66,7	100,0	
Missing		4	33,3		
Total		12	100,0		

Eight of the twelve respondents indicated (either through their multiple-choice selections or through their comments) that the amount of licence-exempt spectrum in their respective countries is about right (although one of these indicated that more might be needed in the future). A ninth indicated that the percentage of spectrum under 30 GHz allocated to licence-exempt use is expected to rise from 6% to 7% over the next decade, thus apparently suggesting that the amount of licence exempt spectrum is not significantly out of line today. Only one respondent spoke of the need for more licence-exempt spectrum to support new applications, and of crowding in the 2.4 GHz band.

Two respondents noted that it is not necessary to make this determination for all time – it can be reviewed as needed.

A.ix Does your government have the legal authority to regulate the sale of unlicensed devices?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	4	33,3	57,1	57,1
	No	3	25,0	42,9	100,0
	Total	7	58,3	100,0	
Missing		5	41,7		
Total		12	100,0		

One respondent noted that they have to be a bit more conservative in their spectrum management practices than for instance the United States, precisely because their government lacks the authority to control the sale of devices (even though they have the ability to impose conditions of use).

3.2.4 Use and monitoring of the frequency bands for "collective use"

A.i Do you undertake monitoring of the use of bands allocated for collective use? If so, how extensive is your monitoring? If you monitor, how is monitoring implemented?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	7	58,3	63,6	63,6
	No	3	25,0	27,3	90,9
	No answer	1	8,3	9,1	100,0
	Total	11	91,7	100,0	
Missing		1	8,3		
Total		12	100,0		

Three respondents spoke of fixed monitoring capabilities to periodically and routinely survey large portions of the spectrum; others explicitly indicated that they have the capability to monitor intensively when a spectrum user who is entitle to protection complains of interference. Several respondents indicated that there is little systematic monitoring of licence-exempt bands (because users have no assurance of interference-free service in any case).

A.ii Have any estimates been made on the potential capacity of specific collective spectrum allocations (e.g. in terms of amount of data traffic or number of users/devices in a given area)?

Most respondents spoke of a lack of data. Some spoke of efforts to make estimates at a European level, while one indicated that a study at the national level was ongoing.

A.iii Have any problems been reported in the frequency bands allocated to collective use?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	10	83,3	83,3	83,3
	No	1	8,3	8,3	91,7
	No answer	1	8,3	8,3	100,0
	Total	12	100,0	100,0	
Total		12	100,0		

In response to a multiple-choice question, “What kinds of problems have been reported?”, 3 responded with congestion, 8 responded with interference, and 2 responded with other. One made no response.

Most regulators indicated that problems occasionally arose, but none seemed to indicate an unacceptable level of problems. One specifically noted that they had encountered surprisingly few problems.

Several spoke of congestion and/or harmful interference in the 2.4 band, particularly in areas with high density of use. A few spoke of issues in the 5 GHz band in their respective countries (with meteorological radars in the 5.6 – 5.65 GHz band and with military radars in the 5.725-5.825 GHz band).

One regulator spoke of problems at the borders in the 35 GHz band. Two respondents spoke of electronic car locks malfunctioning, in one case due to congestion, in the other due to interference from scientific instruments. Yet another spoke of garage door openers malfunctioning due to interference from military land mobile devices.

A.iv If problems have been reported, what actions if any have been taken?

Several respondents spoke of making licence-exempt spectrum available in the 5 GHz band in order to address congestion in the 2.4 GHz band.

Several respondents spoke of case by case resolution. One noted that licence-exempt users had to work the problem out themselves, since they had no assurance of protection. Another noted that the government could mandate withdrawal of non-compliant equipment.

One respondent’s agency held regular annual meetings with relevant associations.

In the aforementioned case of military land mobiles, the military issued a public notice explaining the problem, thus enabling manufacturers of garage door openers to make appropriate accommodations.

A.v Have any competition issues been identified been identified in connection with collective use?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	1	8,3	14,3	14,3
	No	5	41,7	71,4	85,7
	No answer	1	8,3	14,3	100,0
	Total	7	58,3	100,0	
Missing		5	41,7		
Total		12	100,0		

No significant, current concerns were raised. One respondent commented that competition issues tended to be of far greater concern in connection with Exclusive Use allocations than with Collective Use allocations.

3.2.5 The International Dimension

A.i What do you see as the biggest improvement that could be achieved at the European level regarding the "collective use" model of managing spectrum?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Greater harmonisation of spectrum allocations	3	25,0	60,0	60,0
	Greater flexibility in terms of technologies that can be dep	2	16,7	40,0	100,0
	Total	5	41,7	100,0	
Missing		7	58,3		
Total		12	100,0		

The response to harmonisation in this table probably understates the actual interest in harmonisation. Broad support for greater harmonisation on the part of European spectrum management authorities was clear throughout the responses, especially as regards SRDs.

Many respondents emphasized the importance of harmonization, and two emphasized the value of CEPT SRD harmonisation (70-03).

Two respondents indicated that both harmonisation and flexibility were important, thus implicitly rejecting the dichotomy implied by the question.

A.ii Should EU or CEPT based spectrum conditions be part of the national radio interface specifications or harmonised EN standards?

Several respondents expressed enthusiasm for CEPT harmonisation, but nonetheless emphasised the importance of national spectrum management authorities retaining the ability to diverge when necessary in order to accommodate national circumstances (including legacy allocations).

Two respondents noted that CEPT recommendations are harmonised but not necessarily followed.

A.iii What is your view of the role of an EU or CEPT level entity in relation to global bodies such as the ITU and non-European standards organisations such as the IEEE?

Two respondents noted that their role related to harmonisation of allocations, but not for the most part to standards. The IEEE operates for the most part in a separate space from the spectrum management authorities.

One response reflected the importance of CEPT in developing a coordinated European position at the ITU level, thus greatly enhancing the prospects for adoption of European positions.

A.iv How do you think collective use of radio spectrum compares between your country and countries outside Europe (such as Japan, South Korea, the USA, or Canada)?

Two comments received noted that in the US (and China, Japan and Korea), equipment has to undergo type approval; whereas in the EU it can be placed on the market as long as it conforms to the RTT&E Directive. One suggested that these tighter controls on sale enabled more liberal spectrum management practices.

One commenter noted that in the US, Japan, and Korea, Ultra Low Power SRDs need not be subject to customary arrangements of channelisation and power.

Several respondents spoke of the lack of harmonisation between regions. For example, RFID in the US operates at 915 MHz, but elsewhere typically at 869 MHz. Europeans tended to place far greater emphasis on harmonization than did North Americans. Multiple North American respondents (and one European respondent) said that harmonization in such cases was not necessarily a problem, as long as it did not add much cost to the devices – the technology is increasingly capable of accommodating variations. Analogously, GSM phones capable of supporting both US and European bands were initially expensive, but the capability is routinely available today at low cost.

A.v Do you think any particular country or region has a particularly favourable approach to collective use of spectrum that could be adopted in Europe?

No noteworthy comments were offered.

A.vi **It is possible that certain spectrum that was previously harmonised within Europe but is not currently utilised could be suitable for allocating to collective use. One example which we have identified is the former allocation to the terrestrial flight telephone system (TFTS) in the frequency range 1800 – 1805 MHz. On what basis should this spectrum be allocated? If you favour collective use, either with or without licences, do you have a view on the type of applications that could be accommodated in the band?**

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Other collective use	1	8,3	25,0	25,0
	Licensed use	1	8,3	25,0	50,0
	No Answer	2	16,7	50,0	100,0
	Total	4	33,3	100,0	
Missing		8	66,7		
Total		12	100,0		

One respondent said:

> *"There are a great many possible uses. We see this as a subject for harmonization at the European level.*
>
> *WE ARE STRONGLY OF THE OPINION THAT SPECTRUM THAT IS PRESENTLY HARMONISED SHOULD REMAIN HARMONISED. This should not be left to each individual Member State.*
>
> *With Hermes, perhaps 90,000 small users had to be relocated (for a system that never deployed). It is hard to achieve pan-European harmonised spectrum. Where we have it, we should not squander it."*

Another said:

> *"The example used 1800-1805 MHz is not a suitable candidate band for licence-exempt use. We consider that it should be licensed on a technology and service neutral basis in line with the RSPG WAPECS opinion."*

3.2.6 Additional observations

A North American respondent felt that the US practice of making unlicensed spectrum available with NO RESTRICTIONS ON THE APPLICATION (other than minimal technical conditions) was important to innovation.

A German respondent made comments along the following lines in the course of their interview:

> *"We read the Framework Directive to say that, wherever possible, spectrum should be allocated pursuant to a General Authorisation. We review the requirements within a given band, and assign on a Collective Use basis wherever we feel that doing so will not cause harmful interference and/or*

service disruption. We may impose technical conditions such as power limits (on a technologically neutral basis).”

In some instances, however, industry makes it clear that they cannot deploy a service unless they can assure QoS/reliability/scalability. Thus, spectrum for mobile phones is assigned on an exclusive basis through auctions.

Germany has between 9 and 11 neighbours, depending on how you count them. Requirements for coordination are considerable. It would be altogether impractical in most cases to prevent use within, say, 100 Km of the border.

We see no benefit in creating licence-exempt bands that are unique to Germany. Manufacturing economies of scale are extremely important, as is portability of devices. No manufacturer today wants to build equipment solely for one EU Member State. Thus, we support harmonised allocations wherever possible (although we reserve the right to avoid supporting them if necessary, generally due to some historical allocation that got there first).”

3.3 Detailed responses – Spectrum Users

3.3.1 Current Usage

A.i Please identify your current use(s) of licence-exempt spectrum. Please check all that apply. (PMR applications, Radio LANs, Home automation, SRD devices, Telemetry, Other)

Note that respondents could identify more than one use, and many did. Of 30 responses, 14 (47%) were Radio LANs, 1 (3%) were Home automation, 6 (20%) were unspecified short range devices (SRDs), 1 (3%) was Telemetry, and 8 (27%) were other.

Wireless LANs at 2.4 and 5.8 GHz figure prominently in the text replies. Wi-Fi and WiMAX appear in multiple responses. Mention is made of cordless phones, wireless microphones, telemetry, Bluetooth, car key fobs, and PMR446.

A trade association of public network operators noted that its members primarily employ exclusive use (licensed) spectrum in order to offer services with assured Quality of Service; however, some members offer supplementary services such as Wi-Fi hot spots, or road traffic monitoring based on RFID. Several public network operators independently responded, indicating that they provide Wi-Fi hot spots. One public network operator reports that it uses Wi-Fi at 2.4 GHz not only for hot spots but also for dual-mode cellular / Wi-Fi terminals. Phones connected to the public network may of course use DECT.

Two respondents provided wireless microphones. One did so for professional, non-broadcast environments – a theatre production or musical could typically require from 30 to 50 wireless microphones.

Applications associated with rail traffic include train control, radiophones, and WLAN services offered to on-board train customers.

A.ii Please identify your current use(s) of licensed collective use spectrum. Please check all that apply. (PMR applications, Radio LANs, Home automation, SRD devices, Telemetry, Other)

Note that respondents could identify more than one use. Of 10 responses, 2 (10%) were Radio LANs, 1 (10%) was SRD devices, 1 (10%) was Telemetry, and 6 (60%) were other.

Relatively few textual comments appeared in this category. Digital wireless microphones can operate in a dedicated band from 1785-1800 MHz. Broadband WAN is mentioned.

A.iii Please specify the associated frequency bands and equipment used.

Many responses referred to the 2.4, 5.8 and 3.5 GHz bands.

Wireless microphones operate in the UHF TV band on a secondary basis, and digital microphones may operate in the dedicated 1785-1800 kHz band. Analogue microphones

require 75 KHz of bandwidth, while digital require 750-1200 kHz (due to the absence of compression).

Video cameras often operate at 2.4 GHz, but may operate in national, non-harmonised bands – examples cited were 1.3 GHz in the UK, 2.2 GHz in Germany, 1.2 GHz in Italy. One respondent felt that the lack of harmonisation can be a problem at international events."

Train control operates at 27 MHz. Other bands have been proposed.

One manufacturer of equipment for long haul high speed access and backhaul uses licence-exempt spectrum at 5470-5725 MHz and 5725-5875 MHz, and licensed spectrum at 3400-3600 MHz and 3600-3800 MHz.

A.iv Would any of your current wireless applications or products be suitable for underlay or overlay operation?

Six respondents said yes; while seven respondents said no.

Cordless phones were identified as a good candidate for overlay operation, in as much as they have a low duty cycle and require a range of just 10m.

A number of users expressed concerns about capacity, the risk of interference, or simply the fact that standards do not currently accommodate underlay or overlay operation.

A.v What (if anything) would be your alternative(s) to licence-exempt spectrum if it were not available, or if the quality / capacity failed to meet your requirements?

Seven respondents indicated that use of licensed spectrum would be their alternative; one indicated overlays or underlays; and three indicated that there was no alternative. All other respondents either responded No answer or else failed to respond.

Two users responded with possible migration to wired alternatives, at significant engineering and operational cost. One estimated that this would increase their costs by somewhere between 100 – 400%.

A.vi What additional costs would such alternative(s) entail?

Respondents noted unknown and possibly large costs. Possible costs included the cost of obtaining a license; annual fees, if any; and the costs of re-engineering the product or service.

The UK Microwave Group made the following observations:

> *"Investment and developing into a product of higher frequency chipsets would enable access to mm-Wave bands which have far less sharing constraints and could be fully harmonised to the extent that high power licensed applications are excluded altogether (similar to CEPT recommendations for the 860-868MHz SRD band).*

Markets can be kick started by sound forward-looking decisions. For example many GaAs vendors have tooled up for the 77-79GHZ Car radar market and spin offs would be available from these into other mm-Wave bands such has the 56 or 63GHz bands."

3.3.2 Section 2.2 Future needs

A.i Do you have other needs for wireless communication that you feel could be met by new types of licence exempt product / application that is not currently available?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	8	40,0	44,4	44,4
	No	10	50,0	55,6	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

Respondents spoke of WiMAX, telephony, telemetry, telecommand, "citizen networks", and mobile television.

One respondent gave examples of potential applications in health care, such as remote monitoring of blood pressure using an in-home wireless network linked to the public telephone network and also felt that on-line gaming would in the future drive up requirements for wireless bandwidth in the home.

A.ii What is your view of the future needs in terms of spectrum availability for "collective use" applications?

Some respondents felt that the current allocation of collective use spectrum was quite sufficient (and one pointed out that the existing 400 MHz in the 5 GHz band would suffice for WLAN if the 80 MHz in the 2.4 band became full); others felt that there would always be a demand for more spectrum. One respondent noted that demand for spectrum is difficult to predict, because new applications sometimes emerge only after the underlying capabilities have appeared.

Many provided more specific responses. Several commented on the significance of making WiMAX available at 3.5 GHz or 5.8 GHz. A wireless microphone provider claimed that access to three or four 8 MHz UHF channels in order to avoid inter-modulation problems. A respondent from the automobile industry noted the potential value of 5.8 GHz for car-to-car communication, expressed interest in 3 to 10 GHz for UWB, and saw interest generally in sensors and communication.

The ability to use greater power was important to a number of respondents. One commented on the potential desirability of WiMAX at higher frequencies (e.g. 5.8 GHz) in order to use higher power.

One commenter felt that access to spectrum at zero cost would stimulate considerable demand, but that technical measures could nonetheless contain any congestion.

A respondent, that represents amateur radio licensees, advocated making 56 or 63 GHz available for Intelligent Transport Systems (ITS) and supported modest expansion of the 446MHz and 863-870MHz SRD bands.

One respondent argued that licence exempt spectrum was important for innovation and observed that short-range UWB and 'cognitive' radio were technologies that could potentially unlock much more licence-free access to the radio spectrum. An analogy was made with the early days of electricity, in that the wide availability of electricity this inspired inventors to go beyond initial applications like indoor lighting and industrial motors. It is unlikely this innovation would have happened if every electrical device had to be licensed before it could be attached to a power supply.

The respondent also observed that achieving objectives in relation to ubiquitous availability of broadband access would require more licence-exempt spectrum below 1 GHz, and felt that there should be a much greater emphasis on licence-exempt operation in higher frequency bands (above 30 GHz) to take advantage of the higher propagation losses and antenna directivity in these bands.

A.iii Do you have a view on the future demand for collective use of spectrum?

Many respondents indicated a general expectation that demand would increase over time, but few offered specifics.

A number felt that favourable economics (i.e. low cost of spectrum access and use) would continue to drive the use of collective use spectrum. One respondent felt that the transition to digital television would reduce the amount of "white space" in the TV broadcast bands, thus stimulating more interest in collective use as an alternative. One felt that congestion would continue to be a problem in the 2.4 GHz band – that there was a need for two or three times as much collective use spectrum in that general area.

A.iv Do you think there should be various categories of spectrum for collective use, geared towards various levels of spectrum quality (some less crowded, some more monitored, and so on)?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	10	50,0	55,6	55,6
	No	2	10,0	11,1	66,7
	No Answer	6	30,0	33,3	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

A number of respondents expressed positive interest in this proposal. One respondent noted that the French regulator already maintained approximately this arrangement for PMR systems. A number suggested that such a system would be difficult to manage. A number of respondents drew additional parallels to wireless microphones.

A.v If so, would you be willing to pay for the right to access higher quality spectrum (e.g. where the number of users that can access the spectrum were limited)?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	5	25,0	45,5	45,5
	No	2	10,0	18,2	63,6
	No Anser	4	20,0	36,4	100,0
	Total	11	55,0	100,0	
Missing		9	45,0		
Total		20	100,0		

A number of respondents felt that a fee would be justified only in exchange for real protection from interference and congestion, at which point the scheme turns out to be roughly equivalent to normal exclusively licensed use.

One respondent noted that those who were willing to pay for protection from interference already had the option of licensed spectrum. He questioned the willingness of users of unlicensed spectrum to pay.

Another suggested that it would be better to fine offenders than to charge all users.

One respondent observed that there were already such categories, e.g. Citizens Band is separate from RFID, wireless microphones and from radio control of models. It is much easier to design equipment and get good performance if the designer knows the maximum signal strength likely to be encountered in the band, and what waveforms and duty cycles are likely, as well. As the manufacturers of 'Part 15' equipment told the FCC in their group statement for Docket ET 98-42 (on RF lighting in the 2.4 GHz

band), 'systems can be further hardened against limited levels of interference, but only to the extent that the emission characteristics of the interference are known in advance...'

However, the way that spectrum uses are categorised is extremely important. A 'technology and application neutral' approach was preferred, to permit innovation at the hardware and service levels, while characteristics of the emitted signal (e.g. power output levels, spectrum mask, etc.) can be defined specifically and limited.

A.vi Is it feasible to "re-farm" spectrum that is used collectively? If spectrum is made available in a new frequency band, how long should the current band be retained? How difficult is it to change the frequency band that used for a particular "collective use" application?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	4	20,0	26,7	26,7
	No	6	30,0	40,0	66,7
	No answer	5	25,0	33,3	100,0
	Total	15	75,0	100,0	
Missing		5	25,0		
Total		20	100,0		

Most respondents felt that re-farming from collective use to exclusive use would be difficult – much more difficult than refarming from exclusive use to collective.

One respondent expressed a belief that a large number of wireless microphones are used illegally, by way of emphasising that it would be difficult to clear bands.

One respondent noted that the ECC's recently proposed rule that automotive radars at 24 GHz should come with a disabling mechanism to prevent their use after a certain date was an interesting precedent that, if successful, could be applied to other bands to facilitate refarming. Software Defined Radio would eventually change the parameters of the problem, creating both new risks of "rogue" devices, as well as new opportunities to modify devices already in the field.

A.vii How do you think the technology deployed in collective bands will evolve over the coming years? Do you have a view on the potential benefits and/or likely future demand for UWB applications?

Most respondents spoke of the value of ongoing technological evolution, and many (but not all) felt that UWB would likely prove to be increasingly important. Some spoke of the difficulty of evolving technology already deployed.

Many respondents, especially traditional operators and manufacturers, were more concerned with potential interference from UWB than with its ability to benefit their respective businesses.

The limited range of UWB was felt by some to limit its applicability, but at the same time to mitigate the risk of interference.

One respondent felt that the wider use of frequency hopping (reducing the probability and duration of interference), and the ability to build more intelligence into radio chips at lower cost (producing better signal recognition and data recovery, and better/faster selection of transmit frequencies) would facilitate greater sharing of spectrum in the future. A great deal of research is devoted now to the development of automatic “detect and avoid” systems, more effective “listen before talk” protocols, etc. for example in the IEEE 802.22 workgroup and the IEEE P1900.2 standards development committee (next generation radio and spectrum management, coexistence analysis subgroup) is becoming more active.

One respondent noted that over-air-updates were already routine for DVB broadcasting receivers.

3.3.3 Monitoring of the frequency bands for "collective use"

A.i	**Do you have a view on the potential capacity and quality of service that can be achieved in specific collective spectrum allocations (e.g. in terms of amount of data traffic or number of users/devices in a given area)?**

Several users noted that this was very complex and difficult to model.

One respondent observed that all SRDs have historically operated in shared bands and those requiring a high quality of service have incorporated interference mitigation techniques, such as multiple transmissions, forward error correction, frequency diversity and more recently LBT/AFA and intelligent protocols. However, no one claims to be interference proof as this is simply not achievable.

One respondent noted that studies of the 5 GHz band had been performed prior to WRC-2003.

One respondent referred to a recent UK study[10], claiming this showed the limits of our current understanding, in that there are no recognised criteria for acceptable performance of systems in collectively used spectrum, even in a market as developed as WLANs at 2.4 GHz. However the measurement results from the study indicated that protocols were more important to spectrum re-use than the gradual change of signal strength with distance. This implied that we are still far from the ultimate “hard” limits on band capacity and further improvements in protocols are likely to increase the capacity of collective use spectrum. The respondent also cited analysis by universities, companies, and independent research analysts over the past three years that suggest OFDM/OFDMA technology combined with MIMO and AAS wireless enhancements hold the greatest promise for increasing system capacity.

[10] “Evaluating spectrum percentage occupancy in licence-exempt allocations” by Aegis and Transfinite Systems ,for Ofcom (2004)

A.ii Are you aware of any monitoring or enforcement activities relating to your use of licence-exempt spectrum?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	7	35,0	38,9	38,9
	No	10	50,0	55,6	94,4
	No Answer	1	5,0	5,6	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

Awareness of monitoring was not high among the respondents. A few respondents recognised that some spectrum management authorities perform routine, systematic monitoring, while others limit their activities to responding to complaints. They understood the difference between the two.

A.iii If so, how effective do you think these activities are?

One respondent observed that monitoring does nothing to resolve problems among licence exempt users, but acknowledges that they are not expected to do anything. One respondent said: "RA/Ofcom surveys of spectrum occupancy do occur in the 2.4 and 5GHz bands."

Several respondents expressed scepticism as to the effectiveness of monitoring. One respondent in particular felt that present monitoring was inadequate in general, but with exceptions in some Member States.

One respondent noted that it was important for regulators to monitor licence exempt bands regularly so as to know when additional spectrum was needed for licence exempt services. Complaints were considered an unreliable indicator of congestion as users of licence exempt bands are generally aware they are not protected from interference. It was also felt that organised monitoring by private users may become increasingly important as governments release additional spectrum to collective use. Amateur radio was a good example of such self-policing[11].

[11] See "Policing the Spectrum Commons" by Philip J. Weiser and Dale N. Hatfield, Fordham Law Review, Vol. 74, pages 101-132 (2005) - http://ssrn.com/abstract=704741

A.iv Have you experienced any problems such as interference or congestion when using licence-exempt spectrum?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	9	45,0	52,9	52,9
	No	6	30,0	35,3	88,2
	No answer	2	10,0	11,8	100,0
	Total	17	85,0	100,0	
Missing		3	15,0		
Total		20	100,0		

A.v Have you experienced congestion?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	6	30,0	50,0	50,0
	No	4	20,0	33,3	83,3
	No answer	2	10,0	16,7	100,0
	Total	12	60,0	100,0	
Missing		8	40,0		
Total		20	100,0		

A.vi Have you experienced interference?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	5	25,0	45,5	45,5
	No	4	20,0	36,4	81,8
	No answer	2	10,0	18,2	100,0
	Total	11	55,0	100,0	
Missing		9	45,0		
Total		20	100,0		

No user identified problems other than congestion or interference.

A number of respondents spoke of congestion and interference in the 2.4 GHz band, either from their own experience or from anecdotal evidence.

One respondent spoke of problems in the 458 MHz telemetry band in the UK, and in the 433 MHz band in continental Europe. Problems were often caused either by illegal operation or by interference hot spots.

One response spoke of interference in some U.S. cities in the 5.8 GHz band.

In the case of wireless microphones, a lot of planning is required to avoid intermodulation problems where large numbers of microphones are used at the same site, and this planning

helps to keep interference problems under control. Where interference does arise, the user simply switches to another frequency. There is more of a problem in the 863 – 865 MHz band as this is shared with other licence-exempt devices."

A.vii Are you aware of other organisations in your country that have encountered problems (such as congestion or interference) in using licence-exempt spectrum?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	4	20,0	25,0	25,0
	No	10	50,0	62,5	87,5
	No answer	2	10,0	12,5	100,0
	Total	16	80,0	100,0	
Missing		4	20,0		
Total		20	100,0		

A number of respondents spoke of congestion and interference in the 2.4 GHz band, either from their own experience or from anecdotal evidence.

3.3.4 Section 2.4 Impact of Regulation on "collective use"

A.i How familiar are you with national and international regulations concerning use of licence-exempt spectrum?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Very familiar	11	55,0	55,0	55,0
	Somewhat familiar	8	40,0	40,0	95,0
	Not very familiar	1	5,0	5,0	100,0
	Total	20	100,0	100,0	
Total		20	100,0		

Respondents were familiar with regulation, but many indicated that they were focused on regulation relevant to their respective business interests.

A.ii Do you have any views on how these regulations might be improved in order to provide greater benefit from the use of licence-exempt spectrum?

One respondent noted that European regulators tended to be constrained to the extent that they lacked control over the sale of equipment.

Several respondents mentioned the importance of protecting systems from interference, notably from underlay allocations. Conversely, another respondent emphasised the potential benefits of underlay and suggested there was a need for a certain low power threshold below which any device can operate anywhere in the spectrum (i.e. similar to the FCC part

15 approach). This would release other spectrum currently allocated to generic SRDs for other uses. An example is the recently agreed 50 nW limit for micro FM transmitters in Band II (this is a 12.2 dB relaxation on the EMC limit). The EMC limits could be used as the basis for allowing underlay operations – work is underway in CISPR to extend these limits to 18 GHz (currently they only go up to 1 GHz)."

One respondent suggested that widening exemption from radio licensing might require the ITU to revise Radio Regulation S18.1 which still states that: 'No transmitting station may be established or operated by a private person or by any enterprise without a licence...'

A.iii How satisfied are you with your national regulator's current approach to managing collective use of spectrum and do you have any suggestions for improvement?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Very satisfied	4	20,0	21,1	21,1
	Somewhat satisfied	8	40,0	42,1	63,2
	Not very satisfied	1	5,0	5,3	68,4
	very dissatisfied	1	5,0	5,3	73,7
	No answer	5	25,0	26,3	100,0
	Total	19	95,0	100,0	
Missing		1	5,0		
Total		20	100,0		

Many respondents indicated a high degree of satisfaction with their respective regulators.

One respondent noted the desirability of more extensive monitoring.

A few respondents lodged specific concerns about individual authorities. One felt that its regulator was "… disinterested in interference/enforcement … (but at the same time) overly-favourable to UWB at the expense of licensed users."

A.iv Do you think there is a need for more or less international harmonisation of frequency bands identified for collective use?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	More harmonisation	16	80,0	84,2	84,2
	Just right as it stands	2	10,0	10,5	94,7
	No answer	1	5,0	5,3	100,0
	Total	19	95,0	100,0	
Missing		1	5,0		
Total		20	100,0		

The textual comments reflect widespread support for further harmonisation at the European level, especially for bands used for Wi-Fi and WiMAX. Some comments reflect the need both for manufacturing economies of scale and for equipment portability.

One respondent felt that "… CEPT/EU regulations suffer by being administered differently in Member States and by being poorly explained."

Another was concerned about harmonisation of constraints, noting that harmonising the regulations in a less constraining way would be beneficial to reduce customer confusion and uncertainty.

A.v What are your views concerning the regulatory conditions associated with the frequency bands allocated to collective use (e.g. do you think there should be more or fewer constraints on use of specific bands)?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	More contraints	3	15,0	17,6	17,6
	Less contraints	5	25,0	29,4	47,1
	Just right as it stands	3	15,0	17,6	64,7
	No answer	6	30,0	35,3	100,0
	Total	17	85,0	100,0	
Missing		3	15,0		
Total		20	100,0		

One respondent noted that protocol improvements might make regulation less necessary – thus replacing regulatory constraints with technical ones. Another felt there should be more liberalised rules regarding power.

One respondent advocated (1) opening up the 2.4 GHz band consistently to 2.5 GHz in countries that do not yet do so; and (2) opening 55-65 GHz (close to oxygen's absorption point) and above 94 GHz to general licence exemption.

A.vi Are current provisions to protect collective users of spectrum from interference adequate and if not what further measures do you think should be taken?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	8	40,0	44,4	44,4
	No	2	10,0	11,1	55,6
	No answer	8	40,0	44,4	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

Very few respondents commented in detail on this question, but those who did expressed support for current arrangements.

A.vii Do you have a view on which types of licence-exempt systems can co-exist within a given spectrum allocation (e.g. 2.4 GHz, 5.8 GHz)?

Many respondents noted that Wi-Fi and Bluetooth coexist in the 2.4 GHz band. Several respondents noted that systems that coexist are generally short range (SRDs) and/or low power.

One respondent noted that most SRD bands have occupancy by varied applications. Above 1GHz, use tends to be more specific i.e. WLANS, slow scan video and Bluetooth are about the main users at 2.4 GHz, whereas at UHF applications are more generic.

Another respondent felt that whilst WLANs could coexist as their local density is mostly controlled and spectrum coordination is easily manageable between spectrum users in a certain location (e.g. via the location owner, an airport company etc.), introduction of UWB and other SRD applications in the same band might lead to interference and noise increase as their local density is not stable, and cannot be controlled or restricted.

Yet another respondent felt that some common uses of licence exempt spectrum are inappropriate, including (1) sensitive personal data over unsecured Wi-Fi links, and (2) safety systems in car radars using licence exempt non-protected spectrum.

A.viii Do you think collective use should be one of the options considered when spectrum is being re-farmed from one type of use to another?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	9	45,0	50,0	50,0
	No	4	20,0	22,2	72,2
	No answer	5	25,0	27,8	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

Several respondents returned to the point that refarming from collective use would tend to be extremely difficult.

One respondent argued that refarming should be done via auction or spectrum trading (implicitly arguing that this should not be a command-and-control function).

Another respondent expressed the need to consider an implicit trade-off: "… A balance has to be struck because exclusive use licences bring many advantages too. The key point is that collective use spectrum can encourage new ideas and applications without the commitment to a potentially expensive exclusive licence."

One respondent contends that there is no evidence of scarcity of licence exempt spectrum, and therefore no justification for irrevocably committing more spectrum to licence exempt use.

A.ix Do you think it is reasonable that licensed use of spectrum should attract a fee whilst licence-exempt use does not?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	yes	14	70,0	77,8	77,8
	No	1	5,0	5,6	83,3
	No answer	3	15,0	16,7	100,0
	Total	18	90,0	100,0	
Missing		2	10,0		
Total		20	100,0		

The comments are similar to those that appear in the survey of spectrum regulatory authorities. Users of licensed and of licensed exempt spectrum accept this and they recognise that protection from interference has value. The text comments made these points quite clearly.

A.x Does your government have the legal authority to regulate the sale (as opposed to the use) of unlicensed devices?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	Yes	1	5,0	12,5	12,5
	No	2	10,0	25,0	37,5
	No answer	5	25,0	62,5	100,0
	Total	8	40,0	100,0	
Missing		12	60,0		
Total		20	100,0		

3.3.5 Collective use of spectrum outside Europe

A.i How do you think collective use of radio spectrum compares between your country and countries outside Europe (such as Japan, South Korea, the USA, or Canada)?

Many respondents felt that that the USA took a much more relaxed view toward collective use, and that doing so had generated good results. A few respondents identified other countries favourably, notably Korea.

At the same time, several cautioned that Europe had somewhat different issues to contend with. Concerns were also raised that the more liberal rules in the US – for example, with respect to power – could cause problems when equipment made for the U.S. market was

brought into Europe. One respondent felt that the Part 15 (underlay) rules implemented by the US FCC could potentially reduce capacity of other (e.g. licensed) services, especially mobile. Another respondent raised a similar concern about the US approach to UWB.

One respondent felt that European national spectrum management authorities lacked resources in terms both of manpower and of skills.

One respondent regarded the USA as the global leader in developing licence-exempt spectrum use, and also noted Japan's progress towards an "open spectrum" policy[12]. With regard to wireless systems for joint use such as high-output outdoor wireless LAN, the MIC (Ministry of Internal Affairs and Communication) implemented deregulation and introduced a post-check registration system in place of the existing pre-check licensing system. The respondent also felt that there was an important distinction between collective use based on licence exemption and that based on non-individualised licensing such as a general authorisation or class licence. Equipment authorisation was felt to be a better tool for setting minimum conditions for collective use than licensing, although it was noted that the effectiveness of equipment authorisation depends significantly on how much skill, intelligence and politeness can be built into the communications device, relative to what is required of the user.

A.ii Do you think any particular country or region has a particularly favourable approach to collective use of spectrum that could be adopted in Europe?

		Number	Percent of total	Percent of resp.	Cumul. percent of resp.
Responses	No	4	21,1	66,7	66,7
	No anser	2	10,5	33,3	100,0
	Total	6	31,6	100,0	
Missing		13	68,4		
Total		19	100,0		

One respondent felt that the European approach of minimal regulation is much to be admired and contrasted this with Guatemala's experiment with spectrum property rights, even for bands such as 2.4 and 5 GHz, which have significantly impeded the availability of licence exempt spectrum, which in turn has impacted universal services in this developing country.

[12] see "Aspects for Regulation and Public Policy in the Mobile Information Society: Frequency Open Policy in Japan" by Yoshiyuki Takeda, presented at the ITU Symposium on Shaping the Future Mobile Information Society (March 2004 - available online at http://www.itu.int/osg/spu/ni/futuremobile/presentations/takeda-presentation.pdf.)

4 Appendix C: Frequency bands already allocated for "collective use"

ERC Recommendation 70-03 (Tromso 1997 and subsequent amendments) “sets out the general position on common spectrum allocations for Short Range Devices (SRDs) for countries within the CEPT”. It provides in the Annexes information on the applications, frequency bands, and any recommended technical parameters as well as a cross reference to relevant ECC/ERC Decisions and harmonised standards. It also provides a summary of which country have implemented the different frequency bands and applications.

The 36 European countries included in ERC Recommendation 70-03 are shown in the table below.

Table 1 : European Countries included in ERC Rec 70-03

Austria	Ireland	Czech Republic	Bosnia-Herzegovina
Belgium	Liecthenstein	Cyprus	Bulgaria
Denmark	Luxemburg	Estonia	Croatia
Spain	Holland	Hungary	Former Yugolsav
Finland	Norway	Lithuania	Republic of Macedonia
Germany	Portugal	Latvia	Romania
France	Switzerland	Malta	Serbia and Montenegro
Greece	Sweden	Poland	Turkey
Iceland	United Kingdom	Slovenia	
Itay		Slovakia	

As can be seen not all European countries have been included in ERC-70-03.

ERC Recommendation 70-03 lists the restrictions by application and frequency band against specific countries. The restrictions fall into the following categories:

- Limitation on Power
- Channel spacing or specific channels/frequencies only
- Individual License required
- Audio not allowed
- Duty cycle limits

Table 2 shows the restrictions by frequency band and application, which was based on the information provided in appendix 3 of ERC Recommendation 70-03. Although this provides a view of real-harmonisation from an application perspective, from a spectrum viewpoint it is difficult to see. Therefore, Figures 1 – 5 below SRD Allocated Spectrum Charts have been created again from appendix 3, which provide a graphical indication of the amount of spectrum per application and also looks at the reuse of spectrum for different applications.

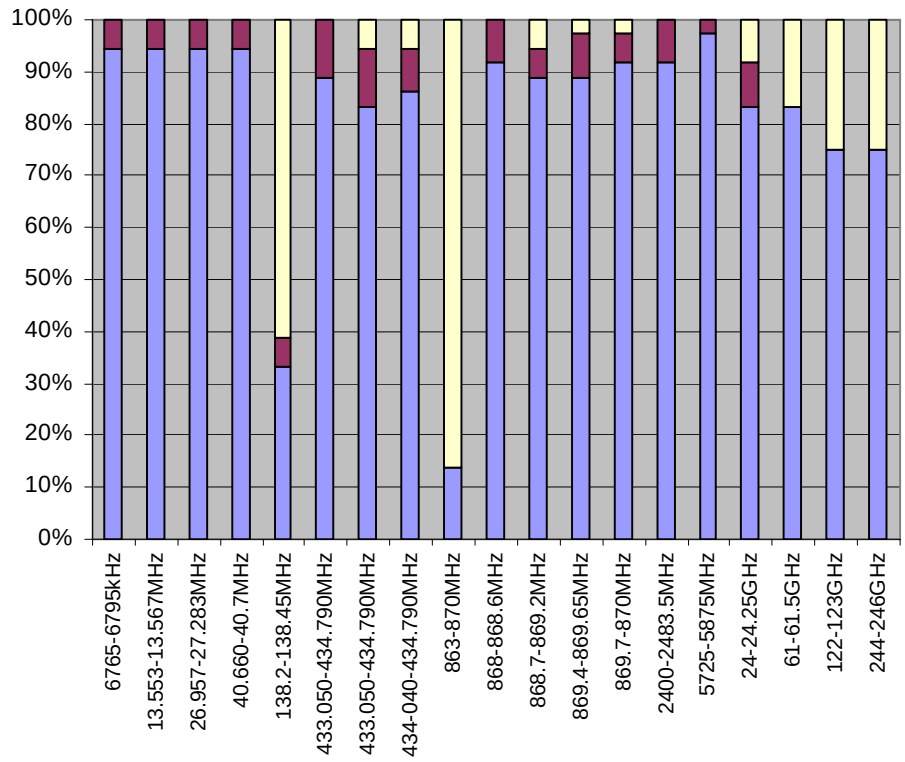
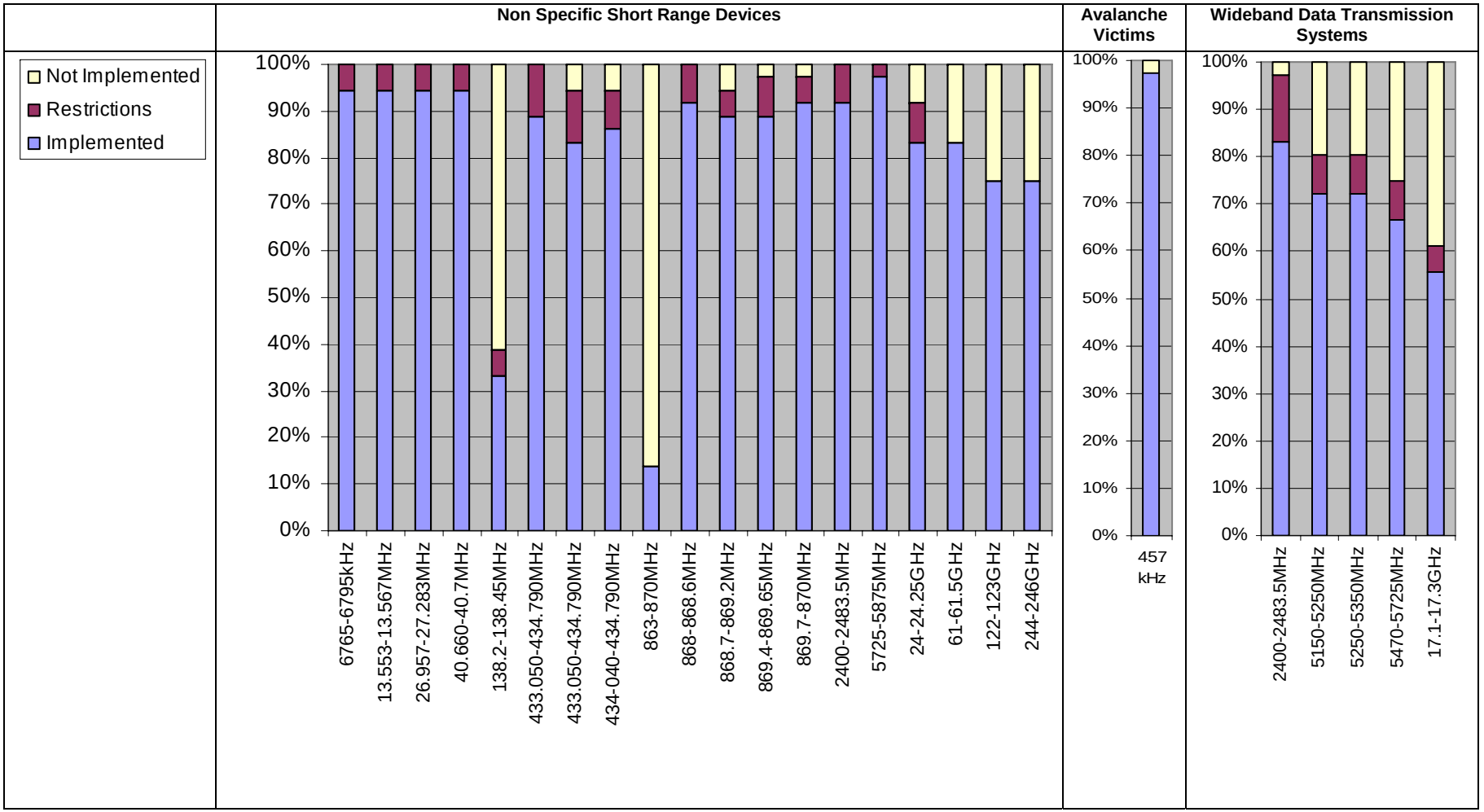
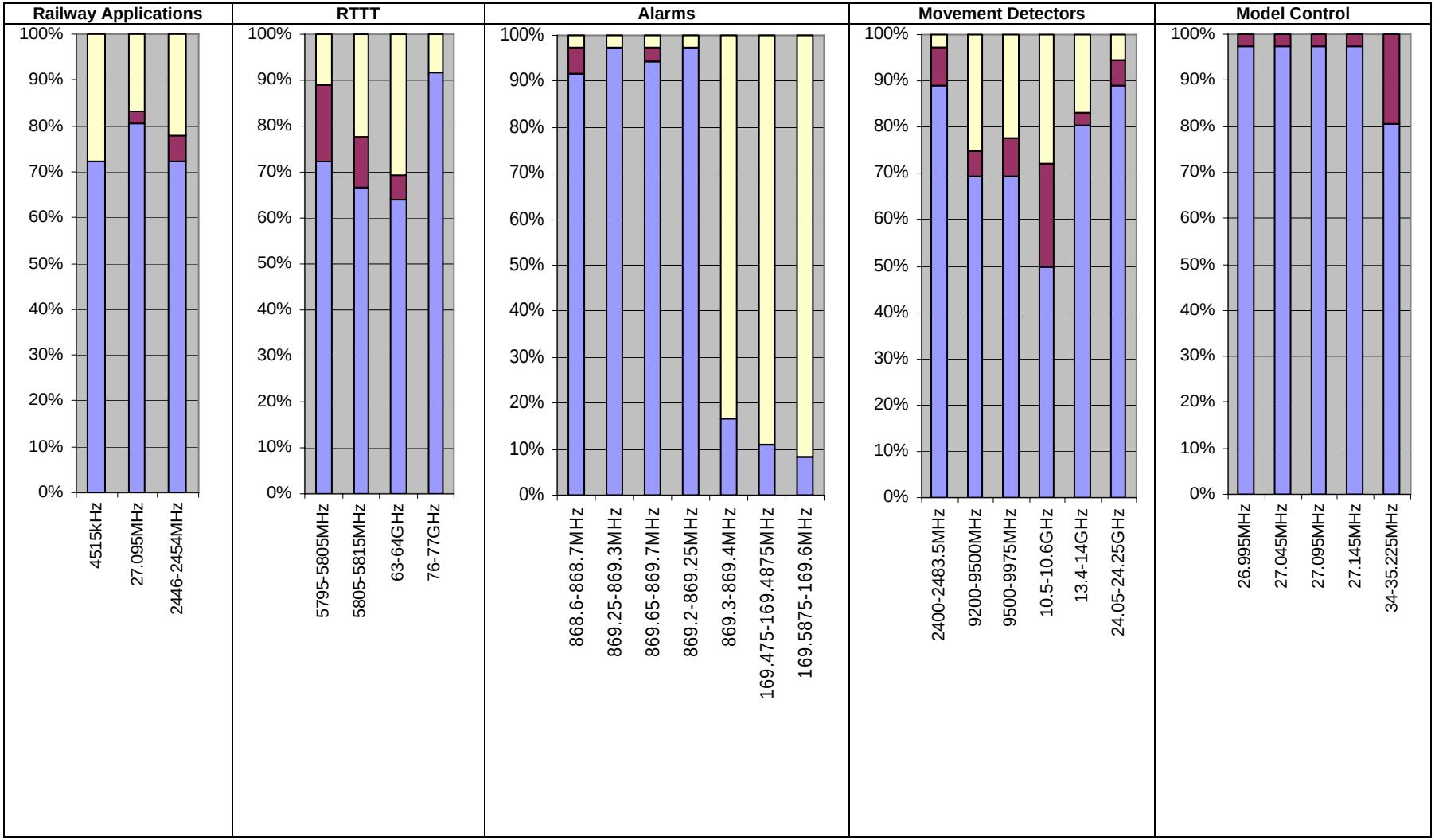


Table 2: Restrictions by Application and Frequency Band




Railway Applications
RTTT
Alarms
Movement Detectors
Model Control
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
4515kHz
27.095MHz
2446-2454MHz
5795-5805MHz
5805-5815MHz
63-64GHz
76-77GHz
868.6-868.7MHz
869.25-869.3MHz
869.65-869.7MHz
869.2-869.25MHz
869.3-869.4MHz
169.475-169.4875MHz
169.5875-169.6MHz
2400-2483.5MHz
9200-9500MHz
9500-9975MHz
10.5-10.6GHz
13.4-14GHz
24.05-24.25GHz
26.995MHz
27.045MHz
27.095MHz
27.145MHz
34-35.225MHz

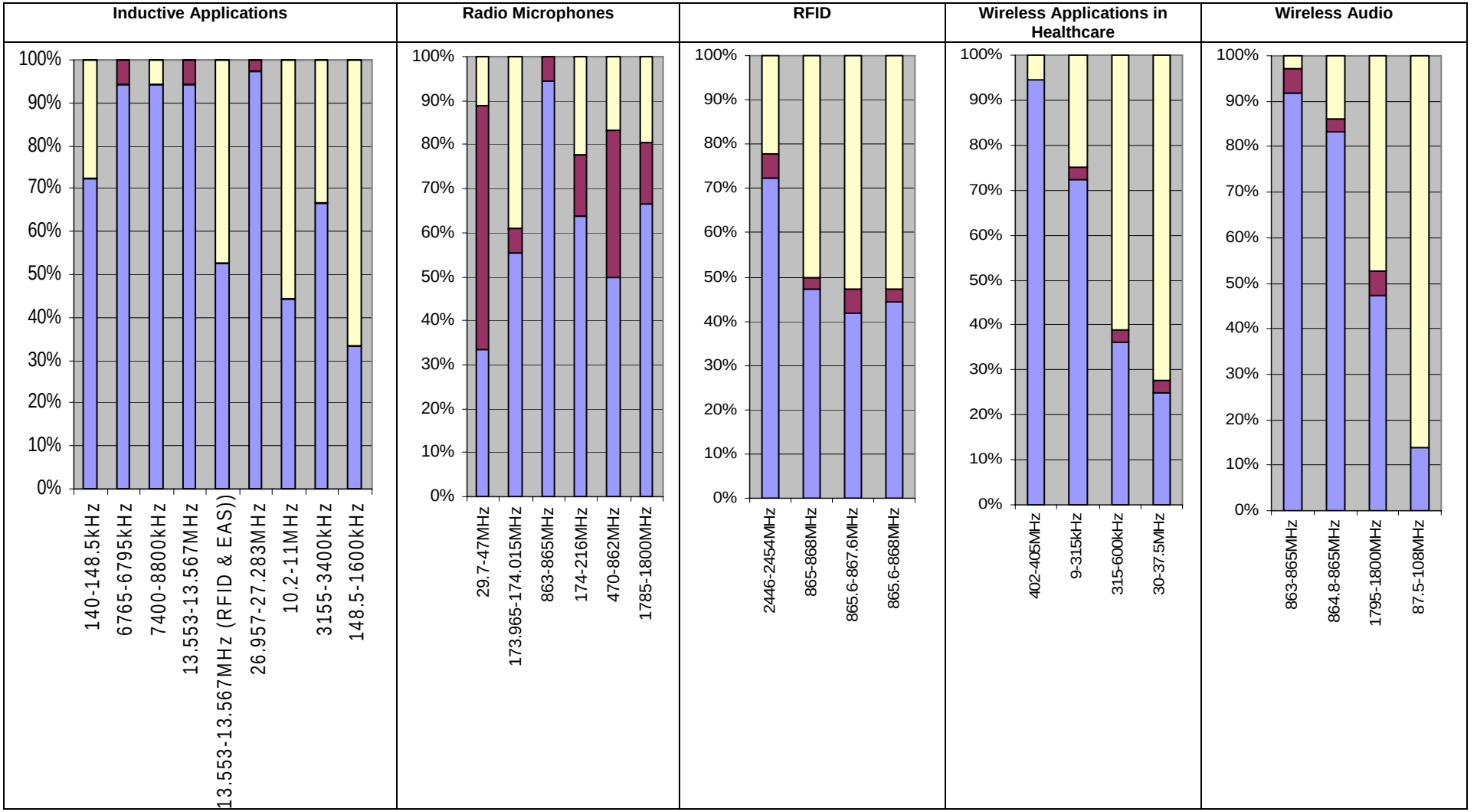

Inductive Applications
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
140-148.5kHz
6765-6795kHz
7400-8800kHz
13.553-13.567MHz
13.553-13.567MHz (RFID & EAS))
26.957-27.283MHz
10.2-11MHz
3155-3400kHz
148.5-1600kHz
Radio Microphones
29.7-47MHz
173.965-174.015MHz
863-865MHz
174-216MHz
470-862MHz
1785-1800MHz
RFID
2446-2454MHz
865-868MHz
865.6-867.6MHz
865.6-868MHz
Wireless Applications in Healthcare
402-405MHz
9-315kHz
315-600kHz
30-37.5MHz
Wireless Audio
863-865MHz
864.8-865MHz
1795-1800MHz
87.5-108MHz

Figure 1: SRD Allocated Spectrum (Full view Log Scale)

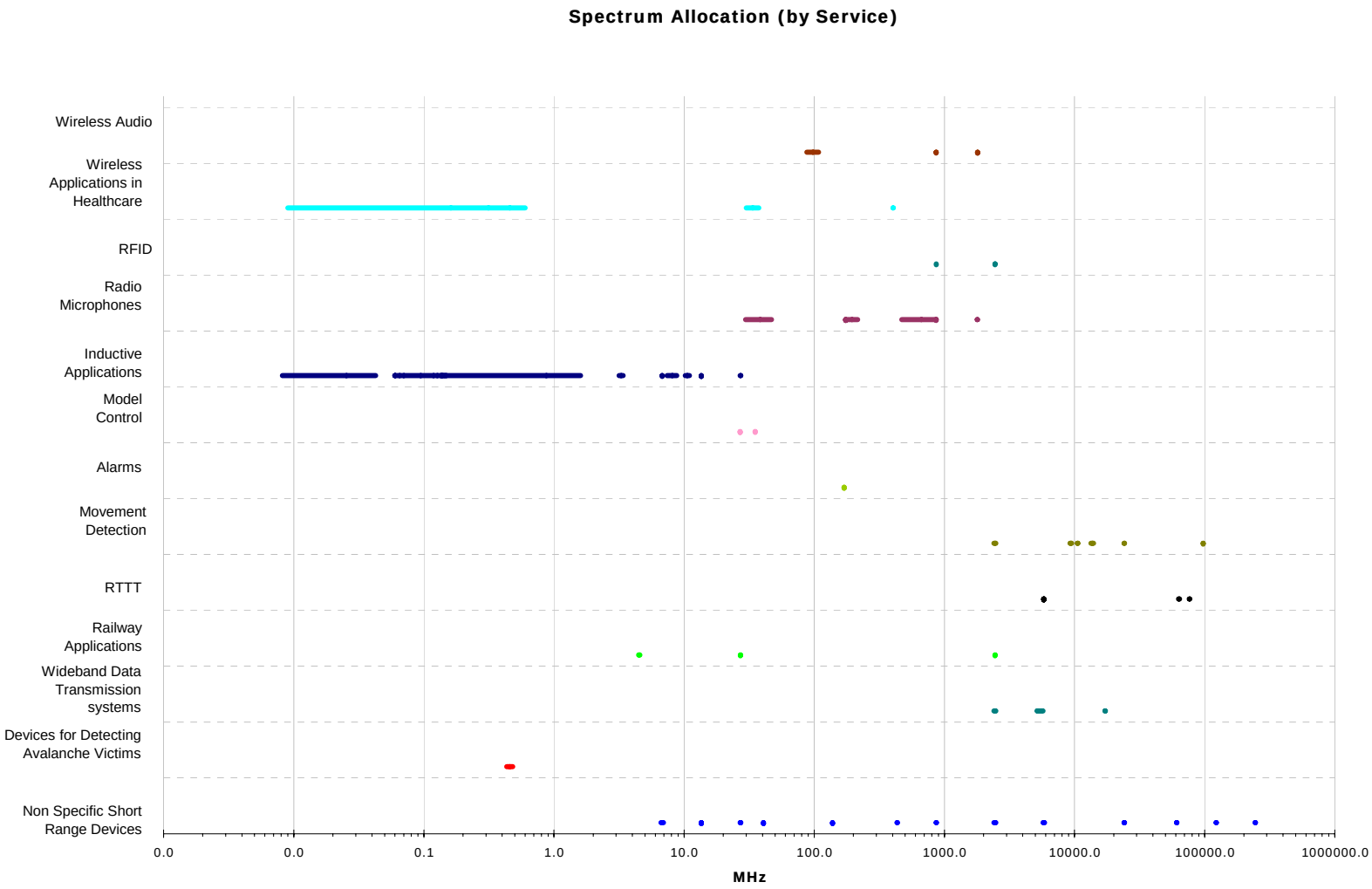


Figure 2: SRD Allocated Spectrum (0 - 1GHz)

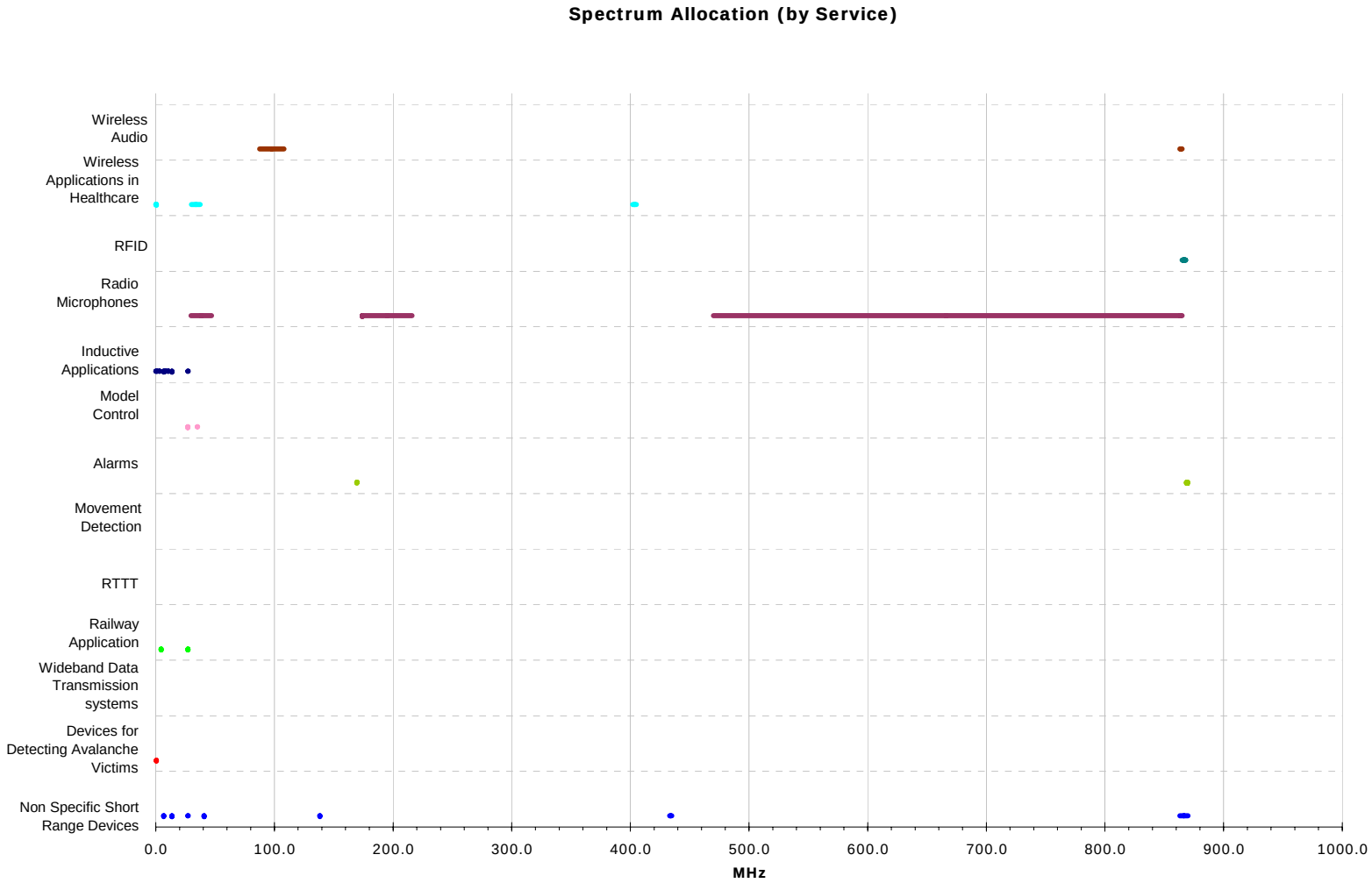


Figure 3: SRD Allocated Spectrum (1 - 10 GHz)

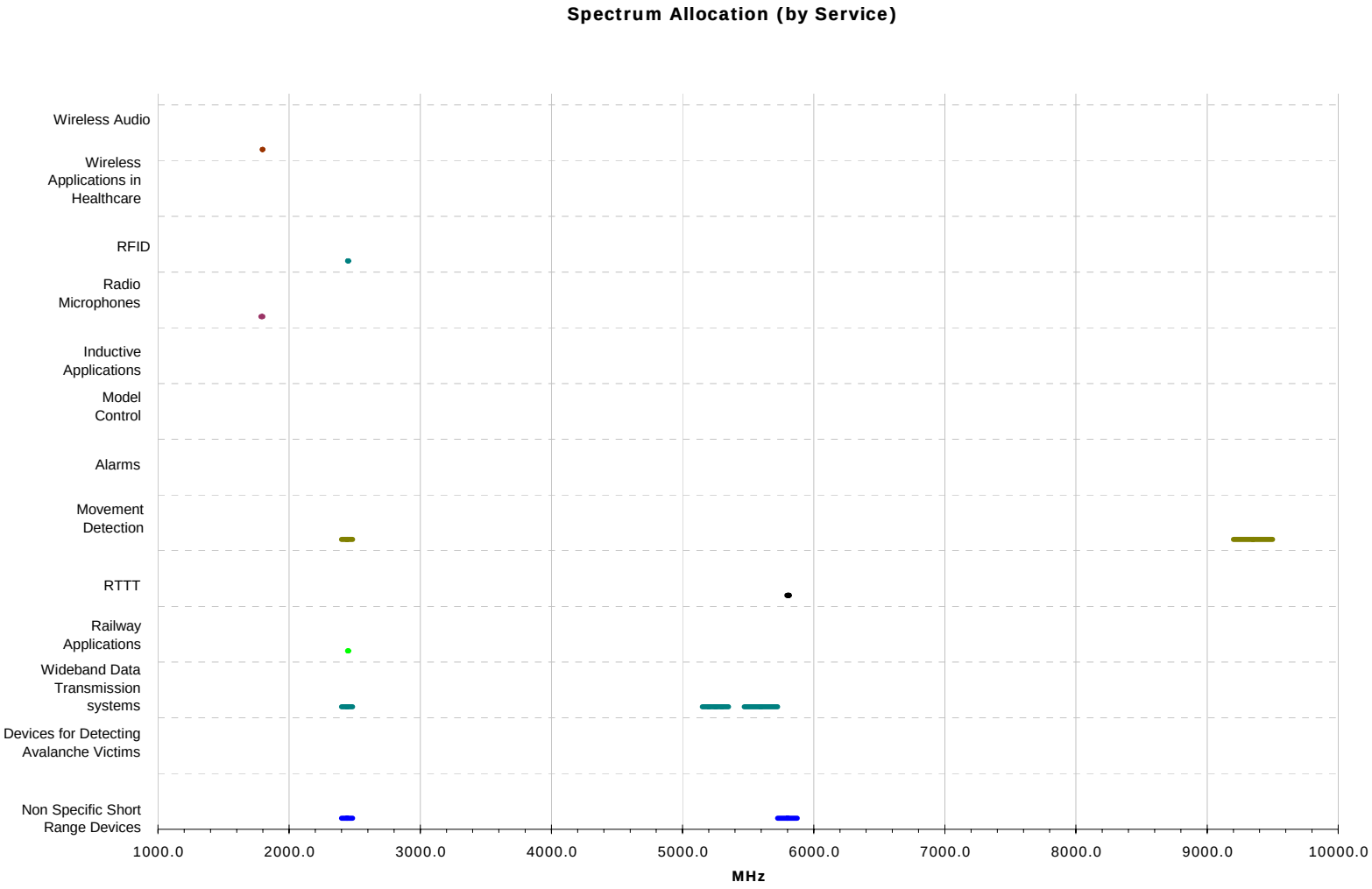


Figure 4: SRD Allocated Spectrum (10-100GHz)

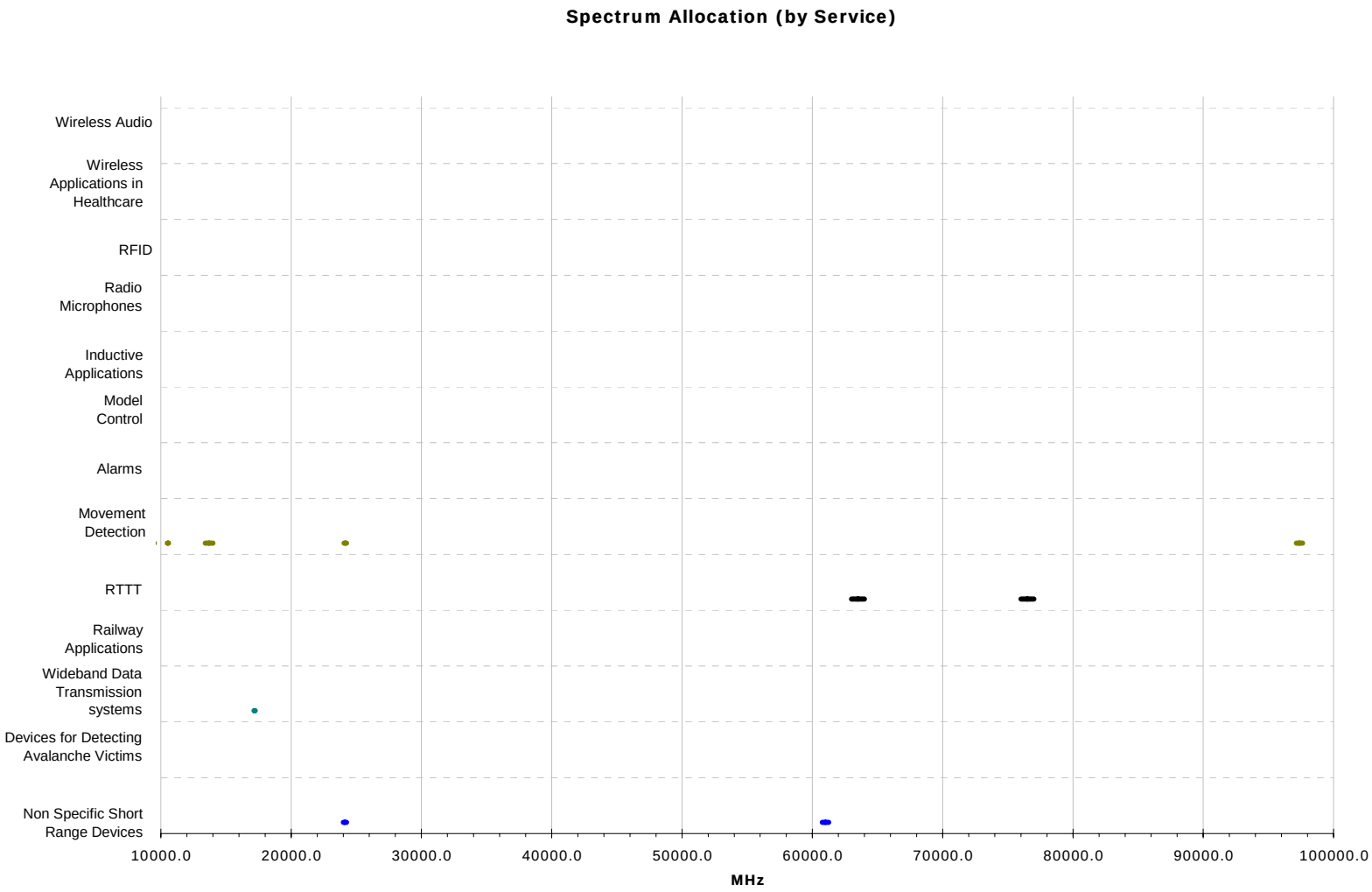
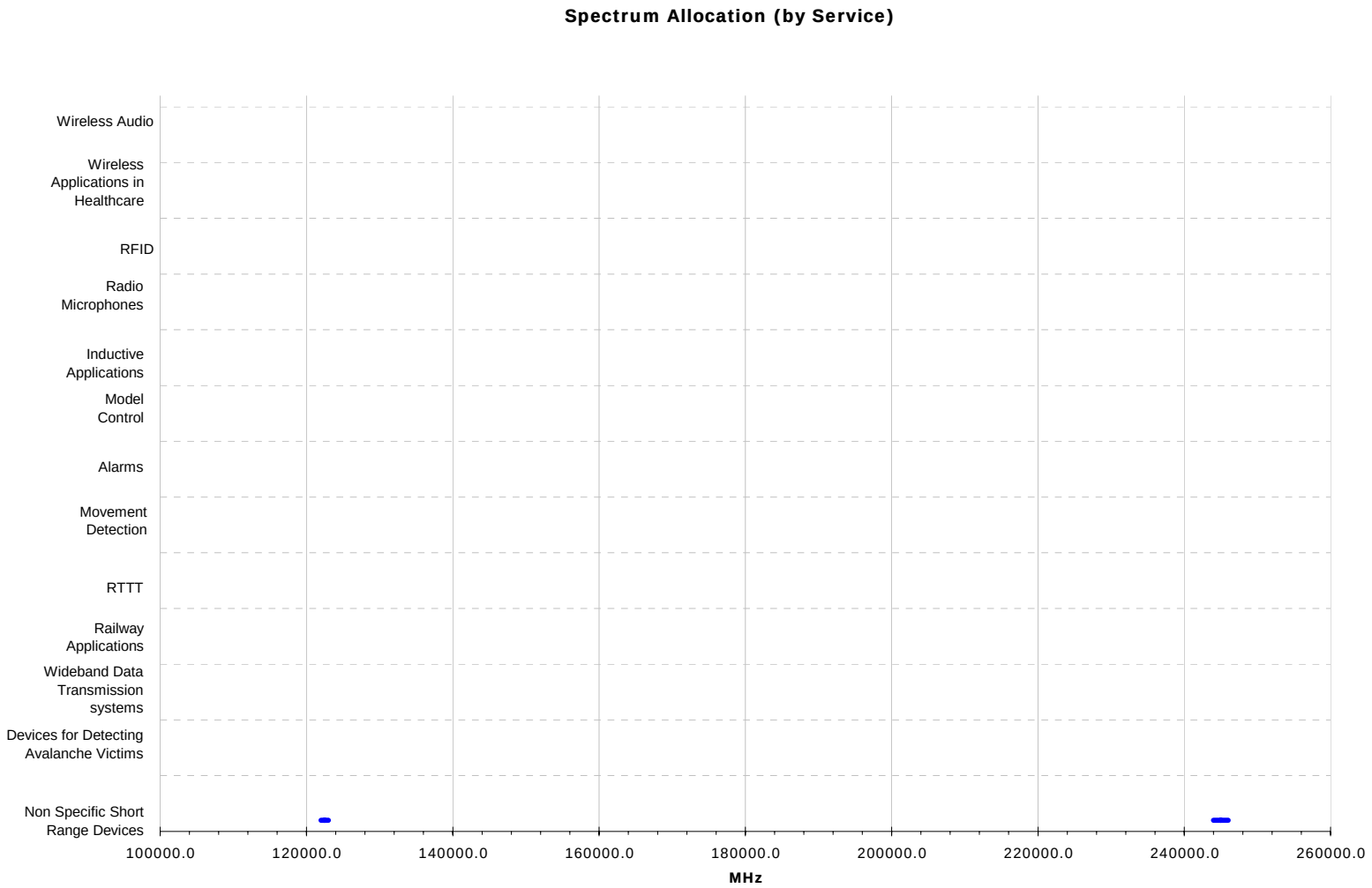


Figure 5: SRD Allocated Spectrum (100-260GHz)


Spectrum Allocation (by Service)
Wireless Audio
Wireless Applications in Healthcare
RFID
Radio Microphones
Inductive Applications
Model Control
Alarms
Movement Detection
RTTT
Railway Applications
Wideband Data Transmission systems
Devices for Detecting Avalanche Victims
Non Specific Short Range Devices
100000.0
120000.0
140000.0
160000.0
180000.0
200000.0
220000.0
240000.0
260000.0
MHz

5 Appendix D: Collective Spectrum Technology Overview

5.1 "Polite" Technologies

A number of techniques have been introduced over the years to facilitate the collective use of particular frequency bands by large numbers of similar devices. These are sometimes referred to as "polite technologies" or "politeness protocols". Three techniques that have gained particular acceptance are LBT, adaptive frequency agility and automatic transmitter power control. It should be noted that that none of these techniques can be assumed to be 100% reliable due to "hidden node"[13] problems. Nevertheless, they can be made very reliable in appropriate cases

5.1.1 Listen Before Talk (LBT)

Listen Before Talk (LBT), sometimes referred to as Listen Before Transmit, is a technique whereby a transmitter monitors its radio environment before commencing transmission. LBT can be used by a radio device to reduce the risk of causing interference to existing transmissions. LBT is not a particularly new technology, e.g. it is used by GSM mobiles to find a network to connect to and in DECT to find a free radio channel, but its deployment as a tool to facilitate sharing and increase spectrum capacity for SRDs is a relatively recent innovation. In particular, its widespread application to low cost consumer devices is relatively recent and has the potential to increase significantly the utility of existing SRD bands.

5.1.2 Adaptive Frequency Agility (AFA)

Adaptive Frequency Agility (AFA) is a technique to avoid transmission in channels that are already occupied. The transmitter periodically monitors its local radio environment and notes channels that are occupied. Based on this information the transmitter selects a frequency that is not yet used in order to avoid interference. AFA can be very useful if a frequency band is shared among a large group of users or if the band has to be shared with another service which has a higher priority and therefore may not be hindered. AFA is usually combined with LBT (see above) and is sometimes referred to as dynamic frequency selection (DFS).

In both LBT and AFA/DFS there is a fundamental trade off between probability of detections and probability of false alarm. Therefore there is a risk that, to achieve a very high probability of avoiding interference, false alarms from noise-like sources may decrease apparent spectrum availability. This trade-off can be improved somewhat with additional processing to confirm that detected signals are not, in fact noise.

LBT / AFA has proved successful in helping co-existence in the 863 – 870 MHz band and could also work in an overlay environment. LBT / AFA chip sets are now down to €2–3 each. The price of these technologies has fallen considerably in recent years - already available at unit costs of €2-5 are intelligent adaptive frequency agile radio chipsets to facilitate sharing

[13] A hidden node situation would arise where an interfering source can be seen by a victim receiver but cannot detect the presence of the victim transmitter, resulting in interference to the victim receiver.

5.1.3 Automatic Transmitter Power Control (ATPC)

ATPC means that the transmitter uses the lowest power level commensurate with maintaining the quality required, thereby helping to keep the level of interference to other users down. A requirement on High Performance Radio Local Area Networks (HIPERLANs) to implement ATPC along with DFS these technologies has allowed allocations to be made in the 5 GHz bands even though these are already occupied by other services. Without these techniques these allocations would not have been possible.

5.2 Spread Spectrum

Spread spectrum techniques, developed in the 1940s for military applications, are characterised by high immunity to interference and low probability of intercept. These qualities, coupled with their potential for high data capacity and relatively low spectral power density (reducing the potential for causing interference to other narrow band devices), make spread spectrum systems an attractive technology for consumer use and the technology behind virtually all of today's wireless local area networks. The technology is also deployed in most 3G phone networks and in the US by the majority of digital cordless phones.

Direct sequence spread spectrum (DSSS) is the most widely used type of spread spectrum system. It is a digital modulation technique achieved by modulating a narrow band radio frequency carrier with a high speed spreading code sequence. The spreading code spreads the narrow band signal over a wider band of spectrum. Because the total power of the original signal is now spread over a much broader bandwidth, the power level at any given frequency is very low. This feature allows direct sequence spread spectrum systems to operate in the presence of narrow band systems with a lower risk of interfering or suffering interference.

Frequency hopping spread spectrum (FHSS) is a form of signal spreading in which the frequency of the transmitted signal "hops" from channel to channel. This occurs many times a second in accordance with a pseudo-random list of channels. The receiver hops in strict conjunction with the transmitter, thereby collecting all data transmitted. Again, the technique minimises the risk of interference both to and from conventional users, because a particular channel is only in service for a very short period before the transmitter hops to a different channel. DSSS can carry considerably higher data rates than FHSS and is therefore the preferred technology for WLANs. FHSS is claimed to have greater interference immunity than DSSS and is widely used for ad-hoc connectivity applications, notably those based on the Bluetooth standard.

Europe has not to date been able to reap the benefits of spread spectrum at frequencies below 1 GHz as the relevant standards have not been in place, however the latest revision of the ETSI SRD standard EN 300 220 includes provision for both FHSS and DSSS in the 863 – 870 MHz band. The Zigbee foundation, an industry grouping promoting the use of spread spectrum technology for home and industrial automation applications, is promoting the use of such technology in the 863 – 870 MHz band and favours the expansion of the band to facilitate the deployment of spread spectrum devices.

5.3 Ultrawideband (UWB)

UWB is a technology for the transmission of broadband data using techniques which spread the radio energy over a very wide frequency band (typically several GHz), with a low power spectral density. UWB can be considered an extension of spread spectrum as many of the basic concepts and concerns apply to each. The low power spectral density limits the interference potential to conventional radio systems, and the high bandwidth can allow very high data throughput for communications devices, or high precision for location and imaging devices. One of the key propagation advantages of UWB is its near-immunity to multi-path, which enables this technology to operate significantly better than other technologies in an indoor environment.

UWB applications include: high speed data communications, precision distance measurement, imaging apparatus used in law enforcement, rescue operations and medicine, automotive anti-collision radars and such indoor/handheld communication equipment as wireless laptops or audio and video links. They generally cause minimal interference to radiocommunications in the same band but they can, in sufficient aggregations raise the noise floor and may need to be regulated in bands where sensitive devices are deployed (e.g. GPS or radio-astronomy). There is also an issue with regard to compatibility with Broadband Wireless Access Technology (e.g. WiMax and TD-CDMA), where both technologies are deployed in close proximity.

5.4 Software Defined Radio (SDR) and Cognitive Radio

Software defined radio is a collection of hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals. SDR provides an efficient and comparatively inexpensive solution to the problem of building multimode, multi-band, multifunctional wireless devices that can be adapted, updated, or enhanced by using software upgrades. As such, SDR can be considered an enabling technology that is applicable across a wide range of areas within the wireless industry. Existing regulatory frameworks are not well adapted to managing the use of SDRs as they are based on regulating access to specified frequencies. Some form of designated spectrum commons may have to be considered for this purpose.

It is worth noting that software radio is not a new concept - for a decade or more many commercial radio systems have been implemented to a large degree in software. In most cases this software was frozen at the factory, although cellular downloads of software are not unknown. Two of the key issues in SDR are allowing explicitly the download of new software after the factory – something already allowed in the US – and giving the radios enough agility that major changes can be made after the factory.

Cognitive radio technology aims to enable the radio to sense and adapt its behaviour according to the environment in which it operates, along with the possibility of negotiating or interacting with existing spectrum users. The cognitive functions are performed by applying a process where a sequence of ‘observe’, ‘orient’, ‘decide’ and ‘act’ is implemented. One way of developing and implementing cognitive concepts is to use a software defined radio (SDR) architecture, as described above. The SDR can be considered as the ability to reconfigure radio operating parameters which makes it attractive for addressing the adaptability component of cognitive radio technology.

In a cognitive radio terminal, the software implements various protocols to achieve cognitive radio's aims. It is likely that such terminals would be capable of achieving much more flexibility in spectrum use and this will improve spectrum utilisation.

There are two principal approaches to sharing spectrum using cognitive radio. Passive cognitive radio (PCR) makes decisions on frequency use autonomously and without any interaction with the licensed user, whereas Co-operative cognitive radio (CCR) works interactively with the licensed user[14]. PCR is usually assumed to require a positive signal to noise ration (SNR) and a radiometric detector to detect the presence of a licensed user. Known signal formats can be detected even with a negative SNR using a cyclo-stationary or feature detector. It is however clearly easier to detect continuous duty, high antenna height signals such as TV broadcasts than terrestrial low power mobile signals.

Some NRAs have expressed concern that it is would be difficult to ensure the absence of harmful interference from overlay applications, such as cognitive radio. It is possible that the cognitive radio device may be shielded from another user's transmitter and may proceed to transmit; causing interference to a nearby receiver that is not shielded (sometimes referred to as the "hidden node" problem). However as wireless technologies become increasingly tolerant to low levels of interference it may be appropriate to question whether the traditional noise limited is appropriate for future spectrum allocations.

5.5 Adaptive Antenna Technologies

Adaptive antenna technology is increasingly being proposed to reduce interference and thereby increase spectrum utilisation and sharing potential. The principle is based on array technology and associated signal processing. On the basis that the direction of an interfering source can be determined it is possible to adjust the overall pattern of the antenna such that a null, or at least some discrimination, is directed towards the interfering source thereby reducing its impact.

Multiple Input Multiple Output (MIMO) MIMO is an emerging technology that effectively detects obstacles in a transmission path and dynamically modifies the transmission and receiver antennas to optimal signal strength. This enables more efficient use of spectrum i.e. the transmission of higher bit rates within a given bandwidth. MIMO offers the potential to place a large number of parallel transmissions on the same frequency, particularly in an urban environment. MIMO is increasingly being deployed in wireless local area networks and is expected to be extended to wide area networks before long.

[14] see "Real Time Spectrum Markets and Interruptible Spectrum: New Concepts of Spectrum Use Enabled by Cognitive Radio", Michael J Marcus, IEEE Dyspan conference, November 2005 (http://www.marcus-spectrum.com/documents/dyspan05.pdf)

6 Appendix E: Collective Spectrum Application Overview

6.1 Consumer Devices

Although it is difficult to find specific data, it is likely that this sector is currently the largest in volume terms, since almost every household is likely to have at least one low cost wireless device. These devices range from wireless key fobs for cars and buildings to baby monitors, doorbells, burglar alarms and video senders. Most of these devices use low cost technology operating in traditional Industrial Scientific Medical (ISM)[15] bands such as 27 MHz and 433 MHz. The main exceptions to this are wireless audio devices operating in the 863-865 MHz band. The 433 MHz band is favoured by low duty cycle applications such as key fobs and door bells, which enables a large number of devices to be accommodated in the available spectrum with low probability of interference. As cost is paramount in the consumer sector there is relatively little deployment of interference mitigation techniques. Where interference does occur, it can usually be overcome by either re-transmitting (in the case of low duty cycle equipment) or re-tuning to another frequency (in the case of audio / video equipment).

Major growth in consumer SRD use is expected over the next decade, spurred on by developments such as 10-year lifetime "fit and forget" batteries which make the technology more attractive in low-cost consumer applications.

6.2 Professional Applications

Professional applications of collective use of spectrum fall into three main area, namely wireless microphones, industrial telemetry and RF identification (RFID) devices. Each of these has its own particular characteristics which raise particular issues in the context of spectrum management, as discussed in the sub-sections below.

6.3 Wireless Microphones

Professional wireless microphones differ from most other collective use applications in that there is 100% duty cycle (the devices transmit continuously when in use) and little or no tolerance to interference or delay. Consequently it is not possible for wireless microphones to share the same frequency at a given time and location. Professional microphones mainly use the Ultra High Frequency (UHF) Television (TV) bands on a secondary basis but there is also a dedicated band at 1785 – 1800 MHz for digital microphones. UHF equipment has typically 20 – 24 MHz tuning range, limited by bandwidth of passive components (filters etc). They can be re-tuned by changing components and crystals but this is expensive and time consuming.

Wireless microphones are extensively used throughout the entertainment industry. For example, a typical London theatre production may use 30 or more microphones, whilst the largest musical productions could use over 50. The economic importance of this sector is significant – a 1997 report estimated the total economic impact of West End theatre was

[15] ISM – Industry Scientific and Medical (ISM) radio bands, defined by ITU-R in the radio regulations 5.138 5.150

£1,075 million per annum[16] – though it is difficult to quantify what contribution the use of wireless microphones makes to this.

Analogue technology continues to be preferred for wireless microphones, as digital compression causes delay which means audio is not synchronised with lip movement. Digitalisation has been slower in the wireless microphone sector because of the compression / delay issue and the inferior spectrum re-use of digital systems when FM capture effect is taken into account. Major manufacturers like Sony, whose other product lines are now mainly digital, still only produce analogue radio microphones. Analogue equipment is also significantly more bandwidth efficient, using as little as 75 kHz bandwidth as opposed to the 750 – 1200 kHz required for uncompressed digital transmission. Whilst improvements to digital signal processing may overcome the delay problem over time, there seems to be no immediate prospect of a switchover from analogue technology in this sector.

Wireless cameras also make use of spectrum on a collective basis – for example the 2.4 GHz ISM band is used in some countries, but there is pressure from CISCO and others to exclude audio/video applications from this band. There are various non-harmonised national bands for video cameras – e.g. 1.3 GHz in the UK, 2.2 GHz in Germany and 1.2 GHz in Italy – this lack of harmonisation can be problematic at international events.

6.3.1 Telemetry

Wireless telemetry applications include remote meter reading, asset tracking and building automation, as well as more conventional telemetry application such as monitoring industrial equipment, reservoirs, storage tanks and intruder alarm systems. Dedicated frequencies have been allocated for alarm systems in the 869 MHz band, however there are no harmonised frequencies for other types of telemetry – these must use the non-specific SRD bands. Some Member States do have national allocations for low power telemetry however and these can be very heavily used. For example, in the UK some monitoring of the telemetry band at 458 MHz has been undertaken and this shows all the channels in use in some areas.

The market for remote meter reading devices is expected to take off over the next few years with the advent of very low cost chipsets and longer life batteries. Two types of system are emerging namely, fixed infrastructure and ‘drive-bys’. Both require reliable operating ranges of 100 – 400 metres with good building structure penetration hence demand for this application is concentrated in the VHF range (100 – 220 MHz). Spectrum for these systems has already been designated in the UK at 173 MHz and more recently within the re-farmed European Radio Messaging System (ERMES) band, though the available spectrum is limited and systems are also available operating at 868 – 870 MHz and in the 2.4 GHz band.

The market for building automation devices is estimated at around 10 million annually and for alarms at around 50 million per annum.

[16] The Wyndham Report, July 1998, by Tony Travers of the London School of Economics, with data compiled by MORI, http://www.artscouncil.org.uk/documents/publications/phpuSGWg5.doc

6.3.2 Radio Frequency Identification Devices (RFID)

RFID provides improvements to the tracking and handling of goods in distribution and retail environments. In some cases it replaces bar codes, which are less reliable and more expensive to use as a human operator is required for the scanner. In other cases there is no tracking at the moment and the adoption of RFID is expected to result in savings due to improved stock control and reduced pilfering. As an example of the potential benefits, Metro, Germany's biggest retail group, claimed recently to have saved over €10M in a year by using RFID to track products from suppliers to one of its retail stores, which it is using to trial the new technology. RFID is also used by smart payment cards and electronic key systems,

There are three main RFID spectrum allocations, namely:

- 13.56 MHz (narrow band short range magnetic field based systems such as "smart card" readers. range 30 – 100 cm),
- 433 MHz (battery powered active devices) and
- 865 – 868 MHz (mainly passive devices but some active, range up to 3 metres).

The latter (UHF) allocation is split – the upper 2 MHz is for higher power applications up to 2 Watts. There is also a low frequency allocation just below 135 kHz used for specialised applications. UHF RFID tags will work over the band 860 – 960 MHz, compatible with European (865-868), North American (902-928) and Far East (955-958 MHz) interrogation frequencies[17]. The market for RFID tags is expected to rise significantly to around 500 million a year by 2010, according to the LPRA. For example, RFID chips will be incorporated into 3 million tickets for this year's Football World Cup in Germany, at a cost of €0.1 per tag according to the manufacturer, Philips.

In the short to medium term, the industry view is that existing RFID spectrum is probably adequate, as technology enhancements such as Listen Before Talk (LBT) and Adaptive Frequency Agility (AFA) enable the spectrum to be used very intensively. However there is a concern that congestion will arise in the longer term if the technology becomes ubiquitous, and particularly if it is adopted in the domestic scenario. This concern was reflected in a speech by EU Commissioner Viviane Reding, at the launch of a recent EU consultation on RFID devices. The Commissioner observed that use of RFID is expected to grow rapidly but only if "we quickly overcome key barriers as regards incompatible standards and inadequate frequency allocation". Industry Research & Development activity is focussing on improving portal design and interrogation algorithms to improve reliability and spectrum capacity. Ultra Wide-Band (UWB) technology is not seen as viable for RFID but could be used to backhaul data from interrogators – Wi-Fi is currently used for this.

[17] Interrogation frequencies are those used by the RFID "readers" to send and receive signals from the tags; the tags themselves act as transponders which send a return signal on the same frequency back to the reader. Although these interrogation frequencies differ around the world, this is not a problem so long as the frequencies are all within the 860 – 960 MHz operational range of the tags.

6.4 Medical and Social Applications

Two important applications of collective spectrum in use today relate to social needs such as emergency alarms for the elderly or infirm, and medical applications such as pacemakers and defibrillators. Clearly interference to such devices could have serious implications and it is likely that some form of dedicated frequencies for specific collective use will be required. There is also likely to be a growth in demand for high quality inductive systems to cater for the hearing impaired. These applications were harmonised using the former ERMES allocation, under an ECC decision (05)02.[18]

6.4.1 Social Alarms

Social alarms are widely used by care agencies (both public and private sectors) and by individuals, to provide a means of summoning help in emergency situations. In addition to providing a wireless "help button" wireless sensors can also be used to detect intruders, fire, gas escapes, etc. Such devices, which operate on dedicated frequencies around 869 MHz and (more recently) 169 MHz are increasingly being used to support "telecare", the remote provision of health and social services. Social alarms operate on separate frequencies from more general wireless alarm systems due to the relatively high density of the latter and the consequent potential for interference. The benefits can be significant, both in social and economic terms. For example, a recent UK study by the University of Sterling estimated the gross annual cost for providing one care home to be £21,840, compared with £7,121 for the support in the community package based on tele-care technology, 24 hour response and ten hours of care[19].

Following the repeal of EC Directive 90/544/EEC (the ERMES Directive), the EC mandated CEPT to investigate he possibilities for accommodating applications for disabled and elderly persons, such as social alarms and wireless hearing aids. Parts of the band have since been designated for such applications in EC Decision 2005/928/EC. During the consultation process undertaken by CEPT under the EC mandate, it was concluded that social alarm systems similar to those operating in the 869 MHz band should be allowed in order to alleviate propagation problems that had been identified with existing systems in the 869 MHz band.

6.4.2 Medical Devices

Wireless applications in healthcare include devices such as heart rate monitors, pacemakers, glucose monitors, insulin pumps, hearing aids, medical alert pendants and remote patient monitoring. Heart monitors, for example, are used by around 1.5 million people within Europe, according to ETSI ERM TG30. More recent innovations include swallowable wireless cameras that can transmit to a receiver worn by the patient. It is difficult to find market data relating specifically to wireless medical devices; however one recent estimate put the size of the US medical devices market in 2005 at US$74.5Bn, with further increases expected due to an increasingly ageing population.

[18] ECC decision of 18th March 2005, on the use of the Frequency Band 169.4 – 169.8125MHz (ECC/DEC/(05)02) http://www.ero.dk/documentation/docs/doc98/official/pdf/ECCDEC0502.PDF

[19] see http://www.tunstall.co.uk/detail.asp?ID=255

Historically, most devices were low-frequency inductive links for transferring data from implanted devices to external equipment. These were limited to very short ranges and often required the external programmer to have contact with the skin of the patient directly over the implant. To overcome range and data-rate limitations, new ultra-low-power (ULP) RF technologies have been developed that operate in the UHF bands, in particular 402–405 MHz band which was recently allocated specifically for such devices. This allocation, which is considered optimal in terms of ability to penetrate human tissue, came about in the mid-1990s following petitioning by industry in the US. The band was subsequently incorporated into ITU-R Recommendation SA1346 and ERC Recommendation 70-03, as a harmonised European band.

Another growing area of interest, particularly in the US, is medical telemetry. In the US, FCC has allocated interference-protected spectrum for wireless medical telemetry[20] in the 608-614 MHz, 1395-1400 MHz and 1427-1432 MHz frequency bands. New Zealand is also considering introducing an equivalent to the USA's WMTS, also at 1400MHz. ETSI ERM TG30 is working on the planning of new frequency bands for wireless medical devices (medical telemetry) in Europe.

6.5 Transport Applications

Collective use of spectrum makes an important contribution to safe and efficient transportation, particularly in the road and rail sectors.

6.5.1 Road transport

Wireless technology is increasingly deployed in road transport, for both infrastructure and vehicular applications. In Europe, many of the infrastructure applications have emerged from EU-funded programmes to apply technology to improving traffic management and road safety. Applications include information provision, collision avoidance and vehicle automation. The concept of an “intelligent car” was one of the flagship initiatives defined as part of the European “i2010” agenda on information society growth and employment. Among other things, an intelligent car should interact with its environment by radio means, via for instance inter-vehicle communications. According to the Short Range Automotive Radar Frequency Allocation (SARA) group, automotive electronics will account for 20 - 30 % of total vehicle value in the future and the focus will be on emerging radio based applications related to improving road safety. Even today, the global market for in-car licence exempt wireless devices such as key fobs, alarms and immobilisers is estimated at around 20 million annually, according to the Low Power Radio Association (LPRA).

Frequencies have been designated around 5.8 GHz (5795 – 5805 MHz) for road transport and traffic telematics (RTTT), which covers a wide range of applications associated with road transport, including both vehicle to vehicle and vehicle to infrastructure communications. Similar (though not identical) frequencies have been designated in the US and in Japan. To date the only significant use of this spectrum for RTTT applications is for electronic road tolling and the predominant use of the band in several countries is for provision of fixed wireless access services. Consequently there are concerns that this band will become

[20] remote monitoring of a patient's health where the RF communication occurs between a patient-worn transmitter and a central monitoring station

prone to interference as demand increases and will be unsuitable for safety critical applications.

Consequently there has been pressure for additional, dedicated spectrum to be allocated. ETSI has proposed two new bands, namely 5885 – 5905 MHz for critical safety related applications and 5850 – 5925 MHz for other applications[21]. The ECC SRD Maintenance Group is carrying out preliminary study on these proposals in the light of the other existing and planned applications and is due to make an initial assessment of the feasibility of finding the requested amount of spectrum

It has also been proposed that the 5 GHz WLAN band could be used to deliver non-critical data to vehicles using the same infrastructure as the safety-critical services at 5.9 GHz. According to the European Car2Car Communication consortium, representing major players in the European road transport sector, deployment of such services in the market is likely to be around 2010 onwards, assuming agreement is reached on the additional spectrum requirement in 2006. The automotive sector is currently one of the few significant users of licence exempt spectrum in the higher microwave and mm-wave bands, with frequencies having been allocated in the 24, 77 and 79 GHz bands for anti-collision radars.

Although this is currently a relatively undeveloped market, considerable sums are being invested in R&D – for example the EU 6th Framework study on Co-operative Vehicle-Infrastructure Systems (CVIS) involves 63 industrial partners and has a budget of €41M over four years.

6.5.2 Railways

Various licence-exempt bands play an important role in supporting rail operations, some of which are mandated by EU regulations[22]. For example, the Euroloop train control system uses spread spectrum technology to transmit data between track and trains via leaky feeders, using frequencies below 30 MHz. These are very short-range systems that by their enclosed nature are unlikely to be interfered with by other devices, and complement licensed railway spectrum in the 900 MHz band (GSM-R).

6.6 Electronic Communications

It is probably fair to say that the biggest single factor driving the take up of collective spectrum use in recent years has been the growth in Wireless Local Area Networks (WLANs). Falling hardware prices and increasing consumer awareness have led to widespread deployment of Wi-Fi based systems in homes, offices and public places. The majority of laptop computers now on sale include Wi-Fi connectivity as standard and the number of public Wi-Fi "hotspots are increasing rapidly (see Table 3 below).

[21] ERM TG 37 on Intelligent Transport Systems – see ETSI Technical Report 102 492-1

[22] Notably Commission Decision of 30 May 2002 concerning the technical specification for interoperability relating to the control-command and signalling subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Council Directive 96/48/EC

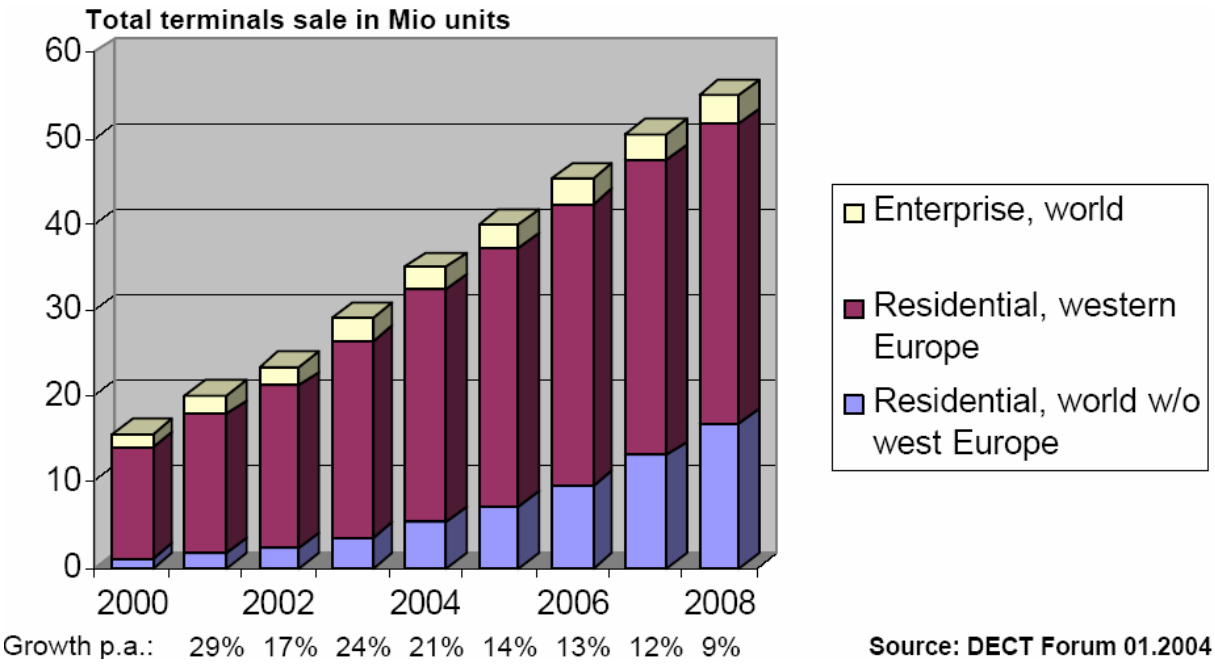
Table 3: Numbers of Registered Wi-Fi Hotspots

Top Cities		Top Countries		Top locations	
Seoul	2056	United States	39951	Hotel/ Resort	30182
London	2044	United Kingdom	16949	Restaurant	23692
Tokyo	1846	Germany	11121	Café	15280
Paris	1073	South Korea	9415	Store / Shopping Mall	14837
San Francisco	809	Japan	6200	Pub	7181

Source: www.jwire.com 18th May 2006

DECT (Digital Enhanced Cordless Telecommunications) is a flexible digital radio access standard for cordless communications in residential, corporate and public environments. DECT provides for voice and multimedia traffic, and contains many forward-looking technical features that allow DECT-based cordless systems to play a central role in important new communications developments such as Internet access and inter working with other fixed and wireless services such as ISDN and GSM. Figure 6 below shows the DECT terminal sales (2004) and projected sales to 2008.

Figure 6: Annual sales of DECT terminals



These figures are set to increase with the sales of DECT 6.0 now available for use in the North American market to provide interference free communication by utilizing the appropriate frequency band of 1920 - 1930 MHz which has seen a relaxing of technical standards by the Federal Communications Commission (FCC) for Unlicensed Personal Communications Services (UPCS). The apparent customer advantages of the DECT technology compared to conventional 2.4 and 5.8 GHz cordless telephones in the US has

accelerated the break-through of DECT and represents a large opportunity for the business growth of the DECT industry.

In recent years a number of EU countries have allowed the use of the 2.5 GHz and 5.8 GHz for FWA, either on a licence-exempt or “light licensing” basis. This has helped to stimulate the availability of broadband access, particularly in Member States where non-line provision has been limited (e.g. Ireland).

7 Glossary

3G	Third Generation Technology
AFA	Adaptive Frequency Agility
AIP	Administered Incentive Pricing
ATPC	Automatic Transmitter Power Control
CCR	Co-operative Cognitive Radio
CEPT	Conference of European Post and Telecommunications Administrations
CISPR	Special International Committee on Radio Interference
DECT	Digital Enhanced Cordless Telephone
DFS	Dynamic Frequency Selection
DSSS	Direct Sequence Spread Spectrum
DVB	Digital Video Broadcasting
ECC	European Communications Committee
EIRP	Effective isotropically-radiated power
ERMES	European Radio Messaging System (former pan-European paging standard)
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
FWA	Fixed Wireless Access
GHz	Gigahertz (frequency of one thousand million Hertz)
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HIPERLANs	High Performance Radio Local Area Network

IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISM	Industrial Scientific Medical
ITS	Intelligent Transport System
ITU	International Telecommunications Union
KHz	Kilohertz (frequency of one thousand Hertz)
LAN	Local Area Network
LBT	Listen Before Transmit
LPRA	Low Power Radio Association
LPRA	Low Power Radio Association
MHz	Megahertz (frequency of one million Hertz)
MIC	Ministry of Information and Communication
MIMO	Multiple Input Multiple Output
NFPG	National Frequency Planning Group
NRA	National Regulatory Authorities
OFCOM	Office of Communications
OFDM	Orthogonal frequency-division multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OOK	On Off Keying
PMR446	Personal Mobile Radio using the 446MHz part of the UHF range which is open without licensing for personal usage in most countries.
PT43	ECC Project Team 43
QoS	Quality of Service
RA	Radio Communications Agency
RFID	Radio Frequency Identification Device
RSA	Recognised Spectrum Access

RSC	Radio Spectrum Committee
RSPU	Radio Spectrum Policy Unit
RSS	Radio Standards Specifications
RTTT	Road Transport and Traffic Telematics
SARA	Short Range Automotive Radar Frequency Allocation
SDR	Software Defined Radio
SNR	Signal to noise ration
SRD	Short Range Device
TD-CDMA	Time Division Code Division Multiple Access
TFTS	Terrestrial Flight Telephone System
UHF	Ultra High Frequency (300 MHz – 3 GHz)
UKSSC	UK Spectrum Strategy Committee
UWB	Ultra Wideband
VHF	Very High Frequency (30 – 300 MHz)
WiFi	Wireless fidelity a term for certain wireless local area networks that use specifications conforming to IEEE 802.11b.
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WRC	World Radio Conference

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