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RADIO SPECTRUM POLICY GROUP

RSPG Report on Strategic Sectoral Spectrum Needs

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Introduction

The identification of spectrum to address the growing demand for broadband services has taken the central stage in European spectrum policy. Furthermore, the European and international regulatory environments have recently evolved with the adoption of the first Radio Spectrum Policy Programme, RSPP[1], which identified in particular the frequency range 400 MHz to 6 GHz in order to identify potential significant uses of spectrum. Therefore, the European Commission has sought the advice of the Radio Spectrum Policy Group (RSPG) on the strategic issues and challenges to be addressed in Europe in order to meet the objective.

Several sectors are addressed in the RSPP. Article 6 refers to wireless broadband[2], Article 7 refers to spectrum needs to support further development of innovative audio-visual media and other services[3]. This report is focusing on Article 8 which highlights specific EU policies other than electronic communication services (ECS), for which spectrum needs should be studied and protected, in particular:

- Galileo
- Global monitoring for environment and security (GMES)
- Intelligent transport management systems (ITS)
- Smart energy grids and smart meters
- Safety services and public protection and disaster relief (PPDR)
- Scientific services
- Programme making and special events (PMSE)
- The Internet of things (IoT) including RFIDs[4]

The RSPG decided that sectors such as civil aeronautical and maritime communications and Professional mobile radio (PMR) are also interrelated with Union policies and have therefore been addressed in this report.

It should also be mentioned that the spectrum usage, needs and demands, in particular from others sectors than the commercial ones, are covering a larger scope than the frequency range 400 MHz to 6 GHz. This is mentioned in case by case basis in this report, where appropriate.

In addition, the RSPG is preparing an Opinion on WRC-15, which will address some of these sectors in a number of agenda items (WRC-15). The intermediate findings of the working group in charge of developing the draft Opinion on WRC-15, which identifies the main themes of WRC-15 where an EU policy is in place,[5] have also been considered in the preparation of this report. This RSPG Report on Strategic Sectoral Spectrum Needs focuses on spectrum needs and demands for different types of functionality, and not specific spectrum users. This focus on uses instead of users is aimed to facilitate flexibility in accordance with the RSPP, which promotes technology and radio service/application neutral authorisations as a general regulatory principle. Restrictions on the principle of technology and

[1] EU Decision 243/2012, OJ L 129, 17.5.2007, p. 67

[2] RSPG Opinion on strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband (RSPG13-521rev1)

[3] RSPG Report on Wireless broadband and Broadcasting in the Frequency Range 400 MHz to 6 GHz (RSPG13-522)

[4] Radio Frequency Identifications

[5] RSPG Interim Opinion on Common Policy Objectives for WRC-15 (RSPG13-525)

service/application neutrality in right of use should be appropriate and justified by the need to avoid harmful interference, while not precluding the possibility of using more than one service or application in the same frequency band, to ensure proper sharing of spectrum to safeguard the efficient use of the spectrum.

This report provides the views from the RSPG on spectrum needs identified at the time of writing of this report for the various sectors which have been investigated.

Summary

In this report the RSPG identified the emerging spectrum needs and demands over the coming years for the eleven different sectors. The work focused on the development of a strategic policy approach to meet spectrum needs, exploring the synergies between the sectors, and the likely development of a number of applications and services from these eleven different sectors:

- Galileo and EGNOS
- Global monitoring for environment and security (GMES)
- Intelligent transport systems (ITS)
- Smart meters
- Smart energy grids
- Public Protection and Disaster Relief (PPDR)
- Scientific services
- Programme Making and Special Events (PMSE)
- The Internet of things (IoT) including RFIDs and Machine-to-Machine (M2M)
- Aeronautical communications and maritime communications
- Professional mobile radio (PMR)

This RSPG Report reveals large differences for the various sectors in terms of their spectrum usages, needs and requirements. The RSPG recognises that different regulatory paths are available, and the sectoral spectrum needs can be addressed via these existing processes (nationally, ETSI-CEPT process and ITU process as described in Section 2.1). The RSPG considers that these different regulatory paths are valid, and in many cases sufficient to be applied for the various sectoral needs addressed. The RSPG also identifies areas where it may be considered that these existing processes could be further developed.

General strategic considerations

When addressing the needs of the different sectors the RSPG considered, where applicable and where appropriate, the possibility to use already available harmonised bands for a given sector, potential usage of commercial networks or existing infrastructures, as well as the possible opportunities (and limitations) to share spectrum with other services.

The RSPG also addressed the possible need for harmonisation and considers that many of the future spectrum needs may be met by generic harmonisation. In addition, the RSPG notices that for a number of sectors there might be a need for a more sector or service specific harmonisation, including a possible identification of dedicated frequency bands. This could be motivated required that such a harmonisation adds large benefits regarding the establishment of the internal market. In this context, where applicable, the relationship between social and economic benefits and the way spectrum resources are used should be considered, e.g. when performing an impact assessment of a given regulation.

The work of the RSPG to identify and evaluate the needs and demands for the studied sectors has been based on the principles described in Chapter 3 using the methodology in Section 1.3. These principles may lay the foundation for general strategic considerations on how to address and respond to the frequency needs and demands that constantly arise from new applications and services within various sectors.

Even though this RSPG Report reveals that there is no *one size fits all* solution, the RSPG has made an attempt to identify elements for a more general approach on how to address future spectrum needs and demands. The RSPG believes that any methodology should consider the different options available to

meet the spectrum needs and demands for an emerging application and service. In Chapter 4, the RSPG uses these strategic considerations to make an attempt to describe a possible methodology and a more general strategy on how to address the spectrum needs and demands using a high level strategic approach.

Sector specific considerations

For smart energy grids, smart meters, ITS and IoT (including RFIDs and M2M), the RSPG has identified no requirements that would motivate a harmonised European solution for dedicated spectrum for specific services or applications (see Section 2.2). However, the large predicted growth within some of these analysed sectors contribute to an increased need and demand for capacity and bandwidth, which may be met in suitably expanded future identification of bands under general authorisations (exemption from individual licensing). The future spectrum needs for smart energy grids, smart meters, ITS and IoT (including RFIDs and M2M) can be addressed via the ETSI-CEPT process.

Sectors such as Galileo, Global Monitoring for Environment and Security (GMES), scientific services aeronautical and maritime communications include global services that often require, a more or less, global harmonisation (see Section 2.3). For these sectors, the need for spectrum and adequate protection are mainly catered for via the ITU process.

The RSPG recognised that the provision of PPDR services, and the associated radiocommunications infrastructure is a sovereign national matter, and that the broadband PPDR needs of Member States may vary to a significant extent. Therefore, the future harmonisation of the broadband PPDR sector in Europe needs to be flexible enough to respect national sovereignties and different national circumstances such as the amount of required spectrum and the type of network to be deployed (which may be dedicated, commercial or a hybrid solution with a mixture of dedicated and commercial networks). The RSPG also noticed that that there are requirements to ensure adequate interoperability between the different countries. (see Section 2.4)

The demand considerations for future PMSE spectrum opportunities need consultation at national level, with subsequent national contribution to on-going studies in the CEPT/ECC. New spectrum opportunities for PMSE need also to be reflected in the harmonised European standards for PMSE equipment coordinated via the existing ETSI-CEPT process. The RSPG notices that the PMSE usage varies greatly in time and location, and depend of the scale of the event or programme. The RSPG found it relevant to identify the spectrum needs for audio applications and video applications separately, but also identified similarities. Possible re-allocation of primary services, new sharing possibilities and efforts to pursue opportunities in higher frequency ranges will require regulatory changes, and the users will have to adapt. Transparency and a reliable regulatory environment would be a prerequisite to give users the confidence needed to make the necessary investments associated with new conditions. (see Section 2.5)

Finally, the RSPG has not identified any indications that the bandwidth requirements of the narrowband PMR sector will increase within the medium or long term future. A possible future evolution towards PMR broadband services would raise the need of availability of spectrum resources. However, before any technical concept has been presented for wideband PMR the RSPG finds it difficult at this stage to estimate any possible new spectrum needs or the future market demand for these applications or services. The RSPG considers that the development in this area should be closely monitored. (see Section 2.6)

Content

Part A

1. Context of the study

1.1. Background information

The RSPG working group on Strategic Sectoral Spectrum Needs[6] examined the likely development of eleven different categories of applications and services listed below from a strategic point of view in order to identify emerging spectrum needs and demands over the coming years. These sectors are:

- Galileo and EGNOS
- Global monitoring for environment and security (GMES)
- Intelligent transport systems (ITS)
- Smart meters
- Smart energy grids
- Public protection and disaster relief (PPDR)
- Scientific services
- Programme making and special events (PMSE)
- The Internet of things (IoT) including RFIDs and Machine-to-Machine (M2M)
- Aeronautical communications and maritime communications
- Professional mobile radio (PMR)

During the work the RSPG decided to add the following sectors to be included in this report; civil aeronautical communication, maritime communication and PMR. Those sectors are not mentioned explicitly in the RSPP but have been considered as relevant by the RSPG when considering spectrum needs due to links with EU Public Policies and internal market issues.

1.2. Scope and objectives

This RSPG report addresses the principles, which should be indicative for future work with respect to strategic sectoral spectrum needs as follows:

- Identify and describe, where appropriate, the suitable regulatory framework to consider at strategic level;

- Propose, where appropriate, ways to address the need and demand for spectrum or capacity for each sector, including the need for further regulatory measures necessary for the establishment and functioning of the internal market.

According to the RSPP, the RSPG conclusions and views in this report mainly address the frequency range of 400 MHz and 6 GHz, however, in some cases they also cover frequencies outside that frequency range. Even though many needs and requirements for the Defense sector can only be met with the use of radio systems they are not addressed in this report.

Finally, there is an important difference between need and demand. In this RSPG Report the terminology are used with the understanding that normally there is more need than demand for spectrum resources. The latter do not only means that individuals or society want access to spectrum, but that they also have the means and are willing to pay for what they want.

1.3. Methodology

In this report the RSPG desktop analysis took into account other on-going processes such as relevant results of ITU, EC, ETSI and CEPT/ECC studies and other available studies. In this context, parts of this work may serve as a basis or reference material for developing the RSPG Report on Strategic

[6] RSPG Request for Report on strategic sectoral spectrum needs (RSPG12-421)

sectoral spectrum needs, which focus on spectrum needs and demands for different types of functionality (uses) and not on specific spectrum users. In addition to this, contributions from Member States have been important components to achieve a useful and well-grounded result which can widely be supported.

The RSPG has completed a detailed review of different sectors identified by the RSPP and other sectors relevant to European policies. For each sector, this review has identified the current processes in place to collect relevant information regarding:

- spectrum needs;
- regulatory requirements;
- strategic issues in terms of spectrum demands and needs;
- bottlenecks due to various demands on the very same part of spectrum.

Where possible and appropriate, the RSPG has performed an assessment of specific or exceptional needs for protection as well as any needs that can be met through a potential for using existing commercial or other types of networks.

1.4. Relationship between allocation and use

According to the ITU Radio Regulations an allocation is an entry in the Table of Frequency Allocations (Article 5) of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radio astronomy service under specified conditions. Any new use or basic characteristic of an existing use shall be made in such a way as to avoid causing harmful interference to services rendered by stations using frequencies in accordance with Article 5 (RR) in another country. In short this means that a country or a group of countries may use frequency ranges where Article 5 (RR) is not supporting this kind of use as long as this particular use does not cause harmful interference in another country using the frequency range in accordance with that article.

1.5. Spectrum inventory

The RSPP established a spectrum inventory on existing uses of the spectrum for both commercial and public use[7], where the matter is closely related to the work in developing this RSPG Report. To implement this inventory, an implementing act has been adopted[8] in order to develop:

- practical arrangements and uniform formats for the collection and provision of data by the Member States to the Commission on existing uses of spectrum and
- a methodology for the analysis of technology trends, future needs and demands for spectrum in policy areas covered by the RSPP,

so as to identify developing and potential significant uses of spectrum, in particular in the frequency range 400 MHz to 6 GHz.

According to this implementing Decision, Member States shall provide data on rights of use and actual use of the relevant spectrum (see Article 2). The Decision mentions also (see Article 3) that *"In order to identify specific spectrum bands which could best accommodate future needs and demand for spectrum and by taking utmost account of the opinion of the RSPG, the Commission shall analyse all information collected"*. Moreover according to the RSPP, the European Commission shall conduct

[7] Article 9 of the Radio Spectrum Policy Programme

[8] Commission implementing Decision of 23 April 2013 (2013/195/EU), OJ 25.4.2013, L 113/18

analysis of technology trends, future needs and demands for spectrum and report on the results of this analysis to the European Parliament and the Council.

The RSPG noted that the European Commission launched a study performed by Analysys Mason, focusing on the "Analysis of technology trends, future needs and demand for spectrum in line with Art. 9 of the RSPP".

The RPSG has carefully considered the results of this study in its analysis and when developing this report. It should be noted that this RSPG Report is responding to a request from the European Commission and is the result of active contributions from Member States providing other types of data and views and thus looking from a different angle than what may be the case in an external study as the one mentioned above.

- The RSPG identified that the application grouping made in the external study differs from the grouping done in this report. For example, the sector scientific services in this RSPG Report are covering a large scope of services (including passive and active sensing) as identified in the Radio Regulations (see conclusion in Section 2.3.4 and Section 6.5).

- The RSPG noted also that the external study covers Defense. This particular sector is outside the EU competences as well as outside of the scope of the RSPP, which is focusing on the Internal Market and is consequently not covered by this RSPG Report.

Nevertheless, during the two past decades, the Defense sector has released a significant amount of spectrum but it remains and will continue to be one of the more important users of spectrum resources. However, detailed information about military usages and needs are often subject to confidentiality requirements and legal obligation associated with defense systems. Information about military spectrum use up to a non-classified level is available in the EFIS database, provided by the Defense community itself (e.g. NATO) (see also Annex 10).

2. Conclusions

2.1. Existing processes to gather and address the relevant sectoral needs

Concerning the review of existing processes to gather the spectrum needs and demands of each of the addressed sectors with a time horizon up to 2020, it is widely understood that spectrum needs and demands can change over time. It is therefore important to regularly review the forecasted long-term needs and demands, in particular when coming from European public policies (see relevant article of RSPP) and will be subject to review during the update of the RSPP in 2015/2016.

All the sectors identified in Section 1.1 have already at least one process available and proven in place to raise any future specific spectrum needs. Two major paths have been reviewed and confirmed by each analysis:

- The ITU process is used for sectors where the sectoral need for spectrum is mainly worldwide (e.g. Galileo, GMES, scientific services as well as aeronautical and maritime communications).
- For other sectors not only relying on the Radio Regulations but requiring additional assessments to respond to the needs, CEPT/ECC is conducting studies and in many cases and is preparing European common positions before modifying the Radio Regulations
- The current ETSI-CEPT cooperation is used for a number of sectors (Intelligent transport systems, smart energy grids and smart meters, PPDR, PMSE, Internet of things including RFIDs and M2M and PMR). This cooperation in practice also includes the possibility for EU to decide on mandates to CEPT[9] and ETSI[10].

Caution shall be applied when trying to address the perceived spectrum need and demand from one sector through this RSPG Report since existing processes may already have been triggered.

2.2. Smart energy grids, smart meters, ITS and IoT (including RFIDs and M2M)

2.2.1. General conclusions concerning Smart energy grids, Smart meters, ITS and IoT (including RFIDs and M2M)

For the studied sectors smart energy grids, smart meters, ITS and IoT (including RFIDs and M2M), the RSPG has identified no requirements that would motivate a harmonised European solution for dedicated spectrum for a specific service or application. However, the large predicted growth within some of these analysed sectors contribute to an increased need for capacity and bandwidth, which may be met in suitably expanded identification of bands under general authorisations (exemption from individual licensing). Given their related key requirements, the RSPG considers that many of these needs are best to be realised using spectrum below 1 GHz.

The future spectrum needs for smart energy grids, smart meters, ITS and IoT (including RFIDs and M2M) can be addressed via the ETSI-CEPT process (see Section 2.1).

2.2.2. Information and description concerning smart energy grids (see Chapter 10)

Europe's integrated utility networks will be subject to substantial restructuring in the coming years as a direct consequence of the on-going liberalisation and innovation of the energy market. For example, the present electricity supply infrastructure, which is characterised by large centralised power stations, may progressively evolve into a system comprising both centralised and decentralised electricity

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[9] Decision 676/2002/EC

[10] Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012

supplies including micro generators and small and medium sized renewable sources. These could also be on consumer premises, where electrical power is locally generated and supplied to the network. The anticipated development, with a rapid growth in the numbers of decentralised micro generators will place new demands on the engineering of these systems, including real time optimisation of overall network operation and centralised control of individual equipment.

In order to identify suitable frequency options it is important to properly identify the communication infrastructure related to smart energy grids. Smart energy grids use wired and wireless communication and the requirements on the communication channels varies for the different levels of the grid, with necessary customisation to fit different types, configurations and extent/density of utility networks as well as utility operators' specific operational and commercial needs.

2.2.3. Conclusions concerning smart energy grids

Spectrum demand for smart grid applications may differ between the networks and countries, depending on network configuration, density of nodes, rate of data collection etc. Due to the large scope of smart grid services and applications, several techniques and spectrum ranges may be suitable to address the relevant requirements. Relevant solutions including PMR networks, fixed links, commercial cellular networks (M2M applications) and SRD using existing harmonised spectrum are already available to meet this demand of wireless solutions, and the RSPG considers that an exclusive designation of spectrum to smart energy grids is not necessary.

For these solutions, several existing spectrum options have been identified by the RSPG, such as:

- 169.4-169.8125 MHz (challenge: limited bandwidth compared with other spectrum options),
- 868-870 MHz;
- 870-876 MHz and 915-921 MHz;
- 2.4 GHz / 5 GHz (challenge: range and wall penetration);
- Commercial networks (e.g. GSM/GPRS and broadband such as LTE/WiMAX) may be feasible for collecting consolidated information from the meters' data aggregating points
- Various bands for broadband fixed wireless access where economics justify ad hoc networks purpose-built by utility operators;
- Private wireless solutions (PMR/PAMR) using national allocations in VHF or UHF bands (promising option given the availability of mass market commercial technologies and products which can be used in such private networks, challenge: limited bandwidth allocated to PMR).

Utility companies may very well use several of these frequency options within their networks and the RSPG considers that this sector can put forward their spectrum needs via the ETSI-CEPT process.

The RSPG notices that smart energy grids need information on the power consumption throughout the network and that smart meters could provide this information. When a utility operator exploits a smart grid and uses smart meters, it may very well wish to use the same frequencies for smart meters as for smart grids. Therefore the RSPG believes that a strict separation may lead to overseeing possible synergies between the two in the future.

2.2.4. Information and description concerning smart meters (see Chapter 9)

Smart meters are devices that are able to communicate bi-directionally both with utility providers and customers. Being able to follow their actual electricity consumption in real time will give consumers stronger incentives to save energy and money. Utility companies in the energy sector (such as electricity, gas, water and heating providers) have started deploying smart metering systems, capable of providing consumption information to the utility provider as well as to consumers in real time and generally allow utility providers to monitor and constantly optimise the supply chain of the given energy resource and ensure the resilient and efficient performance of their infrastructure. The roll-out of these smart meters is obligatory in many Member States.

RSPG has identified the following key operational requirements:

- Low capacity needs per individual metering device combined with use of aggregating devices (network relay points) to create hot-spot like flexible deployment of high density networks;
- Range from a few metres to a few kilometres for links of meshed networks in metropolitan as well as rural areas;
- Moderate requirements on robustness and latency;
- Very high density in urban environments;
- Low per-device cost solution;
- Meters are installed for a long period (>15 years) on customer premises.

In addition to these requirements, utility companies use several strategic criteria when assessing the options for the use of spectrum for communications with smart meters. Amongst these considerations are:

- the availability of standardised solutions with a mature ecosystem of various manufacturers and vendors,
- the price and lifecycle of available communication products that can be integrated in the meters and
- the level of control which can be achieved over the solution.

2.2.5. Conclusions concerning smart meters

The RSPG has identified several technical solutions that could be used for smart meters including PMR networks, fixed links, commercial cellular networks (M2M application) and SRD, using harmonised spectrum that is already available. The most suitable choice of technology and frequency band varies due to for example national circumstances and the operating environment (urban/rural). In some cases SRD technologies may be used, in other cases other technologies are more appropriate. For these solutions, several existing spectrum options have been identified by the RSPG, such as:

- 169.4-169.8125 MHz (challenge: limited bandwidth compared with other spectrum options);
- 868-870 MHz;
- 870-876 MHz and 915-921 MHz;
- 2.4 GHz/5 GHz for SRD (challenge: range and wall penetration);
- Commercial networks (e.g. GSM) (challenge: price and the longevity of GSM networks)
- Private Wireless Solutions (PMR/PAMR) using national allocations in VHF or UHF bands

The RSPG identifies the economies of scale for these mass-market smart metering devices as the greatest motivation for harmonisation of smart metering frequency access in Europe. The RSPG considers that this can be achieved within the current spectrum options available, and that an exclusive designation of spectrum to smart meters is not necessary. The RSPG considers that this sector can put forward their spectrum needs via the ETSI-CEPT process.

The RSPG notices that smart meters have a relation with smart energy grids. A utility company operating a smart grid and smart meters may very well wish to use the same frequencies for smart meters as for smart grids. The RSPG therefore believes that a strict separation may lead to overseeing possible synergies between the two in the future.

2.2.6. Information and description concerning ITS (see Chapter 8)

ITS means systems in which information and communication technologies are applied in the field of transport and traffic telematics including infrastructure, vehicles and users, traffic management and mobility management. Many areas within this sector are still at the research stage, but may have a potential to play a significant role in the area of road safety and traffic management. Examples of services and applications in this area are driver support aids such as collision avoidance, parking space management, safety information and warning alerts.

Vehicle to vehicle (V2V) communication does not need any roadside infrastructure, and is most suitable for short range vehicular communication. Requirements on communication over larger distances could be realised by a Vehicle to Infrastructure (V2I) network. Another way of implementing V2I communication would be via commercial cellular networks. Compared to this solution, a dedicated V2I network would have the advantage of low latency, but would also require a high infrastructure investment. Vehicular Ad-hoc Networks (VANET) is a concept where each vehicle is equipped with a WiFi/WiMax device, using frequency bands already available, that acts as a node to create a mobile network.

ECC Decision (08)01[11] harmonises 30 MHz of spectrum band for ITS applications in the 5875-5905 MHz band and indicates an additional 20 MHz (5905-5925 MHz) for future expansion, if needed. The existing 30 MHz is primarily for road-safety related features. Safety related applications have high requirements on robustness and latency, and may need to operate in a predictable interference environment. Non-safety related applications usually have lower requirements on robustness and latency.

The European Commission launched a policy initiative in 2010 for the framework of deployment of ITS in the field of road transport and for interfaces with others modes of transport[12]. Standardisation and implementation measures are under process.

2.2.7. Conclusions concerning ITS

The RSPG considers that:

- this sector can put forward their spectrum needs via the ETSI-CEPT process.
- there has been no additional demand identified for road-safety related ITS applications that cannot be realised within the current 5.9 GHz harmonisation.
- any possible new frequency demands, non-road-safety related ITS applications could in many cases use frequency bands harmonised for SRD.
- possible needs and demands for ITS applications requiring lower frequencies (larger distances or non-line of sight) should be considered in future harmonisation of SRD below 1 GHz.

2.2.8. Information and description concerning IoT (including RFIDs and M2M) (see Chapter 13)

IoT can be seen as spanning a broad range of application families, from what could be described as non-specific SRD applications to some specialised M2M applications that may be recognised in many cases as distinctive groups of uses, e.g. smart metering application discussed in Chapter 9 in this report. Almost anything to which one can attach a sensor can become a node in the Internet of Things including a very broad variety of different objects, from e-books to cars, from electrical appliances to food packages.

[11] To be reviewed by CEPT ECC WG FM 2014

[12] EU Directive 2010/40

Radio frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, e.g. for the purposes of automatic identification and tracking. The characteristics of RFID are different from conventional SRDs due to the large difference between the power levels transmitted by the interrogator, and the response from the tag.

2.2.9. Conclusions concerning IoT (including RFIDs and M2M)

The RSPG considers that this sector can put forward their spectrum needs via the ETSI-CEPT process.

A large development is foreseen within the sector of IoT and M2M, with potential of a large growth and contribution in socio economic benefits. The typical requirement on low power and low duty cycle makes many applications suitable for non-specific SRD frequency bands. Other applications where for example longer range end-to-end connectivity is required may use commercial mobile networks, and many mobile operators are already offering services for M2M communications and control.

The predicted growth of IoT/M2M applications would put pressure on the use of existing SRD bands, especially in frequency bands below 1 GHz. The need for a predictable sharing environment and also the need to find more efficient spectrum sharing solutions for some IoT applications has already led to investigations in the CEPT on more sophisticated technology and application-neutral spectrum access and mitigation techniques. Any evolutions of SRD regulation shall be carefully consider results of sharing studies.

The RSPG sees large advantages in a European harmonisation that allows that RFID systems in Europe operate within the worldwide harmonised frequency tuning ranges for RFID, using the same technical regulations on for example maximum allowed emission levels. This would lead to improved performance, and allow for simplified handling of international shipments of tagged items.

2.3. Galileo and EGNOS, scientific services, GMES and aeronautical and maritime communications

2.3.1. Information and description concerning Galileo and EGNOS (see Chapter 5)

Galileo will ensure the provision of satellite navigation services and applications for European interests fully independent of others systems. It will support a large number of applications in response to many EU policies such as transport, satellite, communication, research or environment.

Even if the spectrum for the current generation of Galileo system is secured, it seems appropriate to address in the future the issue of the longer term requirements of the Galileo system. The first Galileo satellites have been launched recently and are entering their operational phase. Successors to those first generation satellites are anticipated to be launched around 2024. As a consequence, the first contracts for these second generation satellites are expected to be awarded in 2018 at the latest. This raises the question of the need for any possible new frequency resources to support the operation of those future satellites.

WRC-12, under agenda items 1.3 and 1.4, considered the protection of the use of the frequency bands 5000-5010 MHz and 5010-5030 MHz by the Galileo system. The potential impact of out-of-band emissions from other services on the radio navigation receivers in the band 5010-5030 MHz has also been addressed, leading to the inclusion of a recommended interim out-of-band emissions level in RR No. 5.443C but further studies are required for WRC-15 to confirm, refine or revise this out-of-band power level.

2.3.2. Conclusions concerning Galileo and EGNOS

The RSPG considers that:

- this sector's access to spectrum is mainly catered for via the ITU process.
- the European Commission, in cooperation with Member States, should initiate an investigation to confirm whether or not any additional frequency resources are necessary for next generation of Galileo satellites expected to be operational in 2024, taking into account the currently accessible radio spectrum. This issue should be addressed without delay in order to identify the possible need for an agenda item for the WRC-18, the agenda of which is to be decided at WRC-15.
- appropriate protection of RNSS receivers should be ensured in the 5010-5030 MHz band by triggering the review of ITU Radio Regulation No 5.443C, (this concerns the emission standards of aeronautical systems operating in the adjacent band 5030 to 5091 MHz).

2.3.3. Information and description concerning scientific services (see Chapter 6)

Scientific services cover a large scope of services (including passive and active sensing) identified in the Radio Regulations:

- Meteorological Aids Service
- Earth Exploration Satellite Service (EESS)
- Meteorological-Satellite Service
- Space Research Service (SRS)
- Radio Astronomy Service (RAS).
- Radiolocation for meteorological radars

The facilities used by the science services represent huge public investments, both nationally and by the European Union. This includes the building of radio telescopes, Earth observation or meteorological spacecraft, and the deployment of scientific, meteorological and climatological stations all over Europe of which European companies are stakeholders.

Space assets brought global observation capacity and measure our planet which becomes essential to improve the knowledge of the Earth system and are sometimes critical system components from the operational perspective. They are becoming increasingly common in economic activity and national, European and global governance (e.g. land planning, agriculture, resource management, remote sensing, meteorology, climatology, monitoring and supervision of such territories alert). Some of these operating systems have a dual purpose and serve also objectives of security and Defense.

Exclusive use by scientific services is only given in purely passive bands, governed by Radio Regulations No. 5.340 prohibiting all emissions in these frequency bands. RSPG notes that these bands represent essential unique natural resources. In other frequency bands the scientific services achieve a significant degree of sharing with other services, and among themselves. Potential sharing with other potential non-scientific candidate applications requiring access to spectrum are studied on a case-by-case basis either in CEPT or ITU-R in accordance with ITU-R Recommendations. The RSPG is carefully addressing the WRC-15 agenda items in relation to scientific services, i.e. 1.6, 1.11, 1.12 and 1.13 in an Opinion[13].

In many European countries, a considerable number of reported interference cases from WAS/RLAN outdoor usage to the weather radars in the 5600-5650 MHz frequency band has been recently investigated in CEPT and appears to be caused either by intended illegal use of WAS/RLAN

[13] Draft RSPG Interim Opinion on Common Policy Objectives for WRC-15 (RSPG13-525)

equipment without DFS functionality (DFS switched off by operator/user) or by non-compliant equipment. In order to ensure future effective operation of weather radars in this frequency band, improvement of the situation is required as well as more target oriented enforcement actions may be necessary. Overall, the adequate protection of weather radars must be ensured and CEPT/ECC is continuing investigating the situation.

2.3.4. Conclusions concerning scientific services

Scientific services include many services which are highly prioritised within the European Commission, often associated with documented large socio-economic benefits.

In order to provide adequate protection for these services, great care needs to be taken in developing the regulatory regimes especially for consumer mass-market products using the same bands (e.g. reported interference related to outdoor WAS/RLAN equipment in the 5 GHz band where DFS had been disabled).

As these services are often global in nature (for example satellite and passive services) their requirement are often best addressed globally through the WRC process. There have been no identified needs for additional frequency resources related to scientific services that are not already included in WRC-15 agenda items. The RSPG also noted that several WRC-15 agenda items could challenge a number of European interests in the field of scientific services, including GMES. Relevant agenda items for scientific services may emerge in preparations for future WRCs.

2.3.5. Information and description concerning GMES (see Chapter 7)

The GMES project is a large pan European project, funded by all Member States, and includes the planned launch of five satellite missions. The Global Monitoring for Environment and Security Programme establishes a European capacity for Earth observation. GMES will provide accurate data and information on the Earth's subsystems (land, sea and atmosphere). This data will then inform the monitoring and forecasting of climate change effects, it will contribute to a more effective response in emergency situations such as natural or man-made disasters and humanitarian crises and it will assist in security-related aspects such as border control and maritime surveillance.

The spectrum used by the first generation of satellites, which are going to be launched until 2015, is based on worldwide allocations in the Radio Regulations. The five satellite missions called Sentinels (each of them comprising up to three satellites) will support the operational needs of GMES. The launch of Sentinel satellites 1, 2, 3 and 5 precursor is planned during 2014 and 2015. Sentinel 4 and 5 satellites are to be launched by the end of the decade. In addition to the Sentinel missions, there are existing or planned contributing missions from the European Space Agency, its Member States, EUMETSAT and other European or international third party mission operators that make part of their data available to the GMES programme.

2.3.6. Conclusions concerning GMES

The RSPG considers that the European Commission, in cooperation with Member States, should take into account the needs of the GMES programme in defining common policy objectives related to relevant WRC-15 agenda items (in particular, 1.1, 1.6, 1.9.2, 1.10 and possibly 1.12). Protection of the existing allocations listed in Section 7.2.1 is essential to the GMES success.

The RSPG considers that the European Commission, in cooperation with Member States, should gather information on the various contributing missions of the GMES programme, together with a spectrum inventory of the frequency bands used by these missions.

The GMES project is a large pan European project, funded by all Member States, and includes the planned launch of five satellites. The current need of the first generation satellites to be launched in 2014-2015 has been secured through the ITU WRC-process. Additional frequency bandwidth needs for the later satellites that are to be launched at the end of the decade, as well as any other possible needs that come from the rapid increase in the volume of data requirements, will mostly be handled in WRC-15 Agenda Item 1.12. There is also frequency bands used for GMES observation purposes, which protection needs to be secured via the WRC-15 process.

2.3.7. Information and description concerning Aeronautical and Maritime communications

Aeronautical communications (see Section 14.2)

- The RSPG notes that the spectrum resources are secured for the support of the SESAR project in the current phase.
- The RSPG notes that WRC-15 agenda item 1.17 is to consider allocations and regulatory provisions for Wireless Avionics Intra-Communications (WAIC). This is intended to bring benefits to aviation in terms of weight saving on aircraft, which in turn brings environmental benefits, and also potential safety benefits. Aircraft have an obvious need to be able to operate globally and across national borders and a WRC decision will support this. The issue will be further discussed in the RSPG WRC preparation activity.
- The issue of Unmanned Aircraft Systems (UAS) using the Fixed-satellite service will also be studied further in the WRC-15 preparation (agenda item 1.5).
- Air transport companies and aircraft manufacturers are also seeking to decrease the number and significance of incidents causing damage to aircraft when they are on the ground (e.g. during taxiing). To reach this objective, industry intends to use anti-collision radars operating in the 80 GHz range.

Maritime communications (see Section 14.3)

In the maritime transport sector, spectrum is used for communication purposes (voice and data communications), for satellite communications and for navigational aids. Due to the nature of the service, the spectrum requirements need to be addressed also globally and identified in the ITU Radio Regulations (e.g. RR Appendix 18). Moreover, spectrum is also being used extensively for ground and ship radars.

- The RSPG notes that WRC-15 agenda item 1.16 is to consider regulatory provisions and possible new allocation(s) to facilitate new Automatic Identification System (AIS) technology for both satellite and terrestrial applications. The issue will be further discussed in the RSPG WRC-15 preparation activity.
- The RSPG notes that WRC-15 agenda item 1.8 provides for a review of the regulatory arrangements introduced at WRC-03 for Earth Stations on Vessels (ESVs) which operate in Fixed-satellite service networks in the uplink bands 5 925-6 425 MHz and 14.0-14.5 GHz.
- The RSPG notes that the WRC-15 agenda item 1.15 considers spectrum demands for on-board communication stations in the maritime mobile service[14].

2.3.8. Conclusions concerning aeronautical and maritime communications

Due to the global nature of aeronautical and maritime communications future spectrum needs will be addressed through the WRC process. The RSPG highlights the importance of continuing to develop a SESAR spectrum strategy in cooperation with Member States.

[14] Resolution 358 in the Radio Regulations (2012)

2.4. PPDR

2.4.1. Information and description concerning PPDR (see Chapter 11)

The following definitions are provided in Report ITU-R M.2033 “Radiocommunication objectives and requirements for public protection and disaster relief” (2003):

- Public protection (PP) radiocommunication: Radiocommunications used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property, and emergency situations.
- Disaster relief (DR) radiocommunication: Radiocommunications used by agencies and organizations dealing with a serious disruption of the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by accident, nature or human activity, and whether developing suddenly or as a result of complex, long-term processes.

Typical missions carried out by PPDR organisations include, among others, law enforcement, fire fighting, emergency medical services and response to natural and man-made disasters.

When looking at the future spectrum demand for PPDR, the focus should be on broadband (rather than narrowband and wideband) applications and services. National narrowband PPDR networks using the TETRA or TETRAPOL technology are in operation today in European countries, using the 380-385 MHz/390-395 MHz bands harmonised for narrowband PPDR applications. Those systems are expected to continue to provide voice and narrowband services in Member States for at least the coming decade.

CEPT/ECC is currently studying the relevant harmonised solutions responding to future broadband PPDR needs in ECC FM PT49. However, the WRC-15 agenda item 1.3 on PPDR, and the fact that the 700 MHz band has been identified by ECC FM PT49 as candidate band for PPDR wide area networks has led to the situation where several other groups within CEPT are performing related work in the preparations for WRC-15 (CPG PTA and CPG PTD) as well as the EC mandate on 700 MHz channelling arrangements (ECC PT1).

The RSPG recognised that spectrum needs for broadband PPDR services differ for each Member State. National solutions depend on national political decisions including economics, relevant refarming issues, network mutualisation, etc. The RSPG also recognised that a decision on deployment of broadband PPDR networks is a national matter. LTE technology is expected to be the future technology to meet broadband PPDR needs. The work is in progress regarding standardisation to define functionality enhancements for PPDR operators. Three options have been identified for countries that wish to use broadband PPDR:

1) A national dedicated broadband network: it could provide, among others, possibilities to control the network, coverage, capacity, availability, and to add specific functionality and security measures.
2) PPDR applications over commercial networks: it could provide all benefits of commercial developments and economy of scale advantages. Capacity, security, possible prioritisation and availability are subject to the contract between the Member State and the mobile operator(s).
3) A hybrid solution: a dedicated broadband PPDR network may have limited coverage or capacity. Hence, the use of commercial networks may be complementary if coverage or capacity of the dedicated network is insufficient. Such a solution would require the possibility of roaming, also at national level, between dedicated and commercial networks.

Future decisions on possible harmonisation of PPDR spectrum should take, at least, these three options into account.

The following main spectrum needs and justification for a possible European harmonisation/regulatory framework have been identified:

a) The amount of spectrum to be used for broadband PPDR needs to be flexible to fit each country's needs. Such flexibility would allow national administrations to choose the frequency band out of the agreed candidate bands (or parts thereof) and the regulatory model (dedicated, commercial or hybrid networks). A minimum amount of around 2 x 10 MHz is considered needed for a dedicated broadband PPDR network (see ECC Report 199 and ETSI TR 102 628);
b) There could be additional spectrum requirements on a national basis to cater for Direct Mode Operations (DMO), Air-Ground-Air (AGA), ad-hoc networks and voice communications over the WAN (see ECC Report 199);
c) Recognising the right of Member States how to organise and use their radio spectrum for PPDR, a possible harmonisation of spectrum for broadband PPDR should not limit the ability of individual Member States from using that spectrum for other services or applications as they see fit;
d) Interoperability and roaming between different PPDR networks, as well as commercial networks is also being considered. For hybrid networks this may be essential.
e) Roaming between countries would be beneficial for future broadband PPDR networks for cross-border co-operation;
f) Frequency bands for use by broadband PPDR services supported by commercial mobile broadband equipment (user terminals, base stations, chipsets etc.) would also enable PPDR users to benefit from economies of scale available when using commercial products and from possible synergy with technology development in the commercial sector;
g) Dedicated frequency bands offer the opportunities to roll out dedicated networks responding to national security requirements and enable to provide the specific PPDR services and needed reliability while benefitting from synergy with standards developed for the commercial mobile broadband.
h) Interoperability between radio equipment of different manufacturers of user equipment and infrastructure is required to make roaming possible.

Based on the national requirements brought forward, ECC FM PT49 has made an effort to evaluate the common needs. At time of writing (September 2013), frequency options in the 400 MHz band and the 700 MHz band are being evaluated.

Moreover additional higher frequencies could be suitable to deliver temporary capacity or ad hoc solutions to cover situations such as large emergencies, public events or a natural disaster.

2.4.2. Conclusions concerning PPDR

The RSPG recognised that the provision of PPDR services, including the associated radiocommunications facilities is a sovereign national matter, and that the broadband PPDR needs of Member States may vary to a significant extent. Therefore, the future harmonisation of the broadband PPDR sector in Europe needs to be flexible enough to respect national sovereignties and different national circumstances such as; the amount of available spectrum and the type of network deployed and used which may be dedicated, commercial or a hybrid solution (a mixture of dedicated and commercial networks). There are requirements to ensure adequate interoperability between the different countries. Also the possibilities of maximising the benefits from the economies of scale should be taken into account.

2.5. PMSE (see Chapter 12)

2.5.1. Information and description concerning PMSE

The term Programme Making and Special Events applications (PMSE) is a widespread term gathering various radio applications used for SAP/SAB, ENG, SNG and OB (see Annex 11) in public or private events for perceived real-time presentation of audio visual information. The communication links are also used in the production of programmes, such as talk-back or personal monitoring of sound-track.

Programme making includes:

- the making of a programme for broadcast, the making of a film, presentation, advertisement or audio or video recordings, and the staging or performance of an entertainment, sporting or other public events.
- special event is an occurrence of limited duration, typically between one day and a few weeks, which take place on specifically defined locations. Examples include large cultural, sport, entertainment, religious events and other festivals, conferences and trade fairs.
- in the entertainment industry, theatrical productions may run for considerably longer, also cross border. These events will occur on a daily basis.

Quality requirements of PMSE applications vary depending on the task in hand. The bandwidth of the signal to be transmitted i.e. audio or video has a direct impact on the bandwidth required. The actual demand for PMSE spectrum varies significantly between different countries and applications, different programme makers and different events, the overall trend is steady increase of PMSE demand in most areas.

Special events for large number of people and large broadcast productions use a great number of PMSE equipment. This means a greater amount of spectrum is required to guarantee the necessary quality of service. For these events, the requirements regarding for example reliability and audio or video quality may vary for different types of usage.

2.5.2. Conclusions concerning PMSE

The spectrum demand considerations for future PMSE spectrum opportunities need consultation at the national level with subsequent national contribution to on-going studies in the CEPT/ECC. New spectrum opportunities for PMSE need also to be reflected in the harmonised European standards for PMSE equipment and this should be coordinated via the existing ETSI-CEPT coordination process. As far as in relation to agenda items of WRC-15, PMSE needs should be recognised when impacted by the re-allocation of primary services.

The spectrum needs for PMSE use vary greatly in time and location, depending of the scale of the event or programme. Some spectrum resources are required for daily usage (e.g. theatres), while other usages are more temporary in nature. For planned events, suitable frequencies are identified on a case-by-case basis at national or local level using spectrum available for that time and location. For unplanned events, the spectrum resources need to be available without prior coordination. A reliable regulatory environment is a prerequisite to give users the confidence needed to make the necessary investments associated with new conditions. This study focused mainly on two of the PMSE applications (video and audio applications).

PMSE audio applications

The RSPG noted that industry is moving towards wider tuning ranges. This initiative should be supported because of national differences, and to enable interoperability over national borders. Larger tuning ranges would also make it easier to cater for the spectrum needs at large events with multiple PMSE users. From a regulatory perspective this could be encouraged through harmonisation of those wider tuning ranges.

The reallocation of the 800 MHz spectrum together with the possible release of the 700 MHz band to mobile services is putting pressure on the availability of spectrum for PMSE use. Duplex gaps in the 800 MHz and1800 MHz bands used for mobile broadband are currently being studied for PMSE usage. Whereas a possible future 700 MHz band identification for IMT will reduce the current availability of spectrum for PMSE, there may be an opportunity to exploit the duplex gap[15]. Co-existence with other services (e.g. duplex and guard bands) could be made more favourable to PMSE if their needs are taken into consideration early in the harmonisation process. Migration towards more spectrum efficient digital technology would ease the frequency situation for PMSE, but due to problems with latency this migration has been minor up until today. With the current analogue technology, the remaining UHF band (approximately 470-694 MHz) white space usage may not be enough to cater for all PMSE audio spectrum needs. Opportunities for additional frequencies can be found outside this frequency range, on shared basis. A harmonisation at European level of tuning ranges and sharing conditions covering such bands would be highly beneficial in order to ensure the co-existence with other applications, stimulate research and development, and to provide improved technical conditions for PMSE equipment.

PMSE video applications

If the current and increasing need for PMSE bandwidth is to be met in a more and more competitive spectrum environment, both PMSE users and industry need to adapt. Due to the migration towards high definition video and the intensified use of the current bands by other applications (e.g. mobile broadband), the future needs of PMSE video applications, especially at larger events, are not believed to be completely fulfilled within the current tuning range below 3 GHz.

A harmonisation at European level of expanded tuning ranges and sharing conditions would be necessary to meet future spectrum demands. Examples of uses which could be suitable for sharing spectrum with PMSE video applications are military use, fixed links and the frequency bands that are licensed for mobile broadband but which are not deployed nationwide. CEPT has already identified potential candidate bands and sharing conditions are under study.

Wireless PMSE video equipment is predominantly low volume products which can be adapted to suit national circumstances. Since the prerequisites for sharing spectrum differ amongst countries, the harmonisation measures need to have some degree of flexibility. One also needs to consider that different categories of usage (e.g. fixed, mobile) may have different requirements on, e.g. bandwidth, quality of service and propagation characteristics (which is closely related to the frequency range).

2.6. PMR (see Chapter 15)

2.6.1. Information and description concerning PMR

Professional mobile radio (PMR) is part of the land mobile service based on the use of simplex, half and full duplex modes at the terminal level in order to provide closed user group communications.

[15] The duplex gap might also be attractive to other applications such as PPDR or TDD mobile services or supplemental downlink.

PMR networks, systems, equipment can be used in either in a business or governmental context.

At this stage those networks/systems/on site usage could be digital but also numbers of them are still using analogue transmissions which are less efficient in terms of spectrum usage. The amortisation of such equipment may largely differ depending on the category of usage. Some equipment is staying in operation more than 15 years and there are little benefits for the users to migrate to more efficient technology.

The current spectrum efficiency for analogue PMR is one channel in 25 kHz or 12.5 kHz, while new digital technologies provide a two-fold to four-fold increase to 6.25 kHz equivalent spectrum efficiency such as the technologies standardised in ETSI, e.g. TETRA25, Digital mobile radio (DMR), dPMR. However there is no incentive for users to replace their less efficient equipment. Experience so far with DMR suggests that users use the extra capacity to improve operations (e.g. introduction of data, mainly short messages), so the increased spectrum efficiency does not materialise.

The evolution of technologies is expected to follow the general evolution in the radio communication sector. In general, there is a trend towards mobile usage of services that require access to data high or very high speed, driven by increased use of services for image and video applications which consume more bandwidth, such as video surveillance, real-time video, fast exchange of large files (including the exchange of medical information for remote intervention) and access to databases.

LTE seems to be a technology that can evolve to meet all or part of PMR needs with channel bandwidths of e.g. 1.4 MHz, 3 MHz, 5 MHz or 10 MHz.

In May 2013, one Member State published the results of a public national consultation on broadband PMR, receiving 24 contributions from industry and PMR user groups. The consultation underlined the importance to have sufficient spectrum resources, in particular to satisfy future needs for broadband PMR.

2.6.2. Conclusions concerning PMR

The RSPG considers that:

a) A possible future evolution towards PMR broadband services would raise the need of availability of spectrum resources. However, before any technical concept has been presented for wideband PMR the RSPG finds it difficult at this stage to estimate any possible new spectrum needs or the future market demand for these applications. However, the development in this area should be closely monitored;
b) There are no indications that the bandwidth requirements of the narrowband PMR sector will increase within the medium or long term future;
c) Some Member States have noticed a trend where PMR users are migrating to public mobile broadband systems. New functionalities such as push-to-talk and group calls introduced in future LTE specifications (with PPDR as a main driving force) will probably further accelerate this migration when this functionality is available in public LTE networks;
d) In order to improve spectrum efficiency, and to promote migration from analogue to digital PMR, administrations may consider identification of a minimum required spectral efficiency to support the migration to digital, more spectrum efficient technology which will allow the creation of additional channel capacity within the same radio spectrum, and support more users. This also provides an opportunity to upgrade radio systems and improve interoperability. Furthermore, based on available digital narrowband PMR/PAMR technology and the national needs, the administration may impose a minimum required spectral efficiency such as 6.25 kHz or 12.5 kHz.

3. Principles and guidelines for managing sectoral needs

3.1. Introduction

The RSPG has been using different reports (both RSPG Reports and external reports) which are strategic inputs required to gain a fuller view of the situation. It is therefore advised not to use any elements of this work in isolation.

Previous attempts to harmonise spectrum for European wide applications have been completed and for history not to repeat itself, lessons must have been learnt from this experience.

It is important to identify the different paths available to determine the needs and more importantly identify if the needs are independent. There are a number of the different paths currently available to sectors seeking access to more spectrum, these are:

- ETSI-CEPT: The sector can raise a request for spectrum via the ETSI-CEPT cooperation process. A system reference document (SRdoc) generated within ETSI would then be raised within CEPT where an expert team would address the needs.
- National Authority-CEPT: The sector can raise a request for spectrum via their national authority. The Authority would then raise the need within CEPT/ECC.
- ITU: A sector can raise a request for spectrum via the ITU process where international needs are identified. This process is generally following the WRC preparation and is normally limited to allocations.

A sector may have multiple paths available as the ETSI-CEPT and National Authority-CEPT paths are not incompatible.

The European Commission gives mandates to CEPT on regular basis, which might require it to assess a particular demand, and to ETSI in order to develop technical standards.

3.2. Harmonisation

Harmonisation facilitates applications where radio equipment transits borders and gives economies of scale in radio equipment production. Naturally, economies of scale are more important for mass market products with large production volumes (e.g. consumer equipment such as smart meters).

International harmonisation has many advantages in particular for applications with worldwide usage by nature, e.g. aeronautical or maritime communications. There is a need to be flexible enough to accommodate national needs, or at least leave room for adaption to national circumstances, and not to be an obstruction to future technical development or market demands. This is because sectoral needs may be very different in different Member States. On the other hand an excessively technology and application neutral approach may result in a frequency band being used for different applications in different countries, thus resulting in fragmentation of demand, a reduced benefit from economies of scale and even hampering long term investments.

Hence, as broad an international harmonisation of frequency bands as possible is highly advantageous. Most authorisation frameworks should have the least possible restrictive conditions as this allows the harmonised bands to be used, where applicable, for several applications with similar requirements and co-existence possibilities.

The current European framework for Electronic Communications Networks and Services is promoting technology and service neutrality[16]. Even if the current European harmonisation is flexible with a high degree on technology neutrality, it may be beneficial to put more emphasis on how an EU Decision can be reviewed (or in some cases withdrawn) to adapt to future changes in market or technology trends. This is to avoid decisions becoming barriers to development when new needs are discovered (e.g. GSM900 when demand arose for migration to UMTS/LTE) or a harmonised spectrum use is not realised as expected (e.g. MSS 2 GHz and UMTS TDD).

3.3. Evaluation and choice of most suitable frequency bands

When evaluating new spectrum demands, "available spectrum" resulting from national inventories should be considered[17]. Since the spectrum demand for many uses is largely focused on the range 400 MHz to 6 GHz, care should be taken when addressing needs in this frequency range. Many applications or market sectors are capable of using several frequency bands, e.g. PMSE video applications. At the same time there are several frequency bands with propagation characteristics that make them very well suited for many applications. This results in many overlapping demands for those bands. When deciding on harmonising for applications targeting these bands, alternative frequency bands for these applications should also be taken into account.

3.4. Sharing of spectrum resources

Sharing of spectrum between different applications is always possible, based on the four principle dimensions of spectrum usage (frequency/space/time and signal separation)[18]. However, sharing is only favourable when the benefits of sharing are greater than the costs.

To avoid unused spectrum, sectoral uses which do not need permanent access to spectrum resources or which use the spectrum in limited geographical areas (some PMSE applications are obvious examples) should preferably share with other uses. As a general principle for frequency regulation licensing and allocations granting exclusivity should be avoided, especially for long durations. This is a prerequisite if frequency regulation is to be able to adapt as necessary to future developments in the area of for example cognitive radio or other new technology enabling efficient sharing of spectrum resources.

The Radio Regulations lays the foundation for the international framework on how the spectrum use is structured on a higher level. The Radio Regulations ensure the long term protection for radio services at the country borders, but in addition an allocation in the Radio Regulations on a region-wide or global basis is the necessary prerequisite for many services (e.g. satellite communication, maritime, civil aviation and scientific research). As far as the latter is concerned the Radio Regulations respond to a specific sectoral demand or need (see also Section 1.4).

Most potential new users of shared spectrum actually require an harmonisation measure in order to create a large enough market to form the basis for economies of scale needed for the industry to produce equipment that supports the frequency range, and to develop technical functionality that could possibly be required in order to enable the shared use of spectrum. Therefore, as today the common use of spectrum has to be considered in the future harmonisation work. Furthermore, additional possibilities for frequency sharing should be studied, e.g. the License Shared Access (LSA) concept currently being developed within CEPT and EU. In the broadest sense, LSA is nothing new, for decades spectrum resources have been shared by services compatible to each other. However, what is new is the possibility to apply smarter tools such as dynamic databases, sensing or other mitigation

[16] European Union Directive 2009/140/EC: Electronic communications networks and framework
[17] RSPG Opinion on review of spectrum use (RSPG12-408)
[18] Described in recommendation ITU-R SM.1132-2

techniques or sensing techniques that provides new opportunities for new services to share spectrum resources with an incumbent user. From a European perspective, the LSA concept seeks to address the market demand for harmonised introduction of new applications e.g. applications of the mobile service, operated under an individual license regime, in specific bands characterised by fragmented incumbent uses - typically others than a mobile service - within Europe which have to be maintained in different countries. The concept may provide sharing possibilities for the benefit of the mobile broadband service and herewith it would allow for more efficient spectrum use.

Any new regulation that fosters increased sharing of frequency resources should not interfere with the need for long term protection of existing radio services or services reliant on a region-wide or global allocation.

Various sectors using spectrum, need legal certainty and stability for their long term investments. The timing period for the return of investments varies largely from one sector to another. This report studies in particular projects such as GMES and Galileo, which are supported by European funds which required long term predictability and certainty on the frequency framework.

3.5. Incentives for spectrum efficient equipment

It is important that spectrum regulation creates incentives and opportunities for more spectrum efficient use.

As example, for wireless broadband, the use of auctions for spectrum access (in case of individual authorisations) and licence fees based on licensed bandwidth gives financial incentives for using spectrum efficiently. Second-hand trading possibilities or incentive auctions (where a legacy user can finance migration with auction proceeds) also mean that there is a further cost for using more spectrum than necessary.

The usage of spectrum efficient equipment could – within the framework of the principle of technological neutrality – be part of authorisation framework as a technical standard or as other terms given by technical conditions for usage of the spectrum. Another more indirect way to achieve more spectrum efficient usage would be to use stricter equipment requirements for protection from adjacent bands (probably assessing a combination of transmitter and receiver characteristics). The RSPG approved recently a Report on interference management which emphasised the role the of receiver part in spectrum regulation.

3.6. Social and economic benefits

The RSPP states that a “renewed economic and social approach with regard to the management, allocation and use of spectrum should be adopted”. “The strategic planning and harmonisation of spectrum use at Union level should enhance the internal market for wireless electronic communications services and equipment as well as other Union policies requiring spectrum use, thus creating new opportunities for innovation and employment creation, and simultaneously contributing to economic recovery and social integration across the Union, while at the same time respecting the important social, cultural and economic value of spectrum.”[19] For that purpose Article 3 (a) of the RSPP tasks Member States and the Commission to cooperate in order to “encourage efficient management and use of spectrum to best meet the increasing demand for use of frequencies reflecting the important social, cultural and economic value of spectrum”. An impact assessment should form a key part of the policy making, and “should be sufficiently comprehensive to take account of the full

[19] EU Decision 243/2012, OJ L 129, 17.5.2007

range of costs and benefits, and whether these are what may be termed 'commercial' or 'social'". This approach shall be part of the policy making at European level, but should also be applied (where appropriate) example when identifying and evaluating the spectrum needs for different sectors.

In many cases the benefits can be difficult to quantify or include a high degree of uncertainty. In this report, the studied sectors are very different in nature, which means that the socio-economic benefits are very difficult to compare. It is for example impossible to on equal terms compare the potential benefits from governmental projects such as GMES and Galileo, with those associated with a for example a forecasted increase in applications in the area of Internet of Things. Nevertheless, the needs to access spectrum is equally legitimate. Even if the benefits are difficult to compare, it is still important that the assessment of spectrum needs for a sector or an application are always based on objective and thorough motivated analysis of the estimated benefits, i.e. qualitative information.

3.7. Needs and demands for spectrum use

The fast and accelerating development in market and technology trends means that new spectrum needs from services and applications from various governmental and commercial sectors constantly arise. A prerequisite for potential new spectrum resources to be considered for commercial sectors is that there is a substantiated market demand for the associated services and applications, both regarding the end users, as well as an industry willingness to make the necessary developments and investments. The latter is also true for governmental usage, but it is also important to ensure that there is an underlying political interest and willingness to invest and provide the necessary funding.

The spectrum needs for a service or an application may be defined as a bandwidth requirement, and a suitable frequency range. In addition to this, there are several other requirements such as power levels, geographical distribution and protection criteria that have to be known. The need for protection from interference from services in the same band or adjacent bands is of particular concern for passive services.

When evaluating new substantial sectoral spectrum needs, it important to identify the frequency supply available at Member State level. It is equally important to review and evaluate the current spectrum usage and future spectrum demands of existing users. These requirements and demands should be considered when trying to find the most suitable future usage scenario of a frequency band, or when setting the regulatory framework for adjacent bands.

Relevant principles are already in place in ETSI when preparing a new ETSI System Reference Document (SRdoc) for the designation of spectrum for new demand. The SRdoc has to include the necessary justifications (e.g. information, why the application cannot fit into existing regulation or needs dedicated spectrum and sharing possibilities) and undergoes a consultation process throughout the complete ETSI membership that often gives existing spectrum users the possibility to include their views in the document. CEPT/ECC is subsequently provided with a consolidated ETSI view and not single interests.

The current RSPP already defines the regulatory objectives and the update of RSPP 2015/2016 will provide an opportunity to review the various spectrum EU policy objectives.

3.8. Balanced and objective regulatory work

It is important that the analysis and evaluation of the spectrum needs is factual and objective. The regulation should be based on a balanced contribution between the industry and the national regulators. Administrations should act objectively from a regulatory point of view, with a holistic approach to management of spectrum resources, ensuring an overall high degree of long term spectrum efficiency. Industry is often largely involved in the evolution of regulation either actively contributing to the regulatory work, or via the public consultation.

Furthermore, efficient regulatory solutions should be based on sharing and co-existence studies and requirements at either at European level (e.g. ITS) or at worldwide level (e.g. aeronautonical communication, Galileo, GMES and scientific services). In some cases, some measures are needed at national level, e.g. geographical sharing possibilities may be very different in different Member States (e.g. PMR, PMSE, smart meters and smart energy grids). (see Section 2.1)

The studies should be based on relevant input data regarding realistic user scenarios and relevant technical parameters, normally provided by the industry (e.g. ETSI) and it is important that this information is critically reviewed.

4. General strategic considerations for spectrum needs

4.1. Introduction

Spectrum is a limited resource, and it will be sensitive and difficult in the long run to seek dedicated spectrum for each new application and service. Nevertheless, there will always be some applications and services where the needs for long term investment, quality of service and protection may require and motivate dedicated spectrum. The overall aim for the national administrations and the EU should be to maximise the long-term social and economic benefits, which in many cases are accomplished by efficient spectrum use, based on a harmonised regulatory framework with flexibility to adapt to national circumstances and future technology improvements. In this context the relationship between social and economic benefits and in which way spectrum resources are used should be considered.

The frequency planning and evolution of the regulatory framework is a lengthy process, especially for international harmonisation which often stipulates the conditions for how to use a frequency band for decades ahead. This offers some stability for investments in research and development, but may in some particular cases also lead to a regulatory framework that does not match the needs and demands of an evolving market. For the various sectors which have been considered in this RSPG Report, the RSPG identified suitable ways forward to respond to the needs and assess, where appropriate, the necessity of regulatory update. In some cases it could be very difficult to change an existing regulation without having to migrate existing applications and services, which in turn can be complex and costly. In contrast, technology development and market trends can change quickly and new applications and services with spectrum needs may arise.

The existing processes within ITU and ETSI-CEPT, including cooperation with the EU, are often working satisfactory since they are well established, identified, recognised and therefore well understood by each community of interests. The previous section discussed various principles and guidelines for managing sectoral needs including the reference, where appropriate, on existing processes. Furthermore, to meet the future needs and demands within EU and beyond and to provide greater competitiveness in this region, permanent efforts should be considered in order to provide as broad harmonised regulatory solutions as possible. One possibility for the RSPG to respond to strategic spectrum needs is still, where appropriate, to develop regular opinions or reports on issues with strategic relevance from EU public policies.

The RSPG considers that it is relevant to assess, where appropriate, the possibilities to identify similarities and synergies between different applications and services and create more opportunities for sharing and efficient spectrum use. The various sectors studied in this RSPG Report revealed large differences in terms of usages, needs, requirements highlighting the complexity to implement these principles in practice. In this context it may be considered that the existing processes were to be further developed. The emphasis may, on a case-by-case basis, change from identifying a suitable frequency band for certain applications, and instead focus on which applications are suitable to use a certain frequency range. This RSPG Report assessed, for example, for some applications as IoT the opportunity of usage of generic SRD bands and the limits of this approach. The RSPG largely referred in this RSPG Report to suitable frequency bands for given applications. The RSPG considers also that with this approach there will have to be room for exceptions, e.g. when addressing applications and services with specific or exceptional needs for protection.

4.2. Methodology for managing sectoral spectrum needs and demands

The work of this RSPG Report covers a broad range of strategic sectors including services and applications that are very different by nature. The RSPG recognises that there are major differences between the different sectors' requirements concerning access to spectrum, and therefore concludes that each sector should be assessed carefully based on its individual needs and demands. Even though this RSPG Report reveals that there is no one size fits all solution, the RSPG has made an attempt to identify elements for a more general approach on how to address future spectrum needs and demands.

Bearing in mind that, in common with this RSPG Report, the recent strategic RSPG deliverables such as the Opinion on Wireless Broadband[20] and the Report on Spectrum for Wireless Broadband and Broadcasting in the Frequency Range 400 MHz to 6 GHz[21] have been developed in a rather short time frame, thus limiting the administrative burden whilst providing strategic assessment on sectors' needs and how to address them. This means that, where appropriate, on issues of strategic relevance to EU public policies, the RSPG has the possibility to draft regular opinions/reports to provide general visibility on how to respond to strategic spectrum needs. Furthermore, based on the international regulatory framework in place (e.g. RR), other day to day needs are already addressed by the regular paths (nationally and ETSI-CEPT).

The work to identify and evaluate the needs and demands for the sectors examined in this RSPG Report has been based on the principles as described in Chapter 3 using the methodology in Section 1.3. The RSPG has then aimed to apply these principles, as far as possible, and with a high level approach used them to outline a framework for a general methodology that could be used when addressing the frequency needs and demands that constantly arise for new applications and services within various sectors. Each such demand is legitimate and should be carefully addressed.

If such a general methodology would be developed, the RSPG believes that it should consider identifying the different options available to meet the spectrum needs and demands for an emerging application or service. The different options available could form a generic list of possible regulatory options, but may need to be assessed in more detail when addressing a specific sector. Provided that specific needs for protection are fulfilled and that long term solutions are the objective, the RSPG has identified, among others, a number of options which could be seen as the preferred measures to be applied to meet new or increased spectrum needs and demands for a service or application:

- The use of commercial networks or other existing infrastructure (including the possibility to use priority within a system or network);
- The use of already available harmonised frequency bands, as appropriate;
- A shared approach with other possible uses of future harmonised license exempt bands;
- A national ad hoc solution, where dedicated spectrum may be an option.

The RSPG considers that such a methodology may be useful for the work in the existing ETSI-CEPT cooperation process described in this RSPG Report, and additionally considers that the methodology may also be a useful tool prior of the triggering of this process. Smart energy grids is an example of a sector's spectrum need addressed in this report where the RSPG has identified opportunities how to meet that need in the list above.

In its work the RSPG also concluded that in some cases these options may be difficult or impossible to apply. In these cases, complementary regulatory options that could give access to a frequency band

[20] RSPG Opinion on strategic challenges facing Europe in addressing the growing spectrum demand for wireless broadband (RSPG13-521rev1)

[21] RSPG Report on Wireless broadband and Broadcasting in the Frequency Range 400 MHz to 6 GHz (RSPG13-522)

harmonised for the specific application or service addressed need to be considered. In order to justify such harmonisation options, a thorough analysis of the application or service in question would be considered to be necessary. Harmonised dedicated spectrum could be motivated e.g. if there is an undisputed demand for the application or service in a majority of the Member States and the analysis shows that the application or service addressed provides a high contribution to social and economic benefits, provided that these benefits cannot be achieved using the listed preferred regulatory options. Other important considerations would be that the harmonisation could result in large benefits regarding for example economies of scale and interoperability.

4.3. Spectrum harmonisation

Just as important as the regulatory process that is applied for upcoming spectrum needs and demands is the current frequency regulation that is adapted accordingly. The analysis done in this RSPG Report revealed various harmonisation needs according to the type of applications. If some future spectrum needs and demands are to be fulfilled using existing harmonised spectrum, it is important that the regulatory framework provide a certain degree of flexibility. This RSPG Report addresses the opportunities and limits, where relevant, of sharing spectrum and the various level of harmonisation required by each sector.

The harmonisation work performed in CEPT/ECC is a key tool for developing the sharing conditions managing the regulatory work, and sets the conditions on how the spectrum is used. When stipulating the conditions that are to be the basis for a harmonisation decision, it is important to focus on why a harmonisation is needed, and what one want to achieve. Even though the needs may differ for different sectors, in most cases the most important benefits and objectives for a harmonisation are based on the following factors:

- legal certainty and long-term stability;
- enabling and maximising the potential of development of new applications and services leading to industrial development for sectors which are too small to be attractive when restricted to national utilisation;
- free circulation of equipment and economies of scale;
- reduction of cross border complexity;
- interoperability and international cooperation.

The aim of the harmonisation should be as broad as possible, whilst ensuring that the desired benefits (that are the underlying reason for the harmonisation in the first place) are achieved for the identified applications and services. In order for a harmonisation to be successful, and allow an efficient use of spectrum resources, the regulatory framework for a harmonisation should follow these main criteria:

- the harmonisation responds to realistic assumptions and motivation for demands and actual needs for harmonised spectrum resources;
- the social and economic benefits are maximised over time;
- the harmonisation allow for technical innovation and development of new services and applications;
- the harmonisation is flexible enough to cater for the different national needs and demands, and allows for an efficient usage of spectrum resources in a majority of the Member States that adopt the harmonisation regime;
- the harmonised frequency band is the most suitable for the applications and services that are targeted, also taking into consideration how attractive the spectrum is for other applications and services;
- if possible, a harmonisation based on sharing spectrum resources with an incumbent user is the preferred.

Part B

5. Galileo and EGNOS

5.1. Identification and description of applications/services

Galileo is the European component of the global satellite navigation systems to ensure provision of services and applications for European interests fully independent of others systems. It will support a large number of applications in response to many EU policies such as transport, satellite, communication, research or environment.[22]

5.2. Identification of the needs and demands of applications/services

In the context of this several billion euro project, it is strategically important to secure the radio frequency resources in the long term. WRC-12 (agenda item 1.18) granted a global allocation of the band 2483.5-2500 MHz for the radio determination satellite service. This frequency band provides an extension band for a new generation of satellites in the Galileo system to provide valuable new mobile/navigation services for mass market applications. Moreover the results of the WRC-12 (agenda items 1.3 and 1.4) ensure protection for the use of the frequency bands 5000-5010 MHz and 5010-5030 MHz by the Galileo system. The issue of the potential impact of out-of-band emissions from other services on the radio navigation receivers has also been considered and may require further studies, as per RR footnote No 5.443C.

At this stage, there is no agenda item on the WRC-15 agenda specific to Galileo. Any relevant issues which do arise will be carefully monitored and reviewed by the RSPG working group on WRC-15 and appropriate recommendations presented to the European Commission.

In the context of satellite radio navigation systems, EGNOS (European Geostationary Navigation Overlay Service) augments the Global Positioning System (GPS) Standard Positioning Service (SPS) by using the L1 (1575.42 MHz) Coarse/Acquisition (C/A) civilian signal function. In addition, EGNOS disseminates, on the GPS L1 frequency, integrity signals in real-time, providing information on the health of the GPS constellation. Aviation is by design the first application domain of EGNOS. The ‘Safety of Life’ element of EGNOS has been designed with the needs of the aviation sector in mind.

Galileo (and all other satellite navigation systems) has access to the bands 1164-1300MHz, 1559-1610MHz, 2483.5-2500MHz, and 5000-5030MHz. The spectrum for the first generation Galileo system is secured for the long term. The first Galileo satellites have been launched recently and are expected to become operational in 2014. Successors to those first generation satellites are anticipated to be operational in 2024. As a consequence, the first contracts for second generation satellites are expected to be awarded in 2018 at the latest. Monitoring of the WRC Agenda items is necessary to maintain that access for long term operation. It is expected that the second generation Galileo satellites will use spectrum in all of aforementioned bands. However the question of additional frequency resources to support the operation of these future satellites may need to be addressed at WRC-15 when drafting the agenda for the WRC-18.

5.3. Conclusions concerning Galileo and EGNOS

The RSPG considers that:

- this sector’s access to spectrum is mainly catered for via the ITU process.

[22] http://ec.europa.eu/enterprise/policies/satnav/galileo/files/brochures-leaflets/why-we-need-galileo_en.pdf

- the European Commission, in cooperation with Member States, should initiate an investigation to confirm whether or not any additional frequency resources are necessary for next generation of Galileo satellites expected to be operational in 2024, taking into account the currently accessible radio spectrum. This issue should be addressed without delay in order to identify the possible need for an agenda item for the WRC-18, the agenda of which is to be decided at WRC-15.
- appropriate protection of RNSS receivers should be ensured in the 5010-5030 MHz band by triggering the review of ITU Radio Regulation No 5.443C, (this concerns the emission standards of aeronautical systems operating in the adjacent band 5030 to 5091 MHz).

6. Scientific services

6.1. Introduction

The RSPG adopted a Report and Opinion on “a Coordinated EU Spectrum Approach for Scientific Use of Radio Spectrum” on 25 October 2006 stressing that scientific use of spectrum has a considerable societal value and that most of the data retrieved from the use of the so-called “scientific bands” are directly dedicated to the benefit of every citizen as they relate in particular to meteorology, climatology, environment, civil security and fundamental research.

Furthermore, RSPG noted that the Earth observation data is exploited by a number of European SMEs to generate data products of interest in several commercial areas (mapping, maritime navigation aids, agriculture management, water management, etc.).

RSPG also noted that, following proposals from European countries, ITU-R recently adopted ITU-R Report RS.2178 on “the essential role and global importance of radio spectrum use for Earth observations and for related applications". This essence of this ITU-R Report has been largely inspired by the RSPG Opinion and triggered last WRC-12 revision of Resolution 673.

RSPG reiterates the findings of its Report and Opinion and confirms that the scientific services cover a large scope of services identified in the Radio Regulations: the Meteorological Aids Service, the Earth Exploration Satellite Service (EESS), the Meteorological-Satellite Service, the Space Research Service (SRS), and the Radio Astronomy Service (RAS). Also the Space Operation Service, the Radiolocation Service (RLS) and the Radionavigation Satellite Service are used for scientific applications[23] and the various type of active and passive services as described in the RSPG Opinion. Those three services, even though they are NOT scientific services, but used as a facility by a scientific service, they are essential for the operation of systems and applications under those so-called science services. Only Space research (excluding space commercial applications in meteorology) and Radio Astronomy are, according to ITU, considered as scientific users of radio spectrum.

Table 1, Different types of scientific use[24]

<table>
<tr><th colspan="3"></th><th>Scientific Usage</th></tr>
<tr><td rowspan="9">Scientific Spectrum</td><td colspan="2" rowspan="3">Passive services</td><td>Radio Astronomy</td></tr>
<tr><td>Earth exploration satellite</td></tr>
<tr><td>Space research</td></tr>
<tr><td rowspan="6">Active services</td><td>Ground-based radars</td><td>Radar Astronomy</td></tr>
<tr><td rowspan="2">Meteorological bands</td><td>Meteorology and climatology</td></tr>
<tr><td>Radiolocation</td></tr>
<tr><td rowspan="3">Earth to space data transmission bands</td><td>Space operations</td></tr>
<tr><td>Earth exploration satellite</td></tr>
<tr><td>Space research</td></tr>
</table>

[23] These latter three services also cover applications not related to science.

[24] RSPG Report and Opinion on a Coordinated EU Spectrum Approach for Scientific Use of Radio Spectrum (RSPG06-144)

		Space to earth data transmission bands	Space operations
			Earth Exploration satellite
			Space research
		Space science active sensors bands	Earth Exploration satellite
			Space research
		Ground based sensors	Meteorology and climatology

6.2. Assessment of specific/exceptional needs for protection

Scientific services have specific needs for frequency protection which depend on the type of receivers and applications. Three types of application are shown: passive services, other types of scientific services and the specific case of bands used by meteorological radars.

Passive observation techniques (passive sensing) imply the measurement of naturally occurring radiations, usually of very low power levels, which contain essential information about the physical process under investigation. Some of these passive bands are purely exclusive and are ruled by Radio Regulations footnote RR 5.340 (All emissions are prohibited): RSPG considers that these bands represent essential natural resources and urges Member States to respect their obligations under No. 5.340 of the Radio Regulations, which prohibits all emissions in the corresponding frequency bands.

In other bands, the scientific services achieve a significant degree of sharing with other services and among themselves. Potential sharing with other potential non-scientific candidate applications requiring access to spectrum are studied on a case-by-case basis within CEPT cooperation agreement and in accordance with ITU-R recommendations. In particular, it is to be noted that the frequency bands 2025-2110 MHz (Earth-to-Space) and 2200-2290 MHz (Space-to-Earth) are dedicated for satellite telecommand and telemetry currently used by hundreds of satellites in operation. These frequency bands, which are very busy and also crucial for the satellites, are protected from the development of high density mobile networks by RR 5.391.

For meteorological radars, frequency bands are highly critical source: Handbook Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction, WMO-ITU 2008).

Ground-based meteorological radars operate under the radiolocation service and are used for operational meteorology, weather prediction, atmospheric research and aeronautical and maritime navigation. They play a crucial role in the immediate meteorological and hydrological alert processes. They represent the last line of defence against loss of life and property in flash flood or severe storms events and as such are among the best-known life savers in meteorology.

Meteorological radars are typically volume scanning, pencil beam radars which detect and measure both hydrometeor intensities and wind velocities. They are used to predict the formation of hurricanes, tornadoes and other severe weather events and to follow the course of storms on their destructive paths. Modern radars permit the track of path of large and small storms and provide information precipitation rates, which is used by forecasters in predicting the potential for flash floods. In addition, they provide relevant information on high winds and lightning potential.

The RR contains three specific references to meteorological radars in the Table of Frequency Allocations. The three references are contained in footnotes associated with the bands 2 700-2 900 MHz, 5 600-5 650 MHz and 9 300-9 500 MHz.

In many European countries, a considerable number of reported interferences from the WAS/RLAN outdoor use to the weather radars in the 5600-5650 MHz frequency band has been recently investigated in CEPT and appears to be caused either by intended illegal use of WAS/RLAN equipment without DFS functionality (DFS switched off by operator/user) or by non-compliant equipment. In order to ensure future effective operation of weather radars in this frequency band, improvement of the situation is required as well as more target oriented enforcement actions may be necessary. Overall, the protection of weather radars must be ensured and CEPT is continuing investigating the situation.

6.3. Economical and societal value

Introduction

In spectrum management it is becoming increasingly important to estimate the social and economic value of different usage of spectrum. In the case of scientific use of spectrum it might not be as straightforward as simply weighing up the quantified costs and benefits when considering alternative usage. This is because the benefits of scientific use can be difficult to quantify as they can relate to the society as a whole, may be difficult to foresee and may be realised over a very long period of time. This chapter gives an indication that the economical and societal returns of scientific usage of spectrum are significant.

Benefits of radio Earth exploration satellite

Satellite Earth observation is one of the management tools of risks and crises. It provides not only images but also mapping information developed of any kind, optionally merged with other data types. It also participates in the development of scientific knowledge providing unique information across the globe, improving the study of climate change or weather patterns. Due to homogeneous periods of observation, space observation appears to be now an irreplaceable tool and the following paragraphs show some areas of application.

6.3.1.1. Earth exploration satellite and disaster management

Earth observing can be used in case of a disaster and the corresponding data from can be used in various phases[25] of a disaster.

1) Mitigation – Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards. (Note: such measures are undertaken in advance of the disaster and include the identification of risk.)
2) Preparedness – Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.
3) Relief/response – The provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration.

[25] The terms and associated definitions used below are from the United Nations' International Strategy for Disaster Reduction web site at: http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm, although this classification is not typically used by space agencies at this time.

4) Recovery – Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk[26].

Data may be used in others context outside disaster.

The ITU-D Report “Utilization of ICT for disaster management, resources, and active and passive space-based sensing systems as they apply to disaster and emergency relief situations” fully addresses the general issue of Disaster management.

6.3.1.2. Benefits of meteorology

Direct economic and social benefits can be associated with general benefits deriving from improved weather forecasting capabilities as well as specific benefits such as support to civil aviation, shipping, land transportation and savings resulting from the timely preparation for adverse weather conditions.

A direct illustration of the value of meteorology has been given by the WMO[27]: “Studies in the United States have shown that the value of improved seasonal weather forecasts to farming in the south-eastern quarter of the country alone amounts to some US$ 145 million a year”.

Furthermore, “WMO has estimated that overall economic benefits of modern meteorological services typically outweigh the national cost of maintaining such services by a ratio of as much as 10 to 1.”

For Europe this would lead to the following figures: The total annual budget of European National Meteorological services and related organizations (EUMETSAT and ECMWF) is roughly between 1.8 and 2 billion Euros. On the basis of the WMO calculation the economic benefits can be estimated between 18 and 20 billion Euros per year.

Concerning natural disasters the WMO states, amongst others, that: “The economic impacts of natural disasters have worsened over the past few decades. Data from the International Federation of Red Cross and Red Crescent Societies as well as the Centre for Research on Epidemiology of Disasters reveal clearly that, during the period 1992–2001, about 90 per cent of natural disasters are weather and climate related and that the impacts of such disasters have been most pervasive during the past 10 years. During the same period, natural disasters worldwide have killed 622 000 people and affected over 2 billion people.”

6.3.1.3. Benefits of climatology

Global Change is an important item on the international political agenda. The Kyoto protocol now being ratified, the yearly Conference of the Parties (CoP) of the UN Framework Convention on Climate Change (UNFCCC) continues to give worldwide political guidance. Based on inventories and recommendations developed by WMO’s Global Climate Observing System, Parties are urged to implement climate monitoring systems that are essential to improve our understanding of climate change. This process has led to the establishment of the ad-hoc Group on Earth Observations (GEO), which developed a strategy to realise a Global Earth Observation System of Systems (GEOSS).

6.3.1.4. Benefits of natural hazard assessment

RSPG recalled the UK Natural Hazard Working Group issued in June 2005 a Report to UK Prime Minister on “The role of science in physical natural hazard assessment”. This report, which executive

[26] Recovery (rehabilitation and reconstruction) affords an opportunity to develop and apply disaster risk reduction measures.

[27] The Sixth World Meteorological Organisation Long Term Plan (2004-2011)

summary and Recommendations is given in Annex 4, recognises the high value of scientific services in mitigating natural hazard and is now one of the reference documents of the "Group on Earth Observation" program.

In particular, it highlights an information from the World Bank that, during the 90's, an efficient warning systems could have decrease the economic impact of natural disasters by 240 Billion dollars and that it is reasonable to assume that the cost-effectiveness of anticipatory measures will apply at least as much to catastrophes of global extent as to local natural disasters. Natural disasters cover: coastal hazards/tsunami, drought, earthquake, extreme weather (tornados, blizzards…), tropical cyclones/typhoons, floods, landslide/avalanches, volcanoes and wild land fire. For each of them EESS can provide some precious information by analysing SAR images associated with other visible/infrared instruments.

Finally, this report also states that "The cost effectiveness of spending to mitigate economic losses is an important part of the argument for taking action on preparedness and mitigation, including early warning. However other potential consequences of a global catastrophe are manifold and incommensurable in economic terms, from large losses of life to threats to socio-political stability and security. We are faced with a stark choice when it comes to dealing with global geophysical events. Either take no action and incur the risks –potentially trillions of dollars of economic losses and millions of lives lost – or exercise precaution in the face of scientifically established global threats and take practicable measures to mitigate their impact."

Benefits from Radio Astronomy

Basically, the purpose of Radio Astronomy is to do fundamental research on the nature, its origin and evolution, of the universe. As the science that provides the framework knowledge of where we, and the planet on which we live, fit into the environment of the universe, astronomy is a vital part of the culture of all mankind.

Moreover, Radio astronomy is a science whose progress is driven by the pace of technological improvements for the benefit of its research instrumentation. These instruments that are used must represent the most advanced radio technology existing today and are at the forefront of all the associated technologies.

Radio astronomy has no control over the naturally generated cosmic radio signals transmitters that need to be detected. As a result in order to detect these extremely weak cosmic signals the radio astronomers haves been forced to design and build antennas with the largest possible collecting areas, receivers of the highest sensitivity and with the lowest noise temperatures, and in general instrumentation that defines the state-of-the-art in signal reception and data analysis. The technical requirements of radio astronomy have directly or indirectly fostered technological innovations of very wide applicability. Examples, in the daily tools of human being, are:

- Sensitive microwave receiving systems, including high-gain antennas, low-noise receivers, solid-state oscillators and frequency multipliers, cryogenics now available also on some of the most sophisticated telecommunication systems;
- Data correlation and recording technology, as a precursor of all types of modern digital techniques;
- Medical scanning imaging systems that allow non-invasive examination of patient's internal organs, a derivative of image processing techniques developed by astronomers.
- Image restoration techniques that are extremely important to all environmental surveys;
- Time and frequency atomic standards, reaching the ultimate performance in measurement accuracy and precision (uncertainty levels of few parts in 10-16);

- Remote sensing, satellite navigation, position determination, and geodesy;
- Computer languages and software development.

An application of radio astronomy which has direct economic and social benefits is the monitoring and forecasting of solar activity, which have a strong impact on ground based activities such as wired transmissions, radio communications, power distribution and astronautics, and which are pre-requisite for manned space activities.

Public investments in scientific services

The facilities used by the science services represent billions of Euros of public investments on national or European basis. This includes the building of radio telescopes, scientific or meteorological spacecraft, and the deployment of scientific or meteorological and climatological stations all over Europe of which European companies are stakeholders.

On a general basis, costs for a single passive sensor instrument for radio astronomy, meteorology or Earth observation (both active and passive) can easily be in excess of 100 million Euros. These costs are very often driven by the need to achieve front-line state-of-the-art system performance by means of completely innovative technical developments (including research). Because these instruments define the state-of-the-art, most are by their nature their own prototypes. The construction of these sensor instruments is very labour-intensive and requires specialized hardware.

The 6th and 7th Framework Programme of the European Union actively stimulates the development of forefront scientific instrumentation and also provides partial funding for the hardware infrastructure.

For Earth Observation, the EU, in cooperation with ESA, started the Global Monitoring for Environment and Security initiative (GMES). Aiming at an operational system in a few years, GMES is now being developed using EU Framework Programme funding. GMES should establish a network infrastructure all across Europe to facilitate information gathering for a wide variety of purposes. GMES is seen as the European contribution to GEOSS.

Public investments in for climatology

In addition to GMES it is to be noted that national space agencies in Europe are developing innovative observation systems in cooperation with space agencies outside Europe.

For instance, the French space agency is designing with NASA the SWOT - Surface Water Ocean Topograph - mission for a better understanding of the world's oceans and its terrestrial surface waters. SWOT will make the first global survey of Earth's surface water, observe the fine details of the ocean's surface topography, and measure how water bodies change over time.

Another example is the cooperation with the Chinese space agency (CNSA) to carry out jointly a satellite mission devoted to the monitoring of the ocean surface wind and wave, and related ocean and atmospheric science and applications. This is the so-called CFOSAT project (Chinese-French Oceanic SATellite). CFOSAT will monitor at the global scale the wind and waves at the ocean surface in order to improve the wind and wave forecast for marine meteorology (including severe events) and the knowledge of climate variability.

6.4. National and global context

Scientific services spectrum issues have to be considered on a worldwide basis and in the context of international cooperation between regional and national space agencies (European national space agencies, ESA, EUMETSAT, NASA, Indian Space research Organisation (ISRO), Japan Aerospace

Exploration Agency (JAXA), China National Space Administration (CNSA). The spectrum needs for these services are discussed at the ITU level and a number of the WRC-15 agenda items are allocated to this service.

The RSPG notes that some WRC-15 agenda items (AI) cover scientific services (AI 1.11 considers primary allocation for EESS (Earth-to-space) in the 7-8 GHz range), 1.12 considers extension of the current worldwide EESS (active) allocation at 9.3-9.9 GHz by up to 600 MHz within the bands 8.7-9.3 GHz and/or 9.9-10.5 GHz. Another AI refers to scientific services (AI 1.13) It relates to regulatory changes for a band to be used for docking to the International Space Station. Although not directly related to spectrum resources responding to European interests, this AI appears of easy solution. Those issues will be further addressed in RSPG working group on WRC15.

In addition to these agenda items, RSPG also noted that several WRC-15 agenda items could impact a number of European interests in the field of scientific services, including GMES (see Chapter 7).

In particular, certain proposals for Mobile Broadband identification under AI 1.1 should take into account appropriate sharing studies for various scientific applications such as the 1.4 GHz SMOS instrument, 1.7 GHz meteorological satellite systems (EUMETSAT), 2.8 GHz meteorological radars and 5350-5470 MHz EESS (active) sensors (see also Section 7).

WRC-15 AI 1.6 investigates additional frequency allocations between 10 and 17 GHz for uplink and downlink Fixed-Satellite Service allocations for all 3 ITU regions. The band 13.25-13.75 GHz, currently allocated to EESS (active), is used by altimeters, scatterometers and precipitation radars by ESA and EUMETSAT satellites, and also in cooperation with space agencies outside Europe. This band is essential band for meteorology and monitoring of the planet including climate change issues.

6.5. Conclusions concerning scientific services

Scientific services include many services which are highly prioritised within the European Commission, often associated with documented large socio-economic benefits.

In order to provide adequate protection for these services, great care needs to be taken in developing the regulatory regimes especially for consumer mass-market products using the same bands (e.g. reported interference related to outdoor WAS/RLAN equipment in the 5 GHz band where DFS had been disabled).

As these services are often global in nature (for example satellite and passive services) their requirement are often best addressed globally through the ITU WRC process. There have been no identified needs for additional frequency resources related to scientific services that are not already included in the WRC-15 agenda items. The RSPG also noted that several WRC-15 agenda items could challenge a number of European interests in the field of scientific services, including GMES. Relevant agenda items for scientific services may emerge in preparations for future WRCs.

7. Global monitoring for environment and security (GMES)

7.1. Identification and description of applications/services

The Global Monitoring for Environment and Security Programme establishes a European capacity for earth observation. GMES will provide accurate data and information on the Earth's subsystems – land, sea and atmosphere. These data will then inform the monitoring and forecasting of climate change effects. It will also contribute to a more effective response in emergency situations such as natural or man-made disasters and humanitarian crises; and it will assist in security-related aspects such as border control and maritime surveillance. A specific fund has been established to which all 27 Member States are contributing. Five satellite missions called Sentinels will support the operational needs of GMES. For each of these 5 Sentinel missions up to 3 satellites are planned to be launched. Some satellites use already identified spectrum resources (see Annex 3). The launches of Sentinel satellites 1A, 2A and 3A are planned during the 2013-2015 period and Sentinel 1B, 2B and 3B will follow. Sentinel 5 "precursor" (called Sentinel 5P) is planned in 2015 and Sentinel 4 and 5 satellites by the end of the decade.

In addition to the Sentinel missions, there are around 30 existing or planned contributing missions. These are missions from the European Space Agency, its Member States, EUMETSAT and other European or international third party mission operators that make part of their data available to the GMES programme.

7.2. Identification of the needs and demands of applications/services

7.2.1. Allocation issues addressed in the WRC-15 process

By principle, radio-frequencies are essential for GMES and details of use are given in Annex 3. The main requirement is to maintain the current high level of availability and reliability of the current bands, both for observations and data transmission.

The GMES programme may face growing demand for spectrum due to the rapid increase in the volume of data transmitted from satellites to the ground. The growing number of satellites poses challenges in the sense that data from more and more satellites needs to be downloaded within a certain time window. This, however, does not seem to be a problem specific to the GMES programme. Currently, the space to Earth link will use the 8 GHz range and a possible solution for accommodating the additional bandwidth requirements might be to consider other higher frequency bands for data downlinks in particular the 25.5-27 GHz band already allocated to EESS.

The RSPG considers that the following WRC-15 agenda items will need to be monitored are:

- AI 1.1: New Mobile Broadband allocations / identification with potential issues on several bands used by GMES. In particular, need to protect the 5350-5470 MHz used by the CSAR instrument on sentinel 1 and SRAL altimeter on Sentinel-3 (see details below);
- AI 1.6: New Fixed-Satellite Service (FSS) allocations in Ku-band. Need to protect the 13.25-13.75 GHz band used by the SRAL altimeter on Sentinel-3;
- AI 1.9.2: New Maritime Mobile-Satellite Service (MMSS) allocations in 8025-8400 MHz. Need to protect the 8025-8400 MHz band used by all the GMES satellites for the payload data transmission;
- AI 1.10: New Mobile-Satellite Service (MSS) allocations in the range 22-26 GHz. Need to protect the 23.6-24 GHz purely passive band from unwanted emissions by new MSS systems. Used by the microwave radiometer on Sentinel-3.

7.2.2. Use and possible expansion of the 5 GHz bands by RLANs

In September 2012 the European Commission issued a Communication promoting the shared use of spectrum which noted that:

"The trend towards a connected society demonstrates the added value of low spectrum access barriers in licence-exempt shared bands as the breeding ground for wireless innovation that stimulates the development and deployment of more resilient wireless technologies. A new generation of RLAN equipment (known as IEEE 802.11ac), expected to be on the market by the end of 2012, could approach the user speeds of fixed line networks. While depending on existing RLAN spectrum at 5 GHz, such developments will require very broad frequency channels that are currently limited in number." The Communication, proposed that: "Depending on the outcome of technical sharing studies and of the impact in the market, considering the designation of additional harmonised licence-exempt spectrum for RLAN services (Wi-Fi) at 5 GHz through a revision of Decision 2005/513/EC."[28]

The possible expansion of RLAN in the 5 GHz range concerns part of the band 5350-5470 MHz which is also used by Sentinel-1 and Sentinel-3 for observation purposes.

A Mandate from EC to CEPT was adopted on 2 September 2013[29] in order to assess possible additional opportunities for RLAN in the 5 GHz range whilst preserving the long term development and investment in the Sentinel systems.

The RSPG noted that, currently, the band 5350-5470 MHz does not have any mobile service allocation in Radio regulation and is therefore free from interference risk from RLAN systems. This regulatory framework was the main rationale for developing the very sensitive measurements of the Sentinel-1 SAR in this band. Any new mobile service allocation targeted to high-density RLAN systems would put at serious risk the Sentinel-1 mission that may not be able to return correct SAR data in the areas where these RLANs may be deployed. Therefore it is important that, based on the results of the necessary coexistence studies, the operational sharing conditions for RLANs in particular ensure that adequate protection is guaranteed for GMES.

Finally, although not directly related to GMES, it seems appropriate to note that WRC-15 agenda item 1.12 will consider an extension of the current primary allocation to the Earth Exploration-Satellite Service (active) in the band 9300-9900 MHz range by up to 600 MHz within the overall range 8700-10500 MHz to support the development of the next generation of high resolution synthetic aperture radars (SAR).

7.3. Conclusions concerning GMES

The RSPG considers that the European Commission, in cooperation with Member States, should take into account the needs of the GMES programme in defining common policy objectives related to WRC-15 agenda items (in particular, 1.1, 1.6, 1.9.2, 1.10 and possibly 1.12). Protection of the existing allocations listed in Section 7.2.1 is essential to the GMES success.

The RSPG considers that the European Commission, in cooperation with Member States, should gather information on the various contributing missions of the GMES programme, together with a spectrum inventory of the frequency bands used by these missions.

[28] EC Communication COM(2012) 478

[29] RSCOM13-32rev3 - Mandate to CEPT to study and identify harmonised compatibility and sharing conditions for Wireless Access Systems including Radio Local Area Networks in the bands 5350-5470 MHz and 5725-5925 MHz ('WAS/RLAN extension bands') for the provision of wireless broadband services

The GMES project is a large pan European project, funded by all Member States, and includes the planned launch of five satellites. The current need of the first generation satellites to be launched in 2014-2015 has been secured through the ITU WRC-process. Additional frequency bandwidth needs for the later satellites that are to be launched at the end of the decade, as well as any other possible needs that dome from the rapid increase in the volume of data requirements, will mostly be handled in WRC-15 Agenda Item 1.12. There is also frequency bands used for GMES observation purposes, which protection needs to be secured via the WRC-15 process.

8. Intelligent transport systems (ITS)

8.1. Identification and description of applications/services

ITS means systems in which information and communication technologies are applied in the field of transport and traffic telematics, including infrastructure, vehicles and users, and in traffic management and mobility management.

CEPT Report 44 outlines the current restrictions for this application field: all the existing RTTT entries in Annex 5 of ERC/REC 70-03 as well as other ECC Decisions and Recommendations on ITS rely on technical considerations or studies purely limited to ground based stations, hence there are neither standards or specifications nor compatibility studies in existence in support of airborne applications. It is planned to have technical studies on a helicopter use case in the near future in CEPT. In any case, airborne ITS stations would need technical studies in CEPT first before consideration to allow such a use case. In addition, the usage of terminology on worldwide basis is not harmonised regarding usage of terms such as TTT, RTTT, ITS, SRR and DSRC.

Vehicle to vehicle communication (V2V)

V2V communication is still at the research stage, but may have a potential to play a significant role in the area of for example road safety and traffic management. V2V communication does not need any roadside infrastructure. It has the potential to be fast and reliable, and to support real time road-safety applications such as for example collision avoidance and local warning alert. If not also supported by any roadside infrastructure, V2V communication could use multihop forwarding to enable communication over longer distances than a few hundred meters.

Vehicle to infrastructure/roadside communication (V2I / V2R)

Vehicle to Infrastructure communication provides a solution for longer range vehicular networks. One way of implementing V2I is via commercial cellular networks. Direct communication with roadside infrastructure has the advantage of low latency, but is also related to a high infrastructure investment cost. Possible applications are traffic light and traffic sign alert systems, congestion control and avoidance, parking space management, weather information, safety information and hazards warnings.

Intra-vehicle Communication (IVC)

There are various functionalities inside a vehicle that rely on wireless communication such as, such as wireless keys, tyre pressure monitoring (TPM) and vehicle-driver communication devices.

Cooperative Vehicular Ad-hoc Networks (VANET)

VANET is a technology where each vehicle is equipped with a Wi-Fi device that acts as a node to create a mobile network. The primary goal of VANET is to provide road safety measures such as for example collision avoidance, but VANET could also provide services such as email and audio/video sharing.

8.2. Key requirements

Safety related applications have high requirements on robustness and latency, and may need to operate in a predictable interference environment. Non-safety related applications usually have lower requirements on robustness and latency. ECC Decision (08)01[30] harmonises 30 MHz of spectrum band for ITS applications in the 5875-5905 MHz band (possible expansion in 5905-5925 MHz). This spectrum is for primarily for road-safety related features.

[30] To be reviewed by ECC WG FM 2013/2014

Key requirements:

- Road safety related applications have high requirements on robustness and latency, and may need to operate in a predictable interference environment.
- Non-safety related applications usually have lower requirements on robustness and latency.

8.3. Conclusions concerning ITS

The RSPG considers that:

- this sector puts forward their spectrum needs via the ETSI-CEPT process.
- there has been no additional demand identified for road-safety related ITS applications that cannot be realised within the current 5.9 GHz harmonisation.
- any possible new frequency demands, non-road-safety related ITS applications could in many cases use frequency bands harmonised for SRD.
- possible needs and demands for ITS applications requiring lower frequencies (larger distances or non-line of sight) should be considered in future harmonisation of SRD below 1 GHz.

9. Smart meters

9.1. Identification and description of applications/services

Consumers are increasingly sensitive to resource consumption and in the case of power, their carbon foot print. Smart metering is the first step in integrating consumers' wishes with the supply of these resources. This enables a more efficient use of the resources. There are in excess of 300 million gas and electricity meters in Europe alone which require replacing to meet the requirements of M/441. There are approximately 157 million water meters installed in Europe. There is no legislation driving the adoption of smart metering for water. However, it is expected that 31 % of all new water meters installed worldwide will be smart or smart enabled meters by 2016.[31]

Utility companies in the energy sector (such as electricity, gas, water, or heating providers) have started deploying smart metering systems. These systems are capable of providing consumption information to the utility provider as well as to consumers in real time and generally allow utility providers to monitor and constantly optimise the supply chain of the given energy resource and help ensure the resilient and efficient performance of their infrastructure. The customers will be able to retrieve information on their past consumption patterns to help them better understand their actual energy consumption and make decisions on future energy use. These communication possibilities will also make it possible for the consumer to allow the utility provider to switch on power to specific devices when demand is low or switch the power off when demand increases. This could be done for devices such as electrical cars and heating devices that store power in e.g. batteries and need to be charged for quite some time. This gives the utility provider the possibility to spread the load of the network and to offer consumers advanced tariff structures and remote tariff control consumers to respond to the variation of prices in real time and create basis for efficient competition in utility supply infrastructure. It also enables advanced tariff structures and remote tariff control which allow consumers to (automatically) respond to the variation of prices in real time and create basis for efficient competition in utility supply infrastructure.

The roll-out of these smart meters is obligatory in many Member States. In most Member States the responsibility for the roll-out is placed upon the Distribution Service Operator (DSO).

9.2. Current regulation

A European Standardisation Mandate M/441[32], to CEN, CENELEC and ETSI, "in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability" has been established.

European Commission also issued a Recommendation in March 2012 on preparations for the roll-out of smart metering systems (2012/148/EU) that sets common minimum functional requirements for smart metering systems for electricity for the customer, for the commercial aspects of energy supply, for security and data protection and for the distributed generation.

9.3. Key requirements and functionalities

Key functionalities:

- Frequent updates of the readings provided directly to the consumer.

[31] Smart water meters, Pike Research, 2010

[32] European Commission, Enterprise and Industry Directorate General M/441 "Standardization mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability", Brussels, 12 March 2009.

- Remote reading of meters by the utility network operator in order to help planning of network and utility resources, facilitate switching of suppliers as well as operational maintenance.
- Remote reading of meters (i.e. consumption, behaviour at the edges of the grid – Smart meters may be a part of a smart grid network), also in support of network planning.
- Two-way communication support between the smart metering system and external networks for maintenance and control of the metering system.

Key operational requirements:

- Low capacity needs per individual metering device combined with use of aggregating devices (network relay points) to create hot-spot like flexible deployment of high density networks;
- Range from a few metres to a few kilometres for links of meshed networks in metropolitan as well as rural areas;
- Moderate requirements on robustness and latency;
- Very high density in urban environments;
- Low per-device cost solution;
- Meters are installed for a long period (>15 years) on customer premises.

Utility companies use several strategic criteria when assessing the options for the use of spectrum for communications with smart meters. Amongst these considerations are:

- the availability of standardised solutions with a mature ecosystem of various manufacturers and vendors,
- the price and lifecycle of available communication products that can be integrated in the meters and
- the level of control which can be achieved over the solution.

9.4. Conclusions concerning Smart meters

The RSPG has identified several technical solutions that could be used for smart meters including PMR networks, fixed links, commercial cellular networks (M2M application) and SRD, using harmonised spectrum that is already available. The most suitable choice of technology and frequency band varies due to for example national circumstances and the operating environment (urban/rural). In some cases SRD technologies may be used, in other cases other technologies are more appropriate. For these solutions, several existing spectrum options have been identified by the RSPG, such as:

- 169.4-169.8125 MHz (challenge: limited bandwidth compared with other spectrum options);
- 868-870 MHz;
- 870-876 MHz and 915-921 MHz;
- 2.4 GHz/5 GHz for SRD (challenge: range and wall penetration);
- Commercial networks (e.g. GSM) (challenge: price and the longevity of GSM networks)
- Private Wireless Solutions (PMR/PAMR) using national allocations in VHF or UHF bands

The RSPG identifies the economies of scale for these mass-market smart metering devices as the greatest motivation for harmonisation of smart metering frequency access in Europe. The RSPG considers that this can be achieved within the current spectrum options available, and that an exclusive designation of spectrum to smart meters is not necessary. The RSPG considers that this sector can put forward their spectrum needs via the ETSI-CEPT process.

The RSPG notices that smart meters have a relation with smart grids. A utility company operating a smart grid and smart meters may very well wish to use the same frequencies for smart meters as for smart grids. The RSPG therefore believes that a strict separation may lead to overseeing possible synergies between the two in the future.

10. Smart energy grids

10.1. Identification and description of applications/services

Europe's integrated utility network will be subject to substantial restructuring in the coming years as a direct consequence of the on-going liberalisation and innovation of the energy market. The present electricity supply infrastructure, which is characterised by large, centralised power stations, may evolve into a system comprising both centralised and decentralised electricity supplies including micro generators and small and medium sized renewable sources. These could also be on consumer premises, where power is locally generated and supplied to the network. On the side of power consumption the introduction of new elements such as charging points for electrical vehicles may lead to new and geographical (urban area's) peaks in power consumption in the network. These processes will place new demands on the engineering of these systems, including real time optimisation of overall network operation and centralised control of individual equipment.

Electrical power supply is done most efficient when there is a constant demand. Fluctuations in demand need to be addressed by increasing or decreasing the power generation and distribution. These fluctuations can be the result of increased or decreased demand or of increased or decreased distributed power generation. Fluctuations in demand could increase considerably when equipment storing (large amounts of) energy in batteries or otherwise are becoming mainstream. Electrical cars or electrical heating are examples. If most of these are being charged starting between 18:00 and 20:00 hrs. a massive peak will be the result. Fluctuations in distributed power generation are logical when the sun or wind comes up or decreases. These fluctuations also appear at different locations in the grid. To adapt to these fluctuations the utility operator needs to adapt the grid constantly. To do that, reliable real-time information on both power consumption and generation is needed. This can be done using meters in distribution points, but also and more precisely by using smart meters. In addition to measuring the power consumption and distributed power generation the operator needs the means to control his network constantly and in real-time. This could include new means to balance the supply and demand of energy, e.g. by remotely controlling micro power generators or charging devices.

This anticipated development, with a rapid growth in the numbers of decentralised micro generators require an advanced integration strategy to be developed. Part of this integration will be a supporting communication network to permit the monitoring and control of these generators. Trust and control over these mission-critical communications is pivotal for utilities. The stability of the grid is dependent on these communications.

A smart grid is made possible by robust, end-to-end communications technologies. These technologies, working alongside the electrical grid, pull in data from all over the grid. Sensing devices are placed throughout the electrical grid and in consumers' homes and businesses (see Chapter 9 on smart meters). Information from the devices is sent to utility operators that can constantly monitor and act upon the data. Smart energy grids could be thus described as an upgraded electricity network to which two-way digital communication between supplier and consumer, intelligent metering and monitoring systems have been added.

The European Commission's issued a mandate[33] to CEN, CENELEC and ETSI for smart grids standards in March 2011. In response to this mandate, a final report was issued at the end of 2012 by

[33] Mandate m/490. Standardisation mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment.

the Smart Grid Coordination Group (SG-CG) Reference Architecture Working Group (SG-CG/RA). Its main outcomes could be assumed as starting point and basis for our current work.

Properly identifying communication infrastructure related to smart grid deployment is crucial in order to identify suitable frequency options expected to be used for smart energy grids.

The requirements on the communication channels varies for the different levels of the Smart grid, with necessary customisation to fit different types, configurations and extent/density of utility networks as well as utility operators' specific operational and commercial needs.

In particular in the medium to lower voltage parts of the grid, which require more intensive and more trusted communication, wireless solutions are needed. Given the numbers of assets, the geographical spread of these assets and the relatively lower demands concerning bandwidth and availability, wireless solutions are very cost-effective solutions compared to wired solutions. For many parts of the network, wireless communication is believed to be the most suitable solution, for example to allow the integration of large amount of smart meters and other smart grid assets. The criticality of these solutions for the management of the grid necessitates an adequate communication solution which provides a sufficient and trusted level of control. The necessity to be in control of these communications needed for grid management may call for private wireless network solutions.

The anticipated massive deployment of renewable and decentralised energy sources, as well as managing complex interactions between suppliers and customers, present new challenges for the electricity networks and markets and means that more and reliable information is required.

10.2. Key operational requirements

- High level of link robustness, high reliability for any mission-critical service;
- End-to-end quality of service support;
- Network resilience and end-to-end security provision;
- Short response time;
- Bitrate from kbps to few Mbps.

Distribution automation, management and control of the smart grid network has been identified as the most mission-critical area where communication between the primary stations is very important for the stability and operational safety of the networks, and where high level requirements are needed.

10.3. Conclusions concerning smart energy grids

Spectrum demand for smart grid applications may differ between the networks and countries, depending on network configuration, density of nodes, rate of data collection etc. Due to the large scope of smart grid services and applications, several techniques and spectrum ranges may be suitable to address the relevant requirements. Relevant solutions including PMR networks, fixed links, commercial cellular networks (M2M application) and SRD using existing harmonised spectrum are already available to meet this demand of wireless solutions, and the RSPG considers that an exclusive designation of spectrum to smart energy grids is not necessary.

For these solutions, several existing spectrum options have been identified by the RSPG, such as:

- 169.4-169.8125 MHz (challenge: limited bandwidth compared with other spectrum options),
- 868-870 MHz;
- 870-876 MHz and 915-921 MHz;
- 2.4 GHz / 5 GHz (challenge: range and wall penetration);

- Commercial networks (e.g. GSM/GPRS and broadband such as LTE/WiMAX) may be feasible for collecting consolidated information from the meters' data aggregating points
- Various bands for broadband fixed wireless access where economics justify ad hoc networks purpose-built by utility operators;
- Private Wireless Solutions (PMR/PAMR) using national allocations in VHF or UHF bands (promising option given the availability of mass market commercial technologies and products which can be used in such private networks, challenge: limited bandwidth allocated to PMR).

Utility companies may very well use several of these frequency options within their networks and the RSPG considers that an exclusive designation of spectrum to smart energy grids is not necessary and that this sector can put forward their spectrum needs via the ETSI-CEPT process.

The RSPG notices that smart energy grids need information on the power consumption throughout the network and that smart meters could provide this information. When a utility operator exploits a smart grid and uses smart meters, he may very well wish to use the same frequencies for smart meters as for smart grids. Therefore the RSPG believes that a strict separation may lead to overseeing possible synergies between the two in the future.

11. Public protection and disaster relief (PPDR)

11.1. Identification and description of applications/services

Definitions of PPDR

There are terminology differences between administrations and regions in the scope and specific meaning of PPDR. The following definitions are provided in Report ITU-R M.2033 "Radiocommunication objectives and requirements for public protection and disaster relief" (2003):

- Public protection (PP) radiocommunication: Radiocommunications used by responsible agencies and organizations dealing with maintenance of law and order, protection of life and property, and emergency situations;
- Disaster relief (DR) radiocommunication: Radiocommunications used by agencies and organizations dealing with a serious disruption of the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by accident, nature or human activity, and whether developing suddenly or as a result of complex, long-term processes.

The function of future European broadband PPDR system is to provide, based upon the commonly agreed user requirements between CEPT and PPDR organisations e.g. Law enforcement working party (LEWP), the ability to enable PPDR organisations to efficiently access and share accurate and timely data information at which and in the longer term also the inclusion of voice is envisioned.

PPDR users

Typical missions carried out by PPDR organisations include, among others:

a) law enforcement
b) fire fighting
c) emergency medical services
d) search and rescue
e) border security
f) event security
g) protection of VIPs, dignitaries, etc.
h) evacuation of citizens
i) response to natural and man-made disasters

PPDR applications

Below are the most important PPDR Broadband mission critical applications and services that have been identified by the PPDR users:

- high resolution video communications from wireless clip-on cameras to a vehicle mounted laptop computer, used during traffic stops or responses to other incidents;
- video surveillance of security entry points such as airports with automatic detection based on reference images, hazardous material or other relevant parameters;
- remote monitoring of patients. The remote real time video view of the patient can demand up to 1 Mbit/s. This demand for capacity can easily be envisioned during the rescue operation following a major disaster. This may equate to a net capacity of over 100 Mbit/s;
- high resolution real time video from, and remote monitoring of, fire fighters in a burning building;
- the ability to transmit building plans to the rescue forces.

When looking at the future spectrum demand for PPDR, the focus should be on broadband (rather than narrow and wideband) applications and services. National narrowband PPDR networks using the

TETRA or TETRAPOL technology are in operation today in European countries, using the 380-385 MHz/390-395 MHz band harmonised for narrowband PPDR applications. Those systems are expected to continue to provide voice and narrowband services in Member States for at least the coming decade. Furthermore, the bandwidth requirements for the new broadband applications are far greater compared to those provided today by the narrowband and wideband services.

Key requirements under study refer to coverage, capacity, availability, bandwidth requirements, end user equipment, network management, interoperability and cost related requirements (see ECC Report 199). Another ECC Report concerning the envisaged future frequency usage for BB-PPDR is under development in FM PT49.

11.2. Level of harmonisation within EU, CEPT and globally

EU

Two EC mandates given to CEPT refer to PPDR issues, one Mandate (700MHz) is elaborating on the PPDR issue, while PPDR is only mentioned as one of the possible candidates by the other Mandate (2 GHz Unpaired Bands). The responses are expected by end 2014. They both consider PPDR as a possible candidate for the related frequency bands:

- Mandate to undertake studies on the harmonised technical conditions for the 1900-1920 MHz and 2010-2025 MHz frequency bands (“Unpaired terrestrial 2 GHz bands”): PPDR is mentioned as well as other applications: PMSE, BDA2GC, DECT (IoT).
- Mandate to CEPT to develop harmonised technical conditions for the 694-790 MHz ('700 MHz') frequency band in the EU for the provision of wireless broadband and other uses in support of EU spectrum policy objectives.

CEPT

In 1991, the "Telecom" working party of the Signatories to the Schengen Treaty requested that the CEPT identify some harmonised spectrum for exclusive use by the police and security services across Europe.

CEPT agreed on various regulatory frameworks harmonising the usage for PPDR communications (narrow and wide bands) and for indoor usage of radio LAN.

CEPT is currently drafting responses to EC mandates (see above) and is carefully studying the relevant harmonised solutions responding to future Broadband PPDR needs (see FM PT49). The CEPT work related to PPDR involves several groups. The preparatory work for WRC-15 agenda item 1.3 (se sub-section below on ITU and WRC) is performed in CPG PTA. However, since the 700 MHz band has been identified by FM PT49 as candidate band for PPDR broadband Wide Area Networks (WAN), the preparatory work in CPG PTD (responsible for WRC-15 agenda item 1.2) and ECC PT1 (tasked to develop the response to the EC mandate on proposed channelling arrangements in the 700 MHz band) is also highly related. Concerning the EC mandate for the 2GHz Unpaired Bands, PPDR Video Links (sharing the same technical framework with Video-PMSE) is one possible candidate application among BB-DA2GC, DECT/SRD and possibly others.

ITU and WRC

Resolution 646 (Rev.WRC-12) encouraged administrations, for the purpose of achieving regionally harmonized frequency bands, to consider certain identified frequency bands on a regional basis for public protection and disaster relief (PPDR) solutions.

WRC-15 Agenda Item 1.3 has the objective to review and revise ITU-R Resolution 646 for PPDR, in accordance with ITU-R Resolution 648, which invites ITU-R to "to study technical and operational issues relating to broadband PPDR and its further development, and to develop recommendations, as required, on:

- technical requirements for PPDR services and applications;
- the evolution of broadband PPDR through advances in technology;
- the needs of developing countries.

11.3. Spectrum needs

RSPG recognised that Spectrum needs for broadband PPDR services differ for each Member State. National solutions depend on national political decision including economics, relevant refarming issues, network mutualisation, etc. RSPG also recognised that a decision on deployment of broadband PPDR networks is a national matter. LTE technology is expected to be the future technology to meet broadband PPDR needs, the work is in progress within standardisation to define functionality enhancements for PPDR operators. Three options have been identified for countries that wish to use broadband PPDR:

1) A national dedicated broadband network: it could provide, among others, possibilities to control the network, coverage, capacity, availability and to add specific functionality and security measures.
2) PPDR applications over commercial networks: it could provide all benefits of commercial developments and economy of scale advantages. Capacity, security, possible prioritisation and availability are subject to the contract between the Member State and the mobile operator(s).
3) A hybrid solution: a dedicated broadband PPDR network may have limited coverage or capacity. In addition the use of commercial networks in case coverage or capacity of the dedicated network is insufficient. Such a solution would require the possibility of roaming, including at national level, between dedicated and commercial networks.

Future decisions on possible harmonisation of PPDR spectrum should take, at least, all of these options into account.

The following main spectrum needs and justification for a possible European harmonisation/regulatory framework have been identified:

a) The amount of spectrum to be used for broadband PPDR needs to be flexible to fit each country's needs. Such flexibility would allow national administrations to choose the frequency band out of the agreed candidate bands (or parts thereof) and the regulatory model (dedicated, commercial or hybrid networks). A minimum amount of around 2 x 10 MHz is considered needed for a dedicated broadband PPDR network (see ECC Report 199 and ETSI TR 102 628);
b) There could be additional spectrum requirements on a national basis to cater for Direct Mode Operations (DMO), Air-Ground-Air (AGA), ad-hoc networks and voice communications over the WAN (see ECC Report 199);
c) Recognising the right of Member States how to organise and use their radio spectrum for PPDR, a possible harmonisation of spectrum for broadband PPDR should not limit the ability of individual Member States from using that spectrum for other services or applications as they see fit;
d) Interoperability and roaming between different PPDR networks, as well as commercial networks is also being considered. For hybrid networks this may be essential.

e) Roaming between countries would be beneficial for future broadband PPDR networks for cross-border co-operation;
f) Frequency bands for use by broadband PPDR services supported by commercial mobile broadband equipment (user terminals, base stations, chipsets etc.) would also enable PPDR users to benefit from economies of scale available when using commercial products and from possible synergy with technology development in the commercial sector;
g) Dedicated frequency bands offer the opportunities to roll out dedicated networks responding to national security requirements and enable to provide the specific PPDR services and needed reliability while benefitting from synergy with standards developed for the commercial mobile broadband.
h) Interoperability between radio equipment of different manufacturers of user equipment and infrastructure is required to make roaming possible.

Based on the national requirements brought forward, FM PT49 has made an effort to evaluate the common needs. At time of writing (September 2013), frequency options in the 400 MHz band and the 700 MHz band are being evaluated.

Moreover additional higher frequencies could be suitable to deliver temporary capacity or ad hoc solutions to cover situations such as large emergencies, public events or a natural disaster.

11.4. Conclusions concerning PPDR

The RSPG recognised that the provision of PPDR services, including the associated radiocommunications facilities is a sovereign national matter, and that the broadband PPDR needs of Member States may vary to a significant extent. Therefore, the future harmonisation of the broadband PPDR sector in Europe needs to be flexible enough to respect national sovereignties and different national circumstances such as; the amount of available spectrum and the type of network deployed and used which may be dedicated, commercial or a hybrid solution (a mixture of dedicated and commercial networks). There are requirements to ensure adequate interoperability between the different countries. Also the possibilities of maximising the benefits from the economies of scale should be taken into account.

12. Programme making and special events (PMSE)

12.1. Identification and description of applications/services

The term Programme Making and Special Events applications (PMSE) is a widespread term gathering various radio applications used for SAP/SAB, ENG, SNG and OB (see definitions in Annex 11) in public or private events for perceived real-time presentation of audio visual information. The communication links are also used in the production of programmes, such as talk-back or personal monitoring of sound-track. Programme making includes the making of a programme for broadcast, the making of a film, presentation, advertisement or audio or video recordings, and the staging or performance of an entertainment, sporting or other public events. Special Event is an occurrence of limited duration, typically between one day and a few weeks, which take place on specifically defined locations. Examples include large cultural, sport, entertainment, religious events and other festivals, conferences and trade fairs. In the entertainment industry, theatrical productions may run for considerably longer, also cross border. These events will occur on a daily basis.

There are various fields where PMSE applications are used. For a better understanding these are listed below:

a) Theatres and rock and pop and touring shows;
b) Studio production, these can be single buildings or cover many hectares with multiple studios;
c) News gathering for TV/radio/internet;
d) Sound broadcast;
e) Casual (sport) events and similar outside broadcasts;
f) Special events (i.e. large outside broadcasts);
g) Houses of worship;
h) Film and advert production;
i) Corporate Events;
j) Social use, e.g. homes for the elderly people;
k) Conference/Political events (e.g. shareholder/board meetings, G20 summit).

12.2. Specific considerations

The spectrum for PMSE is not fully harmonised across the EU countries due to divergent national frequency plans and differing demands. Therefore, for many frequency ranges and in particular for Video-PMSE applications the concept of tuning ranges (see Annex 5) is pursued – that is the frequency bands, from where countries may assign specific sub-bands or particular frequencies for e.g. audio/video links subject to availability, actual demand and sharing arrangements with primary services using those bands.

Ideally, PMSE equipment should be capable of being operated within the whole tuning range in which PMSE can share with primary users, and even beyond, to be suitable for operation in different countries.

PMSE audio applications

Currently a wireless microphone receiver is tuneable across between 24 MHz and about 320 MHz in the 470-865 MHz band. Transmitters of wireless microphones and other system components such as dedicated receiving antennas have smaller switching bandwidths. Usually there exists a trade-off between different system parameters and cost of the equipment. A larger tuning range might result in an increased susceptibility to interference and/or a lower battery life time.

PMSE video applications

Currently a wireless camera is tuneable across some 300 MHz in the 1.3-7.5 GHz band. Usually there exists a trade-off between different system parameters. A larger tuning range might result in an increased susceptibility to interference and/or a lower battery life time.

For both, PMSE audio and video applications, this can be further elaborated based on the following:

- Spectrum demand is not constant, since it is normally changing with respect to time and location;

Yet, for the relatively constant regular spectrum demand harmonised core bands would be beneficial. A sufficiently wide tuning range in which PMSE can share spectrum with primary users, is a means to fulfil the often significantly increased spectrum demand for special events, whilst not leaving this spectrum unused when not required by the primary user.

12.3. Identification of the needs and demand of applications/services

Quality requirements of PMSE applications vary depending on the task in hand. The bandwidth of the signal to be transmitted i.e. audio or video has a direct impact on the bandwidth required. The actual demand for PMSE spectrum varies significantly between different countries and applications, different programme makers and different events, the overall trend is that of steady increase of PMSE demand in most of the sectors.[34]

The perceived quality of the signals is going to be dependent on their potential final use but it would be always produced in high quality. The uses can vary from SNG links into a news programme through to a high quality HD TV production.

Special events for large number of people and large broadcast productions use a great number of PMSE equipment. This means a greater amount of spectrum is required to guarantee the quality of service. For these events, the requirements regarding for example reliability and audio or video quality may vary for different types of usage.

PMSE audio applications

Whereas in the past wireless microphone systems with higher required quality of service could not use bands above 1 GHz due to technical issues, some modern systems can operate above 1 GHz for certain applications. New techniques such as cognitive PMSE could increase the efficient use of spectrum by audio PMSE.

The Bands IV/V are the most intensively used for audio applications. For wide band audio currently there seems to be no alternative frequency bands to meet the current and future demands. Evolution of primary usage in the UHF band impacts the PMSE audio community possibilities in this frequency range.

The introduction of mobile broadband in the frequency band 790-862 MHz could partly be compensated by the bands 823-832 MHz (in particular for usage) and 1785-1804.8 MHz. Other usages with higher required quality of service moved to the frequency band 470-790 MHz. If the frequency band 694-790 MHz would be used by mobile broadband, some PMSE usage might remain feasible in a potential novel duplex gap and/or guard band. Other usage might move to the frequency band 470-694 MHz and/or switch to the bands 174 – 223 MHz, 823 – 832 MHz, 1785-1804.8 MHz and the

[34] ECC Report 204 is currently under development and describes the needs and spectrum requirements for future PMSE applications.

recently identified band 1492 – 1518 MHz, if possible. Moreover, new bands might be identified as candidate bands for radio microphone use.

PMSE video applications

In case of a loss of transmission capacity for cordless cameras in the frequency band 2.3-2.4 GHz, appropriate alternative frequency bands below 3 GHz are required.[35]

In 2008 the EBU carried out a survey on spectrum requirements for SAB/SAP and ENG/OB applications.[36] The survey gave indications that the spectrum demands for these applications was generally expected to grow in the foreseeable future. The following drivers of the growth were identified:

a) Broadcasting programmes and events to be covered are getting technically more complex, thus requiring more equipment on the site;

b) The rapid growth of HDTV and associated production which requires higher bandwidths

c) The increasing overall number of users (e.g. beside broadcasters);

d) For cordless cameras, portable and mobile video links the most used band is 2.2-2.5 GHz;

e) Due to the frequency allocations to mobile broadband (e.g. 790-862 MHz, 2.6 GHz band) some bands may not be used by SAB/SAP services any more.

Clear regulation and sufficient amount of spectrum are required to ensure continuation of SAB/SAP operations.

12.4. Sharing possibilities and need for harmonising the usage of spectrum

PMSE mostly shares spectrum with primary services on a secondary basis, e.g. with the broadcasting service as primary user. If there is a reallocation of primary services or when the spectrum is much more intensively used by the existing primary service, the use of PMSE on a secondary basis may be restricted or become impossible. In order to maintain operation of PMSE dedicated spectrum or spectrum of other services that allow sharing with PMSE is required. The various PMSE authorisation regimes across EU countries and sometimes across different applications (licensed, licence exempt, coordinated or uncoordinated) should be publicised on a single source of information to allow users to ensure compliance with the regulatory framework in the country visited.

There are several activities going on within different organisations and on different levels dealing with more or less the same subject: identifying the needs and finding harmonised solutions for PMSE applications. One of the most comprehensive activities has been undertaken by the CEPT WGFM PT51 according to the following work plan:

- Spectrum requirements for PMSE (see Annex 8 and Annex 9)
    - Study the spectrum requirements for PMSE after the transition to digital technology which is expected to take place in the next 5-10 years (revision of the ECC Report 002 or a new ECC Report[37]).
- Respond to EC Mandate on PMSE

[35] ECC is currently investigating several new frequency bands for cordless cameras and video links.
[36] The results were published as the EBU Strategy Report 001
[37] ECC Report 204 is currently under development and describes the needs and spectrum requirements for future PMSE applications.

- Develop the necessary reports in response to the EC Mandate
- Liaise with WG SE as appropriate to gather relevant technical criteria

The EC Mandate on PMSE was issued by the European Commission requesting CEPT to study the technical conditions regarding spectrum harmonisation options for wireless radio microphones and cordless video-cameras (PMSE equipment). The response mentioned above deals with the technical conditions for the use of the bands 821-832 MHz and 1785-1804.8 MHz for wireless radio microphones in the EU, including the technical conditions which can contribute to facilitating the use of PMSE equipment for EU-wide operations as set out in CEPT Report 50 and the supplementary report addressing the usability of the band 1785-1804.8 MHz. The tasks dealing with requirements of cordless cameras are addressed in CEPT Report 51.

Other tasks of the group are the following:

- Prepare input to ITU-R SG5 regarding ITU-R Resolution 58
    - Studies on availability of frequency bands and/or tuning ranges for worldwide and/or regional harmonisation and conditions for their use by terrestrial ENG systems
- Review of ERC Recommendation 25-10 (Frequency ranges for the use of temporary terrestrial audio and video SAP/SAB links (incl. ENG/OB))
- Review of ERC Report 042 (Handbook on Radio Equipment and Systems Radio Microphones and Simple Wide Band Audio Links)
- Review of ERC Report 38 (Handbook on Radio Equipment and Systems. Video Links for ENG/OB use)

12.5. Conclusions concerning PMSE

The Spectrum demand considerations for future PMSE spectrum opportunities need consultation at the national level with subsequent national contribution to on-going studies in the CEPT/ECC. New spectrum opportunities for PMSE need also to be reflected in the harmonised European standards for PMSE equipment and this should be coordinated via the existing ETSI-CEPT coordination process. As far as in relation to agenda items of WRC-15, PMSE needs should be recognised when impacted by the re-allocation of primary services.

The spectrum needs for PMSE use vary greatly in time and location, depending of the scale of the event or programme. Some spectrum resources are required for daily usage (e.g. theatres), while other usages are more temporary in nature. For planned events, suitable frequencies are identified on a case-by-case basis at national or local level using spectrum available for that time and location. For unplanned events, the spectrum resources need to be available without prior coordination. A reliable regulatory environment is a prerequisite to give users the confidence needed to make the necessary investments associated with new conditions. This study focused mainly on two of the PMSE applications (video and audio applications).

PMSE audio applications

The RSPG noted that industry is moving towards wider tuning ranges. This initiative should be supported because of national differences, and to enable interoperability over national borders. Larger tuning ranges would also make it easier to cater for the spectrum needs at large events with multiple PMSE users. From a regulatory perspective this could be encouraged through harmonisation of those wider tuning ranges.

The reallocation of the 800 MHz spectrum together with the possible release of the 700 MHz band to mobile services is putting pressure on the availability of spectrum for PMSE use. Duplex gaps in the 800 MHz and1800 MHz bands used for mobile broadband are currently being studied for PMSE usage. Whereas a possible future 700 MHz band identification for IMT will reduce the current availability of spectrum for PMSE, there may be an opportunity to exploit the duplex gap[38]. Co-existence with other services (e.g. duplex and guard bands) could be made more favourable to PMSE if their needs are taken into consideration early in the harmonisation process. Migration towards more spectrum efficient digital technology would ease the frequency situation for PMSE, but due to problems with latency this migration has been minor up until today. With the current analogue technology, the remaining UHF band (approximately 470-694 MHz) white space usage may not be enough to cater for all PMSE audio spectrum needs. Opportunities for additional frequencies can be found outside this frequency range, on shared basis. A harmonisation at European level of tuning ranges and sharing conditions covering such bands would be highly beneficial in order to ensure the co-existence with other applications, stimulate research and development, and to provide improved technical conditions for PMSE equipment.

PMSE video applications

If the current and increasing need for PMSE bandwidth is to be met in a more and more competitive spectrum environment, both PMSE users and industry need to adapt. Due to the migration towards high definition video and the intensified use of the current bands by other applications (e.g. mobile broadband), the future needs of PMSE video applications, especially at larger events, are not believed to be completely fulfilled within the current tuning range below 3 GHz.

A harmonisation at European level of expanded tuning ranges and sharing conditions would be necessary to meet future spectrum demands. Examples of uses which could be suitable for sharing spectrum with PMSE video applications are military use, fixed links and the frequency bands that are licensed for mobile broadband but which are not deployed nationwide. CEPT has already identified potential candidate bands and sharing conditions are under study.

Wireless PMSE video equipment is predominantly low volume products which can be adapted to suit national circumstances. Since the prerequisites for sharing spectrum differ amongst countries, the harmonisation measures need to have some degree of flexibility. One also needs to consider that different categories of usage (e.g. fixed, mobile) may have different requirements on, e.g. bandwidth, quality of service and propagation characteristics (which is closely related to the frequency range).

[38] The duplex gap might also be attractive to other applications such as PPDR or TDD mobile services or supplementary downlink.

13. Internet of things (IoT) including M2M and RFIDs

13.1. Identification and description of IoT (including M2M)

Networks of objects interconnected through the internet via various access means (fixed and radio) are beginning to include a very broad variety of different objects, from e-books to cars, from electrical appliances to food packages, and thus create an Internet of things (IoT). These objects will sometimes have their own internet protocol addresses, are embedded in complex architecture systems and use sensors to obtain information from their environment (e.g. food product packaging that records the temperature along the supply chain) or use actuators to interact with it (e.g. air conditioning valves that react to the presence of people)[39].

The 'things' in the IoT, or the 'machines' in M2M, are physical entities whose identity, state (or the state of whose surroundings) is capable of being relayed to an internet-connected IT infrastructure. Almost anything to which you can attach a sensor can become a node in the Internet of Things.

Examples of applications

- Home automation applications where a broad plethora of sensors and various controls and actuators interact in order to achieve optimal comfort objectives and management of energy and other resources;
- Applications that use sensors and control devices in all kind of city infrastructure from traffic lights to garbage bins in order to maintain real-time information about their state, environment, and thus allow efficient management of city infrastructure and resources;
- Consumer devices that automatically connect with service centres to notify of actual or impending break-downs and request servicing;
- Within traditional industries, such as logistics (eFreight), manufacturing and retail, intelligent objects facilitate the exchange of information and increase the effectiveness of the production cycle.
- A current market initiative is on-going in one Member State to use SRD generic frequencies to facilitate IoT applications.

13.2. Key requirements for IoT (including M2M)

- Depending on the type of applications (objects/machine)
  - Often low power/low duty cycle (due to battery consumption constraints)
- Various radio access components are needed to address the demands of multi sectors:
  - Several applications require capacity below 1 GHz due to propagation characteristics (e.g. building walls)
  - Usage of commercial networks (responding to various needs) –issue of long term availability;
- Moderate requirements on robustness and latency;
- Very high density in urban environments;
- Low per-device cost solution;
- Often installed for a long period.

13.3. Relationship with SRD regulation

IoT may imply large amount of investments for example in SRD frequency bands. Any evolution of SRD regulation shall be carefully considered based on industry inputs mainly via the ETSI CEPT cooperation process. In particular, a sharing scheme is typically defined based on assumptions

[39] COM(2009) 278 final

regarding other SRD applications operating in the same frequency band. It means that any evolution in the SRD regulation (without compatibility studies) may create a new interference environment to the existing SRD applications (e.g. if the deployment is larger than expected). The success of one application may imply higher deployment than initially expected and could generate interference. In this context, the above assumptions may not be correct any more. However, review of regulation may be complex.

13.4. Identification and description of RFID

Radio frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, e.g. for the purposes of automatic identification and tracking. RFID systems may use either battery assisted tags or batteryless tags. The tag contains electronically stored information which may be read and modified from up to several metres away. Unlike a bar code, the tag does not need to be within line of sight of the interrogator and may be embedded in the tracked object.

The characteristics of RFID are very different from conventional SRDs. There is a great difference between the power transmitted by the interrogator and the response from the tag. To optimise RFID system performance, the downlink and uplink should preferably operate in different channels. This led to the development of the channel plans, which permit many interrogators to operate in close proximity. The characteristics of this spectrum usage may qualify RFID as a spectrum usage type of its own.

The main economic advantages of harmonisation will be that RFID systems in Europe operating within the worldwide harmonised frequency tuning range would allow improved performance and simplified handling of international shipments of tagged items. This may lead to improved deliveries, reduced costs for the manufacture, installation and maintenance of interrogators, reduction of running expenses, improvement of stock management and logistic flows and overall better customer service.

13.5. Key requirements for RFID

- Match global performance in terms of robustness, reading distance and reading speed;
- Sufficient capacity to enable the operation of many RFID readers in close proximity;
- Ranges up to 3m (up to 5-30 metres for battery assisted tags), with predictable interference environment may be required;
- Ideally if additional spectrum is required for RFID the frequency band(s) should be globally harmonised.

13.6. Conclusions concerning IoT (including M2M) and RFID

The RSPG considers that this sector can put forward their spectrum needs via the ETSI-CEPT process.

A large development is foreseen within the sector of IoT and M2M, with potential of a large growth and contribution in socio economic benefits. The typical requirement on low power and low duty cycle makes many applications suitable for non-specific SRD frequency bands. Other applications where for example longer range end-to-end connectivity is required may use commercial mobile networks, and many mobile operators are already offering services for M2M communications and control.

The predicted growth of IoT/M2M applications would put pressure on the use of existing SRD bands, especially in frequency bands below 1 GHz. The need for a predictable sharing environment and also the need to find more efficient spectrum sharing solutions for some IoT applications has already led to investigations in the CEPT on more sophisticated technology and application-neutral spectrum access and mitigation techniques. Any evolution of SRD regulation shall be carefully consider results of sharing studies.

The RSPG sees large advantages in a European harmonisation that allows that RFID systems in Europe operate within the worldwide harmonised frequency tuning ranges for RFID, using the same technical regulations on for example maximum allowed emission levels. This would lead to improved performance, and allow for simplified handling of international shipments of tagged items.

14. Aeronautical and maritime communications

14.1. Introduction

EU Transport policy covers the full range of transportation and travelling within the EU, which includes the use of various radio communication systems for aeronautical and maritime communication as well as the European satellite navigation system, Galileo, to foster clean, safe and efficient travel throughout Europe (see Chapter 5).

Due to the nature of aeronautical and maritime services dependent on international harmonisation, a global allocation of radio spectrum is a legitimate and recognised goal. Global allocations of radio spectrum are agreed at the ITU-R[40] World Radiocommunication Conferences (WRC) and incorporated in the Radio Regulations, an international treaty on the use of the radio spectrum.

Over 90% of world trade is transported by sea. This totals some 7.5 billion tonnes, of which about 33% is oil, 27% is bulk (ore, coal, grain and phosphates), the remaining 40% being general cargo. Operating these merchant ships generates an estimated annual income of $380 billion in freight rates within the global economy, amounting to 5% of total world trade[41].

14.2. Identification and description of aeronautical communications

In the aeronautical transport sector spectrum is being used extensively for ground and airborne radars and for navigational aids. Moreover, spectrum is also used for communication purposes (voice and data communications) and for satellite communications. Safety is a recognised priority for aviation and its systems are developed and used in accordance with international obligations and standards under the ITU and ICAO[42]. The high integrity of these systems must be maintained and harmful interference cannot be accepted. This sector requires various ranges of frequency bands to ensure a safe operation of air traffic services supporting safety and regularity of flights.

The EU Single Sky policy has major spectrum implications through the European project SESAR (Single European Sky ATM Research). SESAR aims to develop the next generation air traffic management system which will be capable of ensuring the safety and fluidity of air transport over the next 30 years.

WRC-12 ensured sufficient spectrum for the aeronautical mobile service, as identified at that time, through the timely introduction of more spectrum-efficient technologies by preserving the decisions of WRC-07. Ground data-links are already planned under the SESAR project in the bands allocated to aeronautical mobile at WRC-07 in the 1 GHz and 5 GHz range. This project will also benefit from the services provided by the Galileo system for which the spectrum resources were also secured at the WRC-12. The result of the WRC-12 agenda item 1.7 supports the SESAR project ensuring the relevant spectrum resources are available for the operation of the satellite component in the bands 1545-1555 MHz and 1646.5-1656.5 MHz. The coordination process for satellites providing safety aeronautical mobile-satellite service in the bands 1545-1555 MHz and 1646.5-1656.5 MHz should ensure the long-term availability of an appropriate amount of spectrum in the required timeframe for the proposed aeronautical (R) mobile satellite systems.

WRC-12, in the frame of the agenda item 1.3, allocated the frequency band 5 030-5 091 MHz to the aeronautical mobile (R) service limited to internationally standardised aeronautical systems, in

[40] International Telecommunication Union
[41] Joint IMO/ITU experts group on maritime radiocommunication matters, October 2012
[42] International Civil Aviation Organisation

complement to the existing allocation for aeronautical mobile-satellite (R) service. These allocations are foreseen for the implementation of unmanned aircraft command and control systems for Unmanned Aeronautical System (UAS) to fly in the non-segregated airspace. The issue of UAS using the Fixed-Satellite Service will be studied further in the WRC-15 preparation (agenda item 1.5).

The band 5 091-5 150 MHz is allocated to the ARNS on a primary basis and is to be used for the operation of the international standard system (microwave landing system) for precision approach and landing. Footnote No.5.444A of the Radio Regulations article 5 permits use of the band 5 091-5 150 MHz by FSS feeder links subject to the requirements of No. 5.444 to protect microwave landing systems (MLS) operating in ARNS. WRC-15 agenda Item 1.7 will review the use of the band 5 091-5 150 MHz by the fixed-satellite service (Earth-to-space) (limited to feeder links of the non-geostationary mobile-satellite systems in the mobile-satellite service) in accordance with Resolution 114.

The band 5 091-5 150 MHz is also allocated to the AMS limited to systems operating in the AM(R)S and in accordance with international aeronautical standards limited to surface applications at airports and aeronautical telemetry transmissions from aircraft stations. Air transport companies and aircraft manufacturers are also seeking to decrease the number and significance of incidents causing damage to aircraft when they are on the ground, e.g. during taxiing. To reach this objective, industry intends to use anti-collision radars operating in the 80 GHz range.

The RSPG notes that WRC-15 Agenda Item 1.17 is to consider allocations and regulatory provisions for Wireless Avionics Intra-Communications (WAIC). This is intended to bring benefits to aviation in terms of weight saving on aircraft, which in turn brings environmental benefits, and also potential safety benefits. Aircraft have an obvious need to be able to operate globally and cross national borders and a WRC decision will support this. The issue will be further discussed in the RSPG WRC preparation activity.

14.3. Identification and description of maritime communications

In the maritime transport sector spectrum is used for communication purposes (voice and data communications), for satellite communications and for navigational aids. Due to the nature of the service, the spectrum requirements need to be addressed also globally and identified in the ITU Radio Regulations (e.g. Appendix 18). Moreover, spectrum is also being used extensively for ground and ship radars. The high integrity of these systems must be maintained and harmful interference cannot be accepted.

The RSPG notes that WRC-15 agenda item 1.15 is to consider the possible improvement and expansion of on-board communication stations in the maritime mobile service in the UHF bands in accordance with Resolution 358 (WRC 12). The importance of on-board communications to safe ship operations is fully recognised, together with the congestion in some geographical area. UHF on board communications is much used on board ships, including on-board emergencies, fire fighting, berthing, passenger control, etc. However studies show that a more efficient usage of the existing frequencies could be achieved with the systematic utilisation of 12.5 kHz bandwidth for all the channels identified in the RR (N° 5.287) for on-board communications. Therefore the identification of new frequencies for on-board communications in UHF is not justified. The technology is currently limited to FM by Recommendation ITU-R M.1174-2, which is found to be very robust in operations in metal ships. IMT is also permitted to use this frequency band under footnote 5.286AA. This could be a future source of interference.

The RSPG notes that the WRC-15 Agenda Item 1.16 is to consider regulatory provisions and possible new allocation(s) to facilitate new Automatic Identification System (AIS) technology for both satellite and terrestrial applications. The issue will be further discussed in the RSPG WRC-15 preparation activity.

The RSPG notes that WRC-15 agenda item 1.8 provides for a review of the regulatory arrangements introduced at WRC-03 for Earth Stations on Vessels (ESVs) which operate in fixed-satellite service networks in the uplink bands 5 925-6 425 MHz and 14.0-14.5 GHz.

The RSPG notes that WRC-15 agenda item 1.1 is to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution 233 (WRC 12). It has to be noted that the following frequency bands is of particular concern to the maritime community:

- 1518-1559 MHz in use for satellite terminals on board SOLAS ships;
- 1626.5-1660.5 MHz in use for satellite terminals on board SOLAS ships;
- 1559-1610 MHz in use for RNSS;
- 2900-3100 MHz in use for Maritime radionavigation (S-band radar); and
- 3400-4200 MHz partly in use for feeder links of Inmarsat.

The S-band radar is of particular importance for safety of navigation (safety of life service) and for use in adverse weather conditions, for instance heavy rain. Previous ITU-R studies on sharing with the band 2900-3100 MHz are no longer valid, because new generation equipment had not been taken into account.

The RSPG notes that WRC-15 agenda item 1.12 is to consider an extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9 300-9 900 MHz by up to 600 MHz within the frequency bands 8 700-9 300 MHz and/or 9 900-10 500 MHz, in accordance with Resolution 651 (WRC 12). Over one million marine radars operate in the frequency band 9200-9500 MHz. The GMDSS Radar Search and Rescue Transponders (Radar SART) operates also in this frequency band which is included in Appendix 15 of the Radio Regulations, listing the frequencies for distress and safety communications for the GMDSS. Protection of the maritime radionavigation service, operating in the frequency band 9 200-9 500 MHz and used by safety service systems in accordance with Nos. 1.59 and 4.10, should be ensured.

For WRC-18, a discussion is foreseen on additional demand for improved navigation (GMDSS modernisation/e-navigation) as set out in Resolution 359 with the support of the IMO (International Maritime Organisation).

14.4. Conclusions concerning Maritime communications

Due to the global nature of aeronautical and maritime communications future spectrum needs will be addressed through the WRC process. The RSPG highlights the importance of continuing to develop a SESAR spectrum strategy in cooperation with Member States.

15. Professional mobile radio (PMR)

15.1. Description

Professional mobile radio (PMR) is part of the land mobile service based on the use of simplex, half and full duplex modes at the terminal level in order to provide closed user group communications.

PMR can be either:

- traditional, self-provided and self-owned by business users small area networks;
  - Example: network in an industrial plant;

or

- tightly controlled closed user groups:
  - Can either be outsourced, or can be owned by a dominant user who allows other related user groups to use the network;
  - Example: closed network of inter-related municipal organisations such as utility, public transportation, water supply and road maintenance.

Typical PMR systems can be described as follows:

- On-site (single, two and/or multi-frequency systems) systems for voice, voice and data or data only. They are typically used to provide communications with personnel on the move within the organisation's premises. These systems can be linked into a telephone system managed by an organisation (sometimes completed by other wireless devices). The range is less than 1-3 km, typically a few hundred meters;
- Wide area, encompassing systems with a range of more than 1 km to regional or national coverage;
- Voice is used in majority but data is increasing.

PMR networks, systems, equipment can be used in either in a business or governmental context.

At this stage those networks/systems/ on site usage could be digital but also numbers of them are still using analogue transmissions which are less efficient in terms of spectrum usage. The amortisation of such equipment may largely differ depending on the sector of usage. Some equipment is staying in operation more than 15 years and there are little benefits for the users to migrate to more efficient technology.

15.2. Expected evolution

At the end of 2012, one of the member states ran a public consultation on the future of PMR and on spectrum requirements in particular in the context of the evolution of networks for high data rate. This consultation was responded to by many very large industry players which triggered our attention. The consultation underlined the importance to have sufficient spectrum resources, in particular to satisfy future needs for broadband PMR : new uses of data transmissions, as for example the transmission of videos, the acquisition of data of industrial systems or means of transportation (trains, planes), the real time division(sharing) of files and the management of crisis situations. LTE technology is identified to satisfy their future needs for broadband PMR in additional frequency bands.

The current spectrum efficiency for analogue PMR is one channel in 25 kHz or 12.5 kHz, while new digital technologies provide a two-fold to four-fold increase to 6.25 kHz equivalent spectrum efficiency such as the technologies standardised in ETSI, e.g. TETRA25, Digital mobile radio (DMR), dPMR. However there is no pressure on users to replace their less efficient equipment. CEPT ECC revised the ECC Decision for narrowband digital PMR/PAMR applications (ECC/DEC/(06)06). During its work ECC considered the introduction of a minimum efficiency threshold similar to the USA, where the FCC issued a narrowband mandate and does only provide new PMR licenses or renewals, if equipment supports a minimum spectral efficiency. However the group concluded that it was up to individual Member State to encourage spectrum efficiency and decide how to deal with legacy systems on a national basis.

The industry estimate for digital market share is around 30–40%.The industry estimate for 2013 for percentage of digital sales is 70%. Experience so far with DMR suggests that users use the extra capacity to improve operations (e.g. introduction of data, mainly short messages), so the increased spectrum efficiency does not materialise. In time, as more systems move to digital, the benefit is more likely to materialise. The RSPG do not identify demand for additional spectrum for narrow band PMR.

The revised ECC/DEC/(06)06 considers that administrations may introduce a minimum spectrum efficiency requirement for narrowband PMR/PAMR equipment when so required in a country. This may be especially the case in metropolitan areas and for the 400 MHz PMR/PAMR frequency bands.

Current technological development to provide PPDR services are triggering some work within 3GPP on how LTE could support some PMR features such as the group call etc. Some of the current documents on the subject are:

- TS GCSE-LTE (Technical Spec Group Communication System Enablers LTE) : 3GPP TS 22.468 V12.0.0 (2013-06)
- TS Release 12 Evolutions, including requirements for ProSe (Proximity Services) : 3GPP TS 22.278 V12.3.0 (2013-06)

It is expected that several PMR users will continue to operate existing systems which provide services and service-related features that are required to meet the needs of professional users such as Direct mode operation (DMO), group calls, fast call set-up with guaranteed access to resources and control of coverage available on these PMR networks, but there is a stated market requirement for more sophisticated PMR services that require digital technologies and high-speed data services.

Nevertheless the evolution of technologies is expected to follow the general evolution in the radio communication sector. In general, there is a trend toward mobile usage of services that require access to data high or very high speed, driven by increased use of services image and video applications to consume more bandwidth, such as video surveillance, real-time video, fast exchange of large files (including the exchange of medical information for remote intervention) and access to databases.

LTE seems to be a technology that can evolve to meet all or part of PMR needs with channel bandwidths of e.g. 1.4 MHz, 3 MHz, 5 MHz or 10 MHz.

15.3. Spectrum needs[43]

The results of the public consultation mentioned in 15.2 did not provide sufficient information to define accurately the amount of spectrum needed to satisfy – this does therefore requires a thorough assessment of all functional needs of users - although some contributors suggest an overall estimate of about 2 x 10 MHz duplex for the purposes of PMR. Additional work has been started by the relevant member state to identify the amount of spectrum needed. It is therefore too early to indicate an

[43] See Annex 2 on Regulatory framework

accurate value, however, it is recommended to monitor this area as other current activities could impact of be impacted.

We note for example that the use of the 400 MHz band (between 380 and 470 MHz) is subject to harmonising provisions at CEPT level, larger than the EU, for the implementation of PMR with channel bandwidth up to 1.25 MHz:

- The frequency bands 410-430 MHz and 450-470 MHz are identified by ECC Decision (04) 06 amended, in which administrations are encouraged to make available, depending on market demand, the amount of spectrum required for digital PMR systems.
- The band 380-470 MHz is identified by ECC Decision (08)05 for the harmonised implementation of digital systems for PPDR applications with channel bandwidths ranging from 25 kHz to 1.25 MHz.

When looking at the future spectrum demand to meet the needs for new PMR services for high and very high data transfer, it should be taken into account the fact that these bands are, in general, highly used by analogue or digital narrowband PMR networks and thus reducing the possibility of deploying broadband PMR networks with larger bandwidths, e.g. 5 MHz or 10 MHz duplex.

ECC/DEC/(04)06 also identifies the frequency range 870-876/ 915-921 MHz for PMR/PAMR. This frequency range is however under-utilised for Professional Mobile Radio (PMR) due to several aspects (duplex gap of the 900 MHz mobile services for GSM900, EGSM900, UMTS and LTE, limited capacity and bandwidth for PMR cellular networks) with almost no PMR specification/implementation available. A limited number of Member States have plans for a GSM-R extension in this upper part of this duplex band. In some areas, PMR spectrum is densely used and any evolution of PMR may raise refarming issues at national level in particular when shifting from analogue to digital transmissions.

In May 2013 one Member State published the results of a public national consultation on broadband PMR, receiving 24 contributions from industry and PMR user groups. The consultation underlined the importance to have sufficient spectrum resources, in particular to satisfy future needs for broadband PMR.

15.4. Conclusions concerning PMR

The RSPG considers that:

a) A possible future evolution towards PMR broadband services would raise the need of availability of spectrum resources. However, before any technical concept has been presented for wideband PMR the RSPG finds it difficult at this stage to estimate any possible new spectrum needs or the future market demand for these applications. However, the development in this area should be closely monitored.
b) There are no indications that the bandwidth requirements of narrowband PMR sector will increase within the medium or long term future.
c) Some Member States have noticed a trend where PMR users are migrating to public mobile broadband systems. New functionality such as push-to-talk and group calls are introduced in future LTE-specifications (with PPDR as a main driving force) will probably further accelerate this migration when this functionality is available in public LTE networks.
d) In order to improve spectrum efficiency, and to promote migration from analogue to digital PMR, administrations may consider identification of a minimum required spectral efficiency to support the migration to digital, more spectrum efficient technology which will allow the creation of additional channel capacity within the same radio spectrum, and support more users. This also provides an opportunity to upgrade radio systems and improve

interoperability. Furthermore, based on available digital narrowband PMR/PAMR technology and the national needs, the administration may impose a minimum required spectral efficiency such as 6.25 kHz or 12.5 kHz.

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Annex 1: Glossary

CEPT	European Conference of Postal and Telecommunications Administrations
CPG	Conference Preparatory Group (of CEPT/ECC)
EC	European Commission
ECC	Electronic Communications Committee (of CEPT)
ECC PT1	ECC Project team 1 on IMT
ECO	European Communications Office
ECS	Electronic Communication Service
EESS	Earth Exploration Satellite Service
EFIS	ECO Frequency Information System
EGNOS	The European Geostationary Navigation Overlay Service
EGSM	Extended Global System for Mobile Communication
ENG/OB	Electronic News Gathering/Outside Broadcasting
ETSI	European Telecommunications Standards Institute
ESA	European Space Agency
EU	European Union
EUMETSAT	The European organisation for the exploitation of Meteorological Satellites
FSS	Fixed-satellite service
FCC	Federal Communications Commission
FM PT49	WG FM Project Team 49 (PPDR)
FM PT51	WG FM Project Team 51 (PMSE)
GMES	Global Monitoring for Environment and Security
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
GSM900	Global System for Mobile Communication in the 900 MHz range
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITS	Intelligent Transport System
ITU	International Telecommunication Union
ITU-D	International Telecommunication Union Development Sector
ITU-R	International Telecommunication Union Radiocommunication Sector
LSA	Licensed Shared Access
LTE	Long Term Evolution
M2M	Machine-to-Machine
MS	Mobile Service
MSS	Mobile-satellite service
NASA	US National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
PMR	Professional Mobile Radio
PAMR	Public Access Mobile Radio
PMSE	Programme Making and Special Events
PPDR	Public Protection and Disaster Relief
RFID	Radio Frequency Identification
RLAN	Radio Local Area Network
RNSS	Radionavigation-satellite service (RR)
RR	Radio Regulations
RSPG	Radio Spectrum Policy Group
RSPP	Radio Spectrum Policy Programme
SAB	Services Ancillary to Broadcasting

SAP	Services Ancillary to Programme Making
SE PT24	WG SE Project Team 24
SRD	Short Range Device
SRD/MG	WG FM Short Range Device Maintenance Group
TDD	Time Division Duplexing
TTT	Transport and Traffic Telematics
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
VHF	Very High Frequency
WAS	Wireless Access Systems
WBB	Wireless Broadband
WG FM	Working Group Frequency Management (of CEPT/ECC)
WG SE	Working Group Spectrum Engineering (of CEPT/ECC)
WiMAX	Worldwide Interoperability for Microwave Access
WMO	The World Meteorological Organization
WRC-12	World Radio Conference 2012
WRC-15	World Radio Conference 2015

Annex 2: Regulatory framework (non-exhaustive)

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
Galileo and EGNOS	Regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo) EC Standardisation Mandate (Space Mandate M/496)	Protection requirements of RNSS from terrestrial RNSS repeaters stipulated in (ECC Report 145, ECC/REC (10)02) and pseudolites (ECC Reports 128, 168, and 183 as well as ECC/REC/(11)08 for indoor PLs only.	RR 5.328A RR 5.328B RR 5.329 RR 5.329A RR 5.398 RR 5.398A RR 5.399 RR 5.443C Resolution 608 (WRC-03) Resolution 609 (Rev.WRC-07) Resolution 610 (WRC-03) Recommendations ITU-R M.1787-1, M.1902, M.1903, M.1904, M.1905, M.1906 Report ITU-R M.2220	Space-to-Earth (and space-to-space) 1164-1300 MHz 1559-1610 MHz 2483.5-2500 MHz 5010-5030 MHz Earth-to-space (and space-to-space) 1300-1350 MHz 5000-5010 MHz Search and rescue payloads on-aboard the Galileo satellites use the 406-406.1 MHz and 1544-1545 MHz bands that are internationally reserved for such applications (see RR Nos. 5.266, 5.267 and 5.356). Telecommand and telemetry of the Galileo satellites are performed in the 2025-2110 MHz / 2200-2290 MHz bands.	Review of No. 5.443C to ensure appropriate protection of RNSS receivers in the 5010-5030 MHz band
Intelligent transport management systems and automotive	Directive 2004/52/EC;	Rec 70-03 (Annex 5) ECC/REC/(08)01…ITS ECC/DEC/(08)01 ITS	Res 654	5795-5815 MHz (RTTT DSRC) 5855-5875 MHz (ITS) 5875-5925 MHz (ITS)	AI 1.18 considers a primary allocation of the band 77.5-78 GHz to the

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
applications	Decision 2008/671/EC 2011/485/EU amending Decision 2005/50/EC; Decision 2004/545/EC Decision 2011/829/EU amending Decision 2006/771/EC General framework for the deployment of Intelligent Transport Systems: Directive 2010/40/EU Standardisation mandate M/453 on corporative ITS	ECC/DEC/(04)10…SRR ECC/DEC/(04)10…SRR Rec 70-03 (Annex 5) ECC/DEC/(04)03…SRR ECC/DEC/(09)01…ITS Rec 70-03 (Annex 5)		21.65-26.65 GHz (SRR) 24.25–26.65 (SRR) 24.05-24.50 (automotive vehicle radars) 77-81 GHz (SRR) 63-64 GHz (ITS) 76-77 GHz (ITS)	radiolocation service to support automotive short-range high-resolution radar operations.
Global monitoring for environment and security (GMES)	COM(2012) 218[44] Regulation No 911/2010 of the European Parliament and of the Council of 22 September 2010 on the European Earth monitoring programme (GMES) and	ECC/DEC/(10)01 ECC/DEC/(11)01 ECC/DEC/(10)02 ECC/REC/(10)01	5.338A 5.340 Resolution 750 (WRC-07) Resolution 752 (WRC-07) Resolution 673	**Space component** Bands on-board the series of SENTINEL satellites *Active sensors bands* 5250 – 5570 MHz	WRC 15 AI 1.11 Protection of the sensors and data bands potentially affected under AI 1.1 (5 GHz), 1.6 (13 GHz). 1.9.2 (8 GHz) and

[44] Not a regulatory text but an Intergovernmental Agreement for the operation of the European Earth monitoring programme (GMES) from 2014 to 2020

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	**CEPT**	**ITU**		
	its initial operations (2011 to 2013)		(rev. WRC-12)	13.4-13.75 GHz *Passive sensors bands* 23.6 – 24 GHz 36 – 37 GHz (Optical sensors are also planned to be used on the SENTINEL satellites) Data gathered by the SENTINEL satellites are sent to ground stations using the 8025 – 8330 MHz band. Telecommand and telemetry of the SENTINEL satellites are perfomed in the 2025-2110 MHz / 2200-2290 MHz bands. TerraSAR: The TerraSAR satellite network consists out of two satellites (TerraSAR-X and TanDEM) each hosting a SAR sensor: 9500 – 9800 MHz. Data gathered by the satellites are sent to ground stations using the 8037.5 – 8262.5 MHz band. Telecommand and telemetry of the satellites are performed in the 2025-2110 MHz / 2200-2290 MHz bands. RapidEye: The satellite network	1.10 (24 GHz).

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				consists out of five satellites. Data gathered by the satellites are sent to ground stations using the 8120 – 8200 MHz band. Telecommand and telemetry of the satellites are performed in the 2025-2110 MHz / 2200-2290 MHz bands. The EnMAP will send the data gathered to ground stations using the 8025 - 8385 MHz band. Telecommand and telemetry of the satellite will be performed in the 2025-2110 MHz / 2200-2290 MHz bands.	
Smart energy grids and smart meters	To be covered in amended Decision 2006/771/EC Standardisation mandates: M/441 for utility meters; M/490 for smart grids	Rec 70-03 (Annex 2) Meter reading Rec 70-03 (Annex 1)		169.4 - 169.475 MHz 169.4-169.8125 MHz Non-specific SRD application, especially in 868 – 870 MHz for wireless metering used. GSM/GPRS (at 900 MHz) and PMR (at 450 MHz) also used. In the long term, other technologies such as UMTS, HSPA, LTE, DECT or RF meshed network solutions may also	ETSI TR 102-649-2 including Generic SRD ETSI TR 102 886 Sub-metering / smart meters and smart grids ETSI TR 103 055 Metropolitan Mesh Machine Networks (M3N) applications ECC Report 182.

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				be considered for some applications.	ECC Report 200 Studies on-going in CEPT (SRD/MG and SE PT24).
Safety services and public protection and disaster relief (PPDR)		ECC/DEC/(08)05 ECC/REC/(08)04 ECC/DEC/(06)05	Res 646 Res 648 ITU-R M.2033	380-385/390-395 MHz (for narrow band PPDR) Identification of a tuning range for wide band PPDR: 380-470 MHz 4940-4990 MHz and 5150-5250 MHz for temporary, local Broadband Disaster Relief actions 384.75 - 385.000 MHz and 394.750 - 395.000 MHz (air-ground-air)	See also agenda item 1.3 (WRC-15) to review and revise Resolution 646 (Rev.WRC 12) for broadband public protection and disaster relief (PPDR), in accordance with Resolution 648 (WRC 12); ECC Report 199 On-going work on broadband PPDR within CEPT (FM PT49)
Scientific research	RSPG06-144 RSPG Opinion on the Scientific Use of Spectrum	ECC/DEC/(11)01 ECC/DEC/(10)02 ECC/DEC/(10)01 Amended ECC/DEC/(09)02 for the protection of RAS from	RR 5.149 RR 5.340 RR 5.565	See RSPG Opinion, ITU RR, EFIS, etc 1610-1626.5 MHz and 2483.5-2500 MHz	WRC 15 AI 1.11 consider primary allocation for EESS (E-to-s) in the 7-8 GHz range 1.12 consider extension

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
		NGSO satellite systems		2500-2520 MHz (RR 5.410) MetAids 2025-2045 kHz (RR 5.104); 27.5-28 MHz: 153-154 MHz; 400.15-406 MHz; 1668.4-1700 MHz; 35.2-36 GHz; Space Research: 2501-2502 kHz; 5003-5005 kHz; 15005-15010 kHz; 18052-18068 kHz; 19990-19995 kHz; 25005-25010 kHz; 30.005-30.01 MHz; 39.986-40.02 MHz; 40.98-41.015 MHz; 137-138 MHz; 138-143.6 MHz (RR 5.210); 143.6-143.65 MHz; 143.65-144 MHz (RR 5.210); 258-261 MHz (RR 5.256A); 400.15-401 MHz; 410-420 MHz 449.75-450.25 MHz (RR 5.286); 2025-2120 MHz; 2200-2300 MHz; 5250-5255 MHz (RR 5.447D); 5650-5725 MHz; 7145-7235 MHz; 8400-8500 MHz; 12.75-13.25 GHz; 13.4-14.3 GHz; 14.4- 14.47 GHz; 14.5-15.35 GHz; 16.6-17.1 GHz; 22.55-23.15 GHz; 25.5-27 GHz; 25.25-27.5 GHz (RR 5.536); 31-31.3 GHz; 31.8-32.3 GHz; 34.2-35.2 GHz; 37-38	of the current worldwide EESS (active) allocation at 9.3-9.9 GHz by up to 600 MHz within the bands 8.7-9.3 GHz and/or 9.9-10.5 GHz

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				GHz; 40-40.5 GHz; 65-66 GHz; 74-86 GHz; Space Operations: 30.005-30.01 MHz sat. identification; 137-138 MHz; 148-149.9 MHz (RR 5.218); 258-261 MHz (RR 5.256A); 267-273 MHz; 400.15-402 MHz; 433.75-434.25 MHz (RR 5.281); 449.75-450.25 MHz (RR 5.286); 1427-1429 MHz; 1525-1535 MHz; 2025-2110 MHz; 2200-2290 MHz; 7100-7155 MHz (RR 5.459); 7190-7235 MHz (RR 5.459); Radio Astronomy (RR 5.149) 13360-13410 kHz; 25550-25670 kHz; 37.5-38.25 MHz; 73-74.6 MHz; 150.05-153 MHz; 322-328.6 MHz; 406.1-410 MHz; 1400-1427 MHz; 1610.6-1613.8 MHz; 1660-1670 MHz; 1718.8-1722.2 MHz (RR 5.385); 2655-2700 MHz; 4800-5000 MHz; 10.6-10.7 GHz; 14.47-14.5	

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				GHz; 15.35-15.4 GHz; 22.21-22.5 GHz; 23.6-24 GHz; 31.3-31.8 GHz; 42.5-43.5 GHz; 48.94-49.04 GHz (RR. 5.555); 51.4-54.25 GHz (RR 5.556); 58.2-59 GHz (RR 5.556); 64-65 GHz (RR 5.556); 76-116 GHz; 123-158.5 GHz; 164-167 GHz; 182-185 GHz; 200-231.5 GHz; 241-248 GHz; 248-275 GHz; Meteorlogical-satellite: 137-138 MHz; 400.15-403 MHz; 460-470 MHz; 1670-1710 MHz; 1770-1790 MHz (RR 5.387); 7450-7550 MHz; 7750-7850 MHz; 8175-8215 MHz; 9975-10025 MHz (RR 5.479); 18.1-18.4 GHz (RR 5.519); Earth Exploration-satellite 401-403 MHz; 460-470 MHz (RR 5.289); 1690-1710 MHz (RR 5.289); 1525-1535 MHz; 2025-2110 MHz; 2200-2290 MHz; 8025-8400 MHz; 13.75-14 GHz; 25.25-27.5 GHz (RR 5.536); 25.5-27 GHz; 28.5-30 GHz; 37.5-40 GHz; 40-40.5 GHz; 65-66 GHz; Earth Exploration-satellite (active)	

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				432-438 MHz; 1215-1300 MHz; 3100-3300 MHz; 5250-5570 MHz; 8550-8650 MHz; 9300-9900 MHz; 13.25-13.75 GHz; 17.2-17.3 GHz; 24.05-24.25 GHz; 35.5-36 GHz; 78-79 GHz (RR 5.560); 94-94.1 GHz; 133.5-134 GHz (RR 5.562E); 237.9-238 GHz (RR 5.563B); Space Research (active) 1215-1300 MHz; 3100-3300 MHz; 5250-5570 MHz; 8550-8650 MHz; 9300-9900 MHz; 13.25-13.75 GHz; 17.2-17.3 GHz; 35.5-36 GHz; 78-79 GHz (RR 5.560); 94-94.1 GHz; 237.9-238 GHz (RR 5.563B); Earth Exploration-satellite (passive)/ Space Research (passive) 1370-1400 MHz (RR 5.338A); 1400-1427 MHz; 2640-2655 MHz (RR 5.338A); 4950-4990 MHz (RR 5.338A); 15.20-15.35 GHz (RR 5.338A); 1660.5-1668.4 MHz; 2655-2700 MHz; 4200-4400 MHz (RR 5.438); 4990-5000 MHz; 6425-7025 MHz (RR 5.458); 7075-7250 MHz (RR 5.458); 10.6-10.7 GHz; 15.35-	

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
				15.4 GHz; 18.6-18.8 GHz; 21.2-21.4 GHz; 22.21-22.5 GHz; 23.6-24 GHz; 31.3-31.8 GHz; 36-37 GHz; 50.2-50.4 GHz; 52.6-59.3 GHz; 86-92 GHz; 100-102 GHz; 105-122.25 GHz; 148.5-151.5 GHz; 155.5-158.5 GHz (RR 5.562F); 164-167 GHz; 174.8-191.8 GHz; 200-209 GHz; 217-231.5 GHz; 235-238 GHz; 250-252 GHz;	
Programme making and special events (PMSE)	EC Mandate PMSE	ERC/REC 25-10 ERC/REC/70-03 (Annex 10)	Report ITU-R BT.2069	See Annex 2 of ERC/REC 25-10	WRC 15 AI 1.2 On-going work on PMSE within CEPT (FM PT51 and SE PT7)
The Internet of things including RFIDs	Decision 2011/829/EU amending Decision 2006/771/EC; Decision 2006/804/EC; Decision 2010/368/EU Decision 2009/381/EC Decision 2009/812/EC	Rec 70-03 (in particular Annexes 1, 3, 9 and 11)	RR 5.138 RR 5.150	119-135 kHz 400-600 kHz 13.553-13.567 MHz 433.05-434.79 MHz 865-868 MHz 2400-2483.5 MHz / 2446-2454 MHz (the above are the six major used RFID frequencies, other frequency opportunities as in Rec. 70-03, e.g. under non-specific applications do also exist).	ETSI TR 102 649-2 Additional demand for UHF RFID under study in CEPT (SRD/MG and SE PT24) ECC Report 200

Application	Regulatory Background (documents, regulations, etc)			Current Spectrum Allocations	Regulatory requirements
	EC	CEPT	ITU		
New AIS (Automatic Identification Systems) applications such as Man Overboard System			RR Appendix 18 Res 360	157.3375-157.4375 MHz paired with 161.9375-162.0125 MHz for experimentation	WRC-15 AI 1.16 to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC 12)

Annex 3: Spectrum information – Sentinel missions

	Spectrum information	
	Communication purposes	**Observation purposes**
Sentinel-1	Earth-Space link: S-Band (Band 2025-2110 MHz Central frequency: 2075.6504 MHz Bandwidth 768 kHz) Space-Earth link: S-Band (Band 2200-2290 MHz; Central frequency 2254.1 MHz Bandwidth 2.2 MHz), and X-Band (8025-8330 MHz, first 140-MHz channel at 8095 MHz, second 140-MHz channel at 8260 MHz)	Synthetic Aperture Radar (SAR) (C-Band, central frequency: 5.405 GHz, Bandwidth 90 MHz)
Sentinel-2	Earth-Space link: S-Band (Band 2025-2110 MHz Central frequency: 2075.6504 MHz Bandwidth 768 kHz) Space-Earth link: S-Band (Band 2200-2290 MHz; Central frequency 2254.1 MHz Bandwidth 2.2 MHz), and X-Band (8025-8330 MHz, first 140 MHz channel at 8095 MHz, second 140 MHz channel at 8260 MHz)	Multi Spectral Instrument (MSI) (13 spectral bands: 443 nm – 2190 nm)
Sentinel-3	Earth-Space link: S-Band (Band 2025-2110 MHz Central frequency: 2075.6504 MHz Bandwidth 768 kHz) Space-Earth link: S-Band (Band 2200-2290 MHz; Central frequency 2254.1 MHz Bandwidth 2.2 MHz), and X-Band (8025-8330 MHz, first 140 MHz channel at 8095 MHz, second 140 MHz channel at 8260 MHz)	Ocean and Land Colour Instrument (OLCI) Sea and Land Surface Temperature Radiometer (SLSTR) Synthetic Aperture Radar Altimeter (SRAL) Dual-band: C-band: 5250-5270 MHz (320 MHz BW) Ku-band: 13.4-13.75 GHz (350 MHz BW) MicroWave Radiometer (MWR) (dual 23.6-24 GHz / 36-37 GHz)
Sentinel-4 **Sentinel-5**		
Sentinel-5P (Precursor)	Earth-Space link: S-Band	No RF sensors

	(Band 2025-2110 MHz Central frequency: 2080.15 MHz Bandwidth 900 kHz) Space-Earth link: S-Band (Band 2200-2290 MHz; Central frequency 2259 MHz Bandwidth 2 MHz), and X-Band (8033-8267 MHz)	

Annex 4: Scientific services

The amount of spectrum used by scientific services represents a moderate part of the total amount of available spectrum. Exclusive use is exceptional and occurs only with passive services, in other cases the spectrum is shared with other services.

Meteorological aids services allocation represent, in primary status, a total number of 7 bands for a total bandwidth of around 83 MHz spread from 400 MHz to 2 GHz. Two bands are allocated to Meteorological aids (Metaids) where they are the only primary services according to the RR (403-406 MHz & 1690-1700 MHz). In addition to these two bands, the total overall allocation to Metaids represents about 38 MHz below 3 GHz. The band 401-403 MHz is also used for tracking of small animals by satellite (ARGOS). Animal tracking is a rapid evolving new application in the Earth exploration-satellite service with a demand of frequency bandwidth in the frequency region below 1 GHz to support very small transmitters and good propagation conditions.

Meteorological satellite (MetSat) service allocations between 137 MHz and 6 GHz are limited to 3 bands, namely 137 – 138 MHz, 400.15 – 403 MHz and 1675 – 1710 MHz which are used for dedicated meteorological satellite applications. In addition to the bands allocated to the Meteorological satellite service, MetSat satellites also have to use the bands 2025 – 2110 MHz and 2200 – 2290 MHz (allocated to the Space Operation Service and the Earth-Exploration Satellite Service (EESS)) for telemetry/telecommanding of the MetSat spacecraft as well as for re-uplinking of the processed meteorological data for later dissemination to the users in the band 1675 – 1710 MHz. However, few countries allocated part of the 3 bands allocated to the meteorological satellite service below 3 GHz to other services, sometimes even with a primary status. Other countries did not allocate some of the bands allocated to meteorological satellite services in the RR to any service and therefore this leads to the false impression that the bands are not used in these countries. This situation is due to the fact that the meteorological satellites are not operated by those individual countries, but by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), which is tasked to deliver weather and climate-related satellite data, images and products to its 26 member states and 5 cooperating states.

Twenty one bands are allocated to passive services (EESS, SRS & RAS) and are totally protected by RR.5.340 1 400-1 427 MHz, 2 690-2 700 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.5 GHz, 31.5-31.8 GHz for region 2, 48.94-49.04 GHz for space airborne, 50.2-50.4 GHz, 52.6-54.25 GHz, 86-92 GHz, 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz) (This represents about 42 GHz, 37 MHz in bands below 3 GHz and approximately 670 MHz in bands below 50.4 GHz. The largest bands of passive services are distributed above 50.4 GHz. Most of time, these bands are imposed and fixed by fundamental physic rules (or behaviour) and match with frequencies of atoms or molecules spectral line (H20, H, SiO, etc…). They allow the study of the environment and its evolution. For example, Earth Exploration Satellite (passive) investigates many of these frequencies and produces accurate measurements of surface ocean salinity and soil moisture. Passive remote sensing of the Earth’s surface and atmosphere has an essential and increasing importance in operational and research meteorology, in particular for mitigation of weather and climate related disasters, and in the scientific understanding, monitoring and prediction of climate change and its impacts. The impressive progress made in recent years in weather and climate analysis and forecasts, including warnings for dangerous weather phenomena (heavy rain, storms, cyclones) that affect all populations and economies, is to a great extent attributable to passive band observations and their assimilation in numerical models. In this case, these bands totally preserve their usefulness especially in the context of actual climate change. No allocation to active services can be done in these bands for several reasons:

- The studied phenomenon present very weak signal and require very sensitive sensor to guarantee a perfect listening of "environmental noise". The passive nature of these services cannot support any man made noise resulting from active services.
- Observations have to be done in a permanent way to ensure accurate scientific statistical model and efficient results.

Although all emissions are prohibited in these bands, the usage of at least one passive frequency band (e.g., on SMOS see E.Daganzo et al. "Characterisation of SMOS RF interferences in the 1400-1427 MHz band as detected during the commissioning phase" in REE n°4-2011 pp. 18-29) has revealed that the retrieved data suffers from radio frequency interferences (RFI) causing unacceptable measurement performance degradation. Any evolution of usage in adjacent bands to 1400-1427 MHz implies careful coexistence studies to ensure that this band remains fully operational for passive services as it is today. The case of the frequency band 23.6-24 GHz which is temporarily allocated to Short Range Radars (SRR) in national allocation tables according to the EC Decision and despite footnote 5.340, is an example not to be followed. As indicated above some exceptions can be seen in the list of bands and some countries did not allocate some of the bands allocated to passive services according to the Radio Regulations (RR) to any services and therefore the bands appear as being not used.

On earth to space data transmission bands, few bands are allocated to scientific services according to the RR. Prominent bands are the 2025-2110 MHz band for EESS, SRS (near Earth) and SOS and 2110-2120 MHz for SRS (deep-space). Both bands are heavily used for telecommanding satellites. Other bands such as 401-403 MHz are used to retrieve tracking data from animals. One additional band in the 7-8 GHz range may be allocated to the EESS as a result of the agenda item 1.11 of WRC-15. These bands represent about 85 MHz below 3 GHz. The bands allocated to this service are generally shared, on a co-primary basis, with fixed service, mobile service (with the restriction given in RR footnote 5.391 for 2025-2110 and 2200-2290 MHz) and, in one case, with radiolocation service (34.2-34.7 GHz).

On space to earth data transmission bands (for example, 2200 – 2290 MHz (EESS, SRS, SOS), 2290-2300 MHz (SRS deep space), 7750 – 7900 MHz (MetSat), 8025 – 8400 MHz (EESS) and 25.5 – 27 GHz (EESS)), no band is exclusively allocated to this service according to the RR. The bands allocated to this service are generally shared with fixed and mobile services which have the same primary status and the operation without interference is controlled by coordination and mitigation techniques.

Concerning space active sensors bands, the bands allocated to this service according to the RR are shared with radio-navigation and radiolocation. These bands have largely demonstrated their usefulness for meteorology, climate change, earth observation, monitoring of catastrophic events and natural disasters mostly.

On ground based sensor bands no band is exclusively allocated to this service according to the RR. The bands are shared with EESS-RAS-SRS only, with the exception of the band 23.6-24 GHz which is temporarily designed to SRR.

From the above it appears globally that about 160 MHz is exclusively allocated to scientific services on a primary basis between 300 MHz and 3 GHz and other 215 MHz in this range is shared with other services (usually Mobile and Fixed Services).

The Radio Astronomy Service strongly depends on the exclusive, so called “passive” bands for extremely sensitive observations. Allocated on a primary basis to this his service uses about 50 bands from 13 MHz up to 275 GHz for a total bandwidth about 150 GHz. However, by far the largest bandwidths appear above 20 GHz, and below this frequency, the spectrum allocated to the Radio Astronomy Service represents less than 200 MHz bandwidth in total. Most of these bands are shared with others passive scientific services (SRS and EESS – see above) and 21 are protected by RR Footnote 5.340, which prohibits all emissions in these bands. An example is the 1 400-1 427 MHz passive band , which is the most intensely used RAS band, in all ITU-R Regions for radio astronomy observation, whose mainly to make spectral line observations of ubiquitous cosmic neutral atomic hydrogen. This band is particularly useful for the study of the origins and evolution of universe. In addition, a number of RAS bands have a shared allocation with an active service, in which radio astronomical observations are only possible under controlled circumstances and using coordination procedures. RR Footnote 5.149 enumerates a further 49 spectral bands which are used for research by the RAS but shared with others operators and are under control of national administrations whom are urged to take all practicable steps to protect the Radio Astronomy Service in these bands.

Annex 5: Tuning ranges for SAB/SAP applications according to ERC Rec 25-10

Radio microphones and In-ear monitors	174-216 MHz 470-862 MHz 1785-1800 MHz
Portable audio links and Mobile audio links and Temporary point-to-point audio links	174-216 MHz 470-862 MHz
Cordless cameras	2025-2110/2200-2500 MHz 10.0-10.60 GHz 21.2-24.5 GHz 47.2-50.2 GHz
Portable video links	2025-2110/2200-2500 MHz 10.0-10.60 GHz
Mobile video links (airborne and vehicular)	2025-2110/2200-2500 MHz 3400-3600 MHz
Temporary point-to-point video links	Fixed service bands 10.0-10.68 GHz 21.2-24.5 GHz

Annex 6: Typical operational set-ups for some broadcasting activities

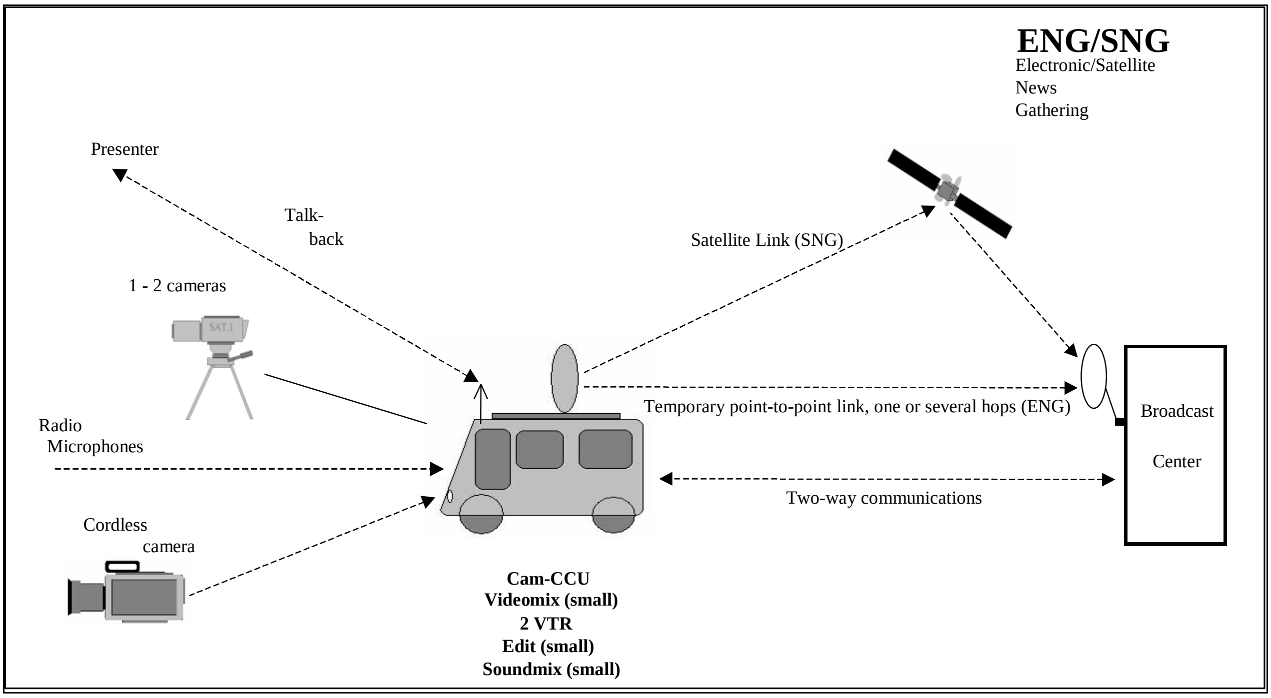

Figure 1: Typical set-up of ENG operations

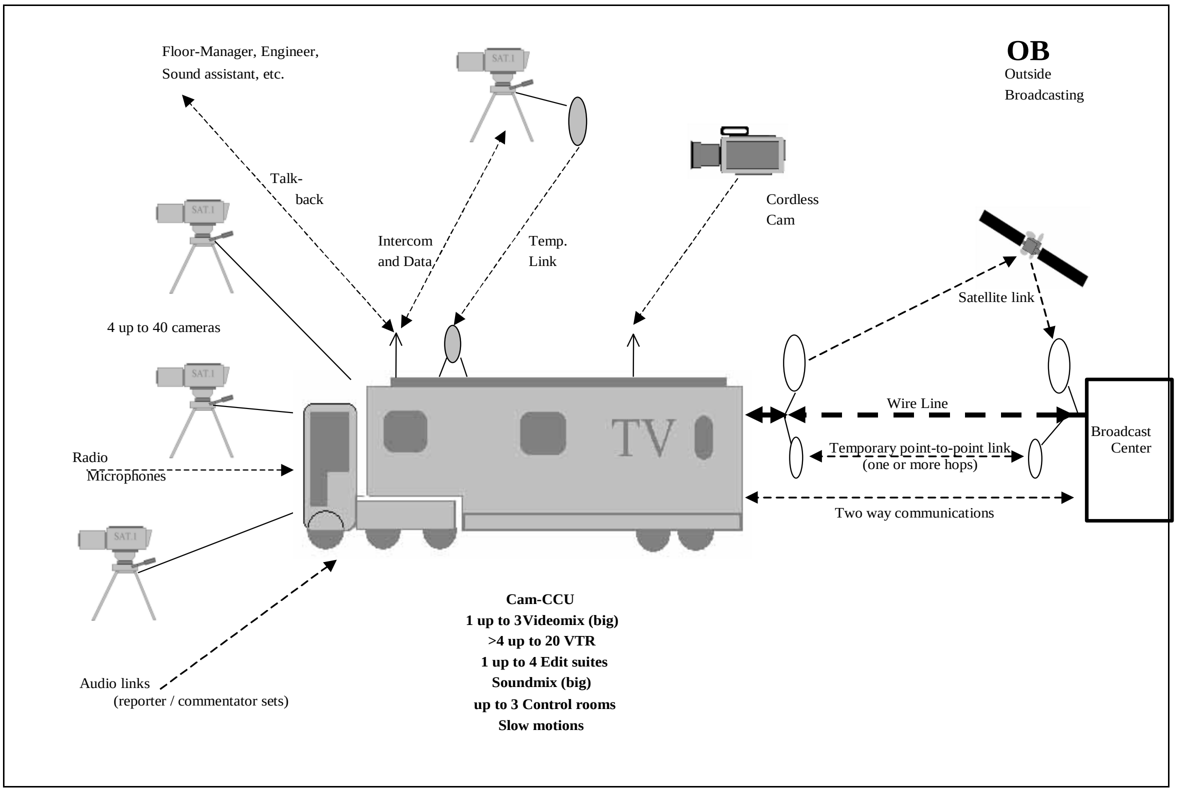

Figure 2: Typical set-up of OB operations

Annex 7: Technical parameters for various PMSE applications

Radio microphones and In-ear monitors	(174-216 MHz) 470-862 MHz 1785-1805 MHz	200 kHz / 50 mW 200 kHz / 50 mW 600 kHz / 50 mW
Portable audio links, Mobile audio links and Temporary point-to-point audio links	174-216 MHz 470-862 MHz	300 kHz / 250 W 300 kHz / 250 W
Cordless cameras	2025-2110 MHz 2200-2500 MHz	20 MHz / 500 W, up to 20 W
Portable video links	2025-2110 MHz 2200-2500 MHz	20 MHz / 500 W, up to 20 W
Mobile video links (airborne and vehicular)	2025-2110 MHz 2200-2500 MHz 3400-3600 MHz	20 MHz / 500 W, up to 20 W

Annex 8: PMSE spectrum requirements

ECC report 002 was published in 2002 and the estimated amount of spectrum needed for different kinds of PMSE equipment and different scenarios is presented in the table below (note that the data provided might be outdated and is currently under revision by FM PT51):

Type of Link	Typical Range	Radio Link Path	Recommended Tuning Ranges	Channel requirement estimates for different activity sectors/events		
				ENG, for major urban area	Casual OB, e.g. football match[2]	OB at major annual events[3]
Cordless Camera	<500 m	Usually clear line of sight, but might be susceptible to multipath impairment	2-2.5 or 2.7-2.9 GHz[4] 10.0-10.68 GHz 21.2-24.5 GHz 47.2-50.2 GHz	**Now:** (2…5) x 20 MHz ch. **In 10 years:** (10…15) x 10 MHz ch.	**Now:** (1…5) x 20 MHz ch. **In 10 years:** (8…10) x 10 MHz ch.	**Now:** (5…10) x 20 MHz ch. **In 10 years:** (10…20) x 10 MHz ch.
Portable Link	<2 km	Normally, but not always clear line of sight.	2-2.5 GHz 10.0-10.68 GHz			
Mobile Airborne	< 50 km	Normally, but not always clear line of sight.	2-2.5 GHz 3.4-3.6 GHz			
Mobile Vehicular	< 10 km	Often obstructed and susceptible to multipath impairment.	2-2.5 GHz 3.4-3.6 GHz			
Temporary Point-to-point links	< 80km per hop	Usually clear line of sight for OB, but often obstructed for ENG use.	7 GHz, 8 GHz bands 10.0-10.68 GHz 21.2-24.5 GHz	**Now:** (2…5) x 20/28 MHz **In 10 years:** (10…15) x 8/10 MHz	**Now:** (1…2) x 20/28 MHz **In 10 years:** (3…5) x 14/28 MHz	**Now:** (2…5) x 20/28 MHz **In 10 years:** (10…15) x 14/28 MHz

Table 4 : Classification and service requirements of video SAP/SAB links[1]

Type of Link	Typical Range	Recommended Tuning Ranges	Channel requirement estimates for different activity sectors/events							
			TV/radio news (ENG), major urban area		Casual OB, e.g. football match[2]		Theatres and touring shows		OB at major annual event[3]	
			Now	In 10 years	Now	In 10 years	Now	In 10 years	Now	In 10 years
In-ear monitors	<100 m	174-216 MHz 470-862 MHz 1785-1800 MHz	10…15 ch.	15…30 ch.	1…5 ch.	5…10 ch.	45…55 ch.	45…55 ch.	20…80 ch.	20…80 ch.
Professional radio micro-phones	<100 m									
Portable audio links	<2 km	VHF/UHF bands[5]	3…5 ch.	5…10 ch.	1…5 ch.	5…10 ch.	2…5 ch.	5…10 ch.	10…20 ch.	10…20 ch.
Mobile (incl. airborne) audio links	<20 (50) km	VHF/UHF bands[5]	3…5 ch.	5…10 ch.	3…5 ch.	5…10 ch.	Not applicable		5…10 ch.	5…10 ch.
Temporary Point-to-point links	<50 km per hop	VHF/UHF bands[5]	1…5 ch.	3…5 ch.	1…3 ch.	2…5 ch.	Not applicable		5…10 ch.	5…10 ch.

Table 5 : Classification and service requirements of audio SAP/SAB links[1]

Note[1]: for further technical characteristics (powers, antenna gains, etc.) refer to ERC Report 38 (video links) or ERC Report 42 (audio links)
Note[2]: Channel estimates for casual OB operations are given per routine event/single broadcaster
Note[3]: Major annual event means typical recurring special event, like annual marathons, races, major stage shows (Eurovision Song Contest), etc.
Note[4]: The final decision awaits results of sharing studies in the band 2.7-2.9 GHz
Note[5]: Depending on application scenario, channel width and required transmitter power, portable, mobile and temporary point-to-point audio links may be accommodated either in SAP/SAB bands or in other VHF/UHF bands, including the Private Mobile Radio (PMR) bands

Annex 9: Suitability of frequency bands for the (short term) use of cordless cameras and video links in Germany

The following table provides information on the current usability of frequency ranges for cordless cameras/video links in Germany. Most of the bands have not been addressed in the response to the FM51 questionnaire since they are not allocated to cordless cameras in the German frequency allocation table and/or the usage is only possible on a short term basis and subject to the approval of the assigned users of the bands.

The frequency ranges categorised as most suitable for cordless camera usage (taking into account the conditions in the "Remarks" column), less suitable and the ones that cannot be used. The marked cell indicates the core band for cordless cameras in Germany. Although this application has also a primary allocation in 1980-2010 MHz, 2170-2200 MHz, 2400-2483.5 MHz and 3400-3600 MHz, the core band is the only frequency range where cordless cameras can be used without prior coordination with other applications and on a long term basis.

It should be noted that the high spectrum requirement usually is limited to major events (particular place and a particular time).

Frequency Range (options of use for wireless cameras)	**Remarks**
1900 - 1920 MHz (most suitable)	unpaired For short term use with the approval of the mobile operators
1920 -1980 MHz(not suitable)	used by: MS uplink(UMTS)
1980 - 2010 MHz (most suitable) primary allocation	preferably for indoor cameras Short term frequency assignments for digital wireless cameras are possible until the effective operation of the MSS starts
2010 - 2025 MHz (most suitable)	unpaired For short term use with the approval of the mobile operators
2025 - 2110 MHz (most suitable)	For short term use with the approval of the military

2110 – 2170 MHz (not suitable)	used by: MS downlink (UMTS)
2170 - 2200 MHz (most suitable) primary allocation	preferably for indoor cameras Short term frequency assignments for digital wireless cameras are possible until the effective operation of the MSS starts
2200 - 2300 MHz (most suitable)	For short term use possible for cameras outside the geographical areas of the earth stations (uplink) also used by: Earth observation (uplink), military applications, Space telecontrol (uplink), space research (uplink)
2300 - 2320 MHz	For short term use. Preferably for indoor cameras used by: airborne telemetry
2320 - 2400 MHz (most suitable) primary allocation 2320 – 2350 MHz (most suitable) 2333 – 2350 MHz (most suitable) *2347 – 2385 MHz (PPDR)* (most suitable) 2384 – 2400 MHz (most suitable)	“core band” for wireless cameras in Germany that can be used without prior coordination with other applications and on a long term basis.
2400 - 2483,5 MHz (most suitable) 2400 – 2450 MHz (most suitable) 2450 – 2483,5 MHz (most suitable) primary allocation	The band can be used on a long term basis but is also (heavily) used by: WLAN, Telecontrol, SRDs, RFIDs, amateur radio, military applications
2483,5 - 2500 MHz (most suitable)	For short term use. Preferably for indoor cameras

	used by: MSS (downlink)
2500 - 2570 MHz (not suitable)	used by: MS uplink
2570 - 2620 MHz	For short term use with the approval of the mobile operators used by: MS no significant use yet
2620 - 2690 MHz (not suitable)	used by: MS downlink
2700 - 2900 MHz	used by: air traffic control radar see ECC Rec.(02)09 for wireless cameras
2900 - 3400 MHz (not suitable)	used by: Naval radars, military applications.
3400 - 3600 MHz 3400 – 3475 MHz 3475 – 3600 MHz primary allocation	preferably for cameras on the ground also used by: MS
3600 - 3800 MHz (not suitable)	used by: MS, FSS (downlink)
3800 - 4200 MHz (not suitable)	used by: microwave links, FSS (downlink)
4200 - 4400 MHz (not suitable)	used by: aircraft radar (altimetry)
4400 - 5000 MHz	For short term use with the consent of the military preferably for cameras on the ground, in urban areas

Annex 10: Key features for Defense

A key feature, among others, of the Defense sector is that in order to fulfill its missions, systems working in almost all the services are required. The associated applications can vary from very similar to civilian one (such as radio relay and radionavigation systems) or very specific (such as weapon systems and fast hopping radar).

Despite the finding of a reduction of military forces, the trend for the future military spectrum need is not downward but rather implies have more efficient means of command and intelligence in order to maintain a same level of effectiveness (e.g. growing need for data or video exchange, improvement radar performances requiring larger bandwidths and development of new applications such as unmanned aerial vehicles or robots).

As other sectors, Defense has also achieved a certain level of harmonisation of its spectrum use, especially within NATO nations in Europe. Some non-NATO European countries have even aligned their military spectrum usage on NATO standard. This harmonisation doesn't prevent Defense to share its spectrum and shared basis is the most common use case. It should be also noted that initiatives to make military spectrum needs more visible are currently in development supported by NATO (e.g. update of NJFA) or by EDA to support CSDP.

Annex 11: Definitions of SAP/SAB and ENG/OB

The definitions of SAP/SAB and ENG/OB are set out as follows:

- Services Ancillary to Programme making (SAP) support the activities carried out in the making of "programmes", such as film making, advertisements, corporate videos, concerts, theatre and similar activities not initially meant for broadcasting to general public.
- Services Ancillary to Broadcasting (SAB) support the activities of broadcasting industry carried out in the production of their programme material.
- Electronic News Gathering (ENG) is the collection of video and/or sound material by means of small, often hand-held wireless cameras and/or microphones with radio links to the newsroom and/or to the portable tape or other recorders.
- Satellite News Gathering (SNG) comprises applications similar to ENG using satellite radio communication channels between the ENG team and the studio.
- Outside broadcasting (OB) is the temporary provision of programme making facilities at the location of on-going news, sport or other events, lasting from a few hours to several weeks. Mobile and/or portable radio links are required for wireless cameras or microphones at the OB location. Additionally, radio links may be required for temporary point-to-point connections between the OB vehicle, additional locations around it, and the studio.

For a better understanding of the differences between ENG and OB see Annex 6, where two figures show typical operational set-ups for those two scenarios of broadcasting activities.

The definitions of PMSE applications cover various range of applications are set out as follows:

a) Radiomicrophone - Handheld or body worn microphone with integrated or body worn transmitter.
b) In-ear monitor - Body-worn miniature receiver with earpieces for personal monitoring of single or dual channel sound track.
c) Portable audio link - Body worn transmitter used with one or more microphones, with longer operating range capabilities than that of radiomicrophones.
d) Mobile audio link - Audio transmission system employing radio transmitter mounted in/on motorcycles, pedal cycles, cars, racing cars, boats, etc. One or both link terminals may be used while moving.
e) Temporary point-to-point audio link - Temporary link between two points (e.g. part of a link between an OB site and a studio), used for carrying broadcast quality audio or for carrying service (voice) signals. Link terminals are mounted on tripods, temporary platforms, purpose built vehicles or hydraulic hoists. Two-way links are often required.
f) Cordless camera - Handheld or otherwise mounted camera with integrated transmitter, power pack and antenna for carrying broadcast-quality video together with sound signals over short-ranges.
g) Portable video link - Handheld camera with separate body-worn transmitter, power pack and antenna.
h) Mobile airborne video link - Video transmission system employing radio transmitter mounted on helicopters, airships or other aircraft.
i) Mobile vehicular video link - Video transmission system employing radio transmitter mounted in/on motorcycles, pedal cycles, cars, racing cars or boats. One or both link terminals may be used while moving.
j) Temporary point-to-point video links - Temporary link between two points (e.g. part of a link between an OB site and a studio), used for carrying broadcast quality

video/audio signals. Link terminals are mounted on tripods, temporary platforms, purpose built vehicles or hydraulic hoists. Two-way links are often required.

k) Talk-back - For communicating the instructions of the director instantly to all those concerned in making the programme; these include presenters, interviewers, cameramen, sound operators, lighting operators and engineers. A number of talk-back channels may be in simultaneous use to cover those different activities. Talk-back usually employs constant transmission.

l) Telecommand/remote control - Radio links for the remote control of cameras and other programme making equipment and for signalling.

Wireless conference and interpretation systems - Wireless conference and interpretation systems are used in houses of parliament, courts, at banks and insurance companies, multipurpose halls, hotels, conference centres, industry meeting and discussion rooms as well as designed board rooms or historical meeting places that do not allow installations etc. These systems are very often combined with wireless microphone systems and in-ear monitor systems for those that lead through a presentation or discussion.