Back to Single-carrier for beyond-5G communications above 90 GHz

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Executive summary

Apprehension of the spectrum regulations evolution to support new telecommunication usage in millimetre-wave and sub-THz frequency ranges requires a general understanding of the spectrum management framework at global, regional and national levels.

This document provides an overview of the main regulatory bodies involved in spectrum management, their role and how their respective deliverables interrelate. Particular attention is given to the harmonisation process in Europe and on the necessary complementarity between regulations on frequencies use and harmonised standards applicable to radio equipment. This cooperative process, which is steered in Europe by CEPT, also involves key organisations representing spectrum users and industry stakeholders. It helps achieving effective regulatory solutions that allow for new usage while ensuring the protection of existing/legacy usage. Practical examples of regulatory solutions supporting various fixed and mobile communication applications - under different regulatory regimes - are presented for illustration.

The international regulatory framework for frequencies above 90 GHz as set by the Radio Regulations is mainly structured by the sharing and compatibility constraints between passive scientific services and active services. However today, only limited regulation is available for an effective use of these frequencies by communication applications.

Within the range 90-200 GHz, of particular interest for the BRAVE project, national administrations will have to consider the implementation of European harmonisation measures adopted in 2018. Fixed service applications are foreseen within the frequency ranges 92-114.25 GHz (“W-band”) and 130-174.8 GHz (“D-band”) for both ultra-high capacity backhauling/front-hauling in wireless networks and indoor connections into a data centre. Administrations will also have to consider ways to ensure equitable spectrum access to other applications, including mobile.

This document also gives an insight into the outcome of WRC-19 (World Radiocommunication Conference) under agenda item 1.15, which offers new opportunities for the implementation of land mobile and fixed services applications within the frequency range 275-450 GHz.

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List of Acronyms

APC	Adaptative Power Control
ATPC	Automatic Transmit Power Control
BCA	Bands and Carriers Aggregation
BEM	Block Edge Mask
BS	Base Station
CEPT	Conférence Européenne des Postes et Télécommunications European Conference of Postal and Telecommunication Administrations
CPMS	Close Proximity Mobile System
DAA	Detect And Avoid
EC	European Commission
ECC	European Communications Committee
ECS	Electronic Communications Service
EESS	Earth Exploration Satellite Service
EIRP	Equivalent Isotropic Radiated Power
ETSI	European Telecommunications Standards Institute
EU	European Union
FDD	Frequency Division Duplex
FHSS	Frequency Hopping Spread Spectrum
FS	Fixed Service
IMT	International Mobile Telecommunications
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
LMS	Land Mobile Service
LPWAN	Low Power Wide Area Network
LRTC	Least Restrictive Technical Conditions
LSA	Licensed Shared Access
MIFR	Master International Frequency Register
MFCN	Mobile Fixed Communication Network
MoU	Memorandum of Understanding
NTFA	National Table of Frequency Allocations
PMR	Private Mobile Radio
QAM	Quadrature Amplitude Modulation
RAS	Radio Astronomy Service
RED	Radio Equipment Directive
RLAN	Radio Local Area Network
RR	Radio Regulations
RSC	Radio Spectrum Committee
SRD	Short Range Devices
TDD	Time Division Duplex
Tx	Transmitter
UWB	Ultra Wide Band
WiFi	Wireless Fidelity
WPAN	Wireless Personal Area Network
WRC	World Radiocommunication Conference

1 Introduction

This document provides a general analysis of the regulatory framework for the use of radio frequencies. It has been developed in the context of the BRAVE project, which considers more specifically frequencies within the range 90-200 GHz for operating fixed and mobile communication applications.

The main regulatory bodies involved in spectrum management at international, regional and national level, and their respective role, are described in this deliverable. Particular attention is given to the harmonisation process in Europe and on the necessary complementarity between regulations on the use of frequencies and harmonised standards. This process helps to achieve effective regulatory solutions that allow for new usage while ensuring the protection of existing/legacy usage.

For practical illustration, three different categories of European regulatory solutions enabling in practice various fixed and terrestrial mobile applications - under different regulatory regimes - are introduced:

- Mobile Fixed Communication Networks (MFCN);
- Fixed point-to-point links;
- Short Range Devices (SRD).

A particular focus is put on the provisions established in millimetre-wave (mmW) bands, at 60 GHz (SRD) and 70/80 GHz (fixed service).

The international framework for the use of frequencies above 90 GHz is then introduced. It provides the basis for existing European regulations adopted in 2018 for the fixed service within the frequency ranges 92-114.25 GHz (“W-band”) and 130-174.8 GHz (“D-band”). On-going activities at European level and in the context of the World Radiocommunication Conferences (WRCs) in sub-THz frequency ranges are also presented.

2 Spectrum management framework

When apprehending spectrum management framework, it is convenient to distinguish between three levels: global, regional and national as illustrated in Fig. 1 below. The role of the spectrum regulations at each level is described in following sub-sections.

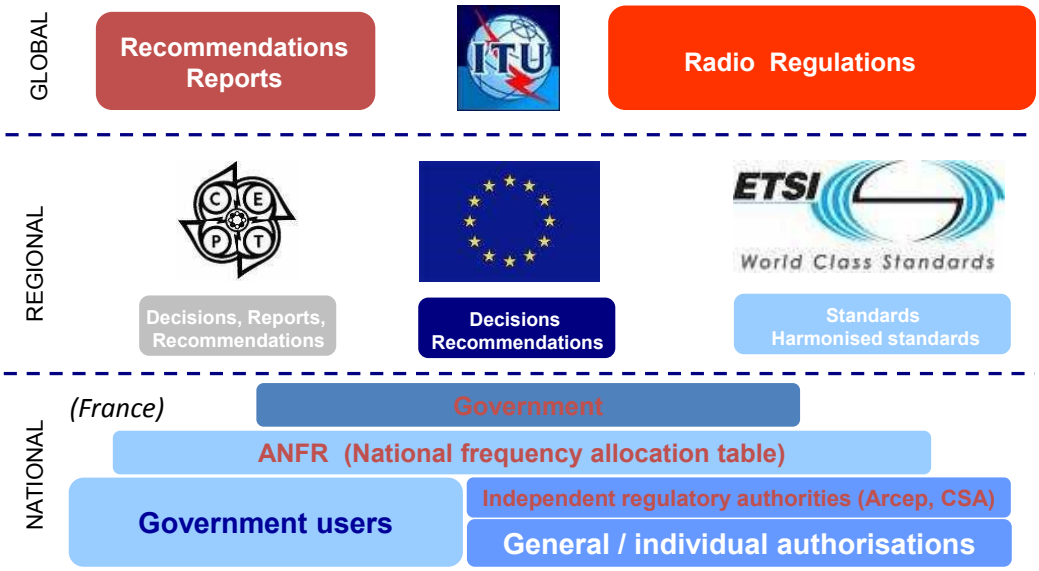

Figure 1 : General framework for the spectrum usage management : 3 levels.

2.1 Global framework

A radio apparatus uses the frequency spectrum resource, according to the rules managed by the administration that is responsible for the use of this scarce resource within its territory. Administrations should manage frequency in a way to provide sufficient quality to existing applications and offer the possibility to introduce new ones. This has led to the development of an international regulatory framework, which is primarily materialised by the Radio Regulations (RR). The RR is an international treaty to which signatory states commit. It is periodically revised by WRCs, meetings that are typically held every four years. The RR complements other fundamental texts [1], which are the Constitution and the Convention of the International Telecommunication Union (ITU), a specialised United Nations agency based in Geneva. It stipulates rights and obligations for an individual state towards other states with respect to the use of the radio spectrum and orbital resources. It does not regulate the different usage within a state, which belongs to national regulation.

The Radio Regulations allocate frequency bands to radiocommunication services. It accounts for the need for global harmonisation in specific domains (satellite communication, maritime, civil aviation, scientific research…) and economies of scale for the industry, as well as for coexistence capability

between different types of radiocommunication networks, and physical properties of the frequency bands.

A radiocommunication service is defined as the transmission, emission and/or reception of radio waves (“Electromagnetic waves of frequencies arbitrarily lower than 3 000 GHz, propagated in space without artificial guide” [2]) for specific telecommunication purposes. Terrestrial services are distinguished from space services. Those two categories can themselves be subdivided in several different types of services: fixed, mobile, broadcasting… The list of the different services with corresponding definitions is given in Article 1 of the RR. Frequency bands are allocated to radiocommunication services on a primary or secondary basis. Stations of a secondary service shall not cause harmful interference to stations of primary services and cannot claim protection against harmful interference from stations of a primary service.

The principle underpinning most of the provisions of the ITU Radio Regulations is set out in RR No. 4.3, which stipulates that any new assignment (i.e. any new authorisation to operate a radio station) must be made in such a way as to avoid causing harmful interference to services rendered by stations using frequencies assigned in accordance with the Table of Frequency Allocations and previously recorded in the Master International Frequency Register (MIFR). Subsequently, a new assignment can be recorded in the MIFR only after completion of a procedure (for instance, Articles 9 and 11) aimed at ensuring that it will not cause harmful interference to existing assignments made in accordance with the RR.

An administration may also assign to a station a frequency in derogation of the Radio Regulations, but only on the condition that such station shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the Radio Regulations (RR No. 4.4).

The ITU-R also develops number of Recommendations and Reports in support of international and national spectrum management.

2.2 European regulatory framework

2.2.1 Harmonisation measures

National administrations in Europe in charge of the management of the radio spectrum resource cooperate within the frame of the European Conference of Postal and Telecommunications Administrations (CEPT), and more specifically its Electronic Communications Committee (ECC) [3]. The prime objective of the ECC is to develop harmonised European regulations for the use of radio frequencies. ECC seeks consensus between administrations for the development of Decisions and Recommendations. Their implementation by national administrations is made on a voluntary basis. With 48 administration members, CEPT covers almost the entire geographical area of Europe.

Industry consistently asks for harmonised spectrum to ensure development of innovative systems. Permanent negotiation is critical over Europe as it enables adapting spectrum use conditions to industry requirements and national situations.

The European Commission (EC) also plays a role in spectrum management in accordance with the "Radio Spectrum Decision" (676/2002/EC) [4]. Assisted by the Radio Spectrum Committee (RSC), the EC issues mandates to the CEPT, setting out various tasks and corresponding timetable.

ECC develops CEPT Reports in response to mandates from the EC. Those CEPT Reports provide input for the development of Commission Decisions which reflect the technical parameters and sharing conditions identified by ECC/CEPT. Commission Decisions are mandatory harmonisation measures within the European Union (EU).

EC harmonisation measures provide legal certainty to industry stakeholders that an identified spectrum is available for a given usage and under specified conditions within the EU. Deviations in terms of national implementation may exceptionally occur, after the concerned EU Member State has requested derogation from the EC. The derogation may be granted for a limited duration only.

The cooperation between ECC and ETSI is also essential in the development of harmonisation measures. A 'System Reference Document' (SRDoc), which is an ETSI Technical Report, is usually developed in order to provide a consolidated view from the industry on specific requirements to change existing spectrum regulations to support a new system, service or application or evolution of existing ones. A Memorandum of Understanding (MoU) between CEPT and ETSI describes the cooperative process applying to the development of harmonised standards and of relevant ECC deliverables, in view of ensuring their consistency.

2.2.2 Making available on the EU market of radio equipment

For a more comprehensive understanding of the legal framework applicable to radio equipment within the European Union, it is necessary to distinguish between two regulatory layers:

- Regulation of the radio frequencies use: legal text adopted at national level, based where applicable on relevant European harmonisation measure (as seen above);
- Regulation related to the making available on the market of radio equipment: harmonised standards adopted at the European level (EU).

The "Radio Equipment Directive" (RED) 2014/53/EU establishes the EU regulatory framework for 'making available on the market'[1] of radio equipment [5]. It ensures a single market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum.

Applying harmonised standards referenced in the Official Journal of the European Union [6] enables manufacturers and service providers to benefit from a presumption of conformity with the requirements of the RED, and thus be able to sell, deploy and put into service (without prejudice to

[1] 'making available on the market' means any supply of radio equipment for distribution, consumption or use on the Union market in the course of a commercial activity, whether in return for payment or free of charge (see Article 2.1 (9) of the RED)

conditions attached to authorisations for the use of frequencies or other applicable EU legislation) the radio equipment within the European Union.

When the harmonised standards are not followed or only partially followed by a manufacturer, the advice of a notified body is required to assess the compliance of the radio equipment with the applicable essential requirements of the RED.

ETSI standards can be downloaded from [7].

2.3 National regulatory framework

Authorising the use of the spectrum is a national prerogative, subject to international obligations and community law in the case of EU Member States.

The notion of National Table of Frequency Allocations (NTFA) plays a central role in spectrum management at national level. NTFAs in Europe are based on the Radio Regulations and various harmonisation measures adopted at European level; they account for compatibility issues between the different types of radio services. They are critical assets for national administrations to plan the allocation of frequency bands, whether on an exclusive or shared basis, between various governmental users which have access to spectrum to perform their own duties, and commercial services or public uses (e.g. amateur, SRD…), so that consumers can benefit from innovative applications.

National Tables of Frequency Allocations (NTFAs) primarily specify the various radio service allocations at national level throughout the spectrum, as well as the entities which have access to them.

National frequency assignments, as derived from the ITU concept, allows the fine management of frequency bands in accordance with the rules set in NTFAs, particularly in bands shared by different types of users and also in respect of coexistence issues in adjacent bands. They may contain sensible data and their management requires confidentiality procedures.

In France, the access to radio frequencies is based on a two-step regulatory process:

1. The national allocation of frequency bands, which decides on the spectrum usage in terms of radio services and confers to relevant administrative bodies the necessary spectrum access rights: ministries or governmental bodies (MoD, home office, civil aviation, maritime, Meteo France, CNES, ministry of research…) for their own use; and independent national regulatory authorities (Arcep, CSA) for the purpose of assigning frequencies to third parties.
2. The authorisation of the use of frequencies.

The ANFR (“Agence nationale des fréquences”) is responsible in France for maintaining and publishing the French national allocation table [8], which is a legal text adopted by decree of the Prime Minister.

The authorisations for the use of frequencies for the provision of electronic communication services (ECS) in France are delivered by the Arcep ("Autorité de régulation des communications électroniques et des postes"), except in the field of broadcasting audio-visual content for which the frequency assignment is entrusted to CSA ("Conseil supérieur de l'audiovisuel").

Authorisations may be delivered on a general or individual basis, in accordance with the legal framework set by the European Electronic Communications Code (Directive (EU) 2018/1972). Where the granting of rights of use for radio spectrum needs to be limited, Member States shall grant such rights on the basis of selection criteria and a selection procedure which are objective, transparent, non-discriminatory and proportionate.

The main processes and stakeholders involved in the national regulatory framework that enables the use of radio frequencies in France are illustrated by Figure 2.

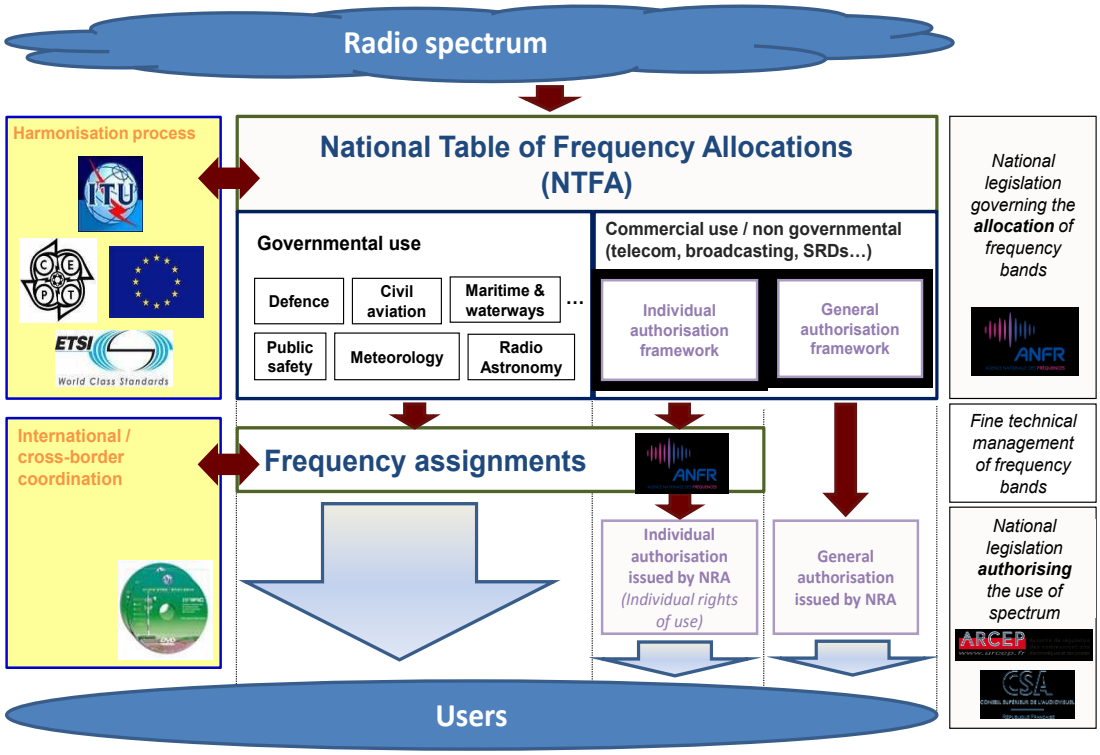

Figure 2 : Spectrum regulatory framework in France.

3 Regulatory solutions, spectrum sharing and authorisation regime

The harmonisation process in Europe aims to establish regulatory solutions to permit new spectrum usage while ensuring the protection of existing uses. These solutions rely to a great extent on spectrum sharing, along with appropriate spectrum management. However, sharing might not always be feasible or desirable, and refarming can therefore be an option.

Spectrum sharing can take place at different levels from a regulatory perspective and be implemented through technical solutions developed in partnership with industry and international standardization organisations:

- Between different radiocommunication services or applications in accordance with the ITU Radio Regulations, or national level regulatory framework;
- Between different entities or type of users, e.g. governmental vs commercial use;
- Between different licensed users of the same application, e.g. PMR services, point-to-point links;
- Between protected primary users and licence-exempt users, e.g. radars and Earth exploration-satellite service (EESS) stations vs. 5 GHz Radio Local Area Networks (RLANs);
- Between different licence-exempt users, e.g. Short Range Devices and Wi-Fi.

A regulatory solution is primarily characterised by the nature of the applicable “regulatory regime” in Europe, which may be either general authorisation or individual authorisation, depending on the objectives or constraints in terms of quality of service, coexistence and efficient use of the spectrum. Practical implementation may further vary according to the circumstance: see ECC Report 132.

For “general authorisations”, the compatibility studies conducted by CEPT determine a set of regulatory parameters to ensure efficient use of the spectrum and protection of radiocommunication services, e.g. maximum EIRP (Equivalent Isotropic Radiated Power), or maximum allowed duty cycle, see section 4 for precise examples. Harmonised implementation by national administrations is critical to support effective enforcement policies.

In the case of “individual authorisations”, “frequency assignments” may need to be coordinated, at national or international level, to ensure coexistence between existing and future systems. A “frequency assignment” may be specific to a frequency band, location and time.

Cross-border coordination is supported by specific recommendations developed by CEPT.

Finally, the effective level of sharing experienced by a user depends on the conditions that have been authorized to this user and, also, on the knowledge of the other types of users who have access to the same spectrum.

4 Regulatory solutions for fixed and mobile applications

The BRAVE target scenario encompasses the following three categories of fixed and terrestrial mobile applications as defined by the European regulatory:

- Mobile Fixed Communication Networks (MFCN);
- Fixed point-to-point links;
- Short Range Devices (SRD).

The regulatory aspects related to those three categories are described in the following sub-sections. A particular focus is put on the provisions established in millimetre-wave (mmW) bands.

4.1 Mobile Fixed Communication Networks (MFCN)

4.1.1 Harmonisation measures

The bands harmonised in Europe for mobile networks operation are quoted in Table 1.

Table 1 : Frequency bands harmonised in Europe for mobile network operation.

Band	Frequency band	ECC Decision	EC Decision
700	694-790 MHz	ECC Decision (15)01	2016/687 (EU)
800	790-862 MHz	ECC Decision (09)03	2010/267/EU
900	880-915 MHz / 925-960 MHz	ECC Decision (06)13	2009/766/EC
1800	1710-1785 MHz / 1805-1880 MHz	ECC Decision (06)13	2009/766/EC
L	1427-1518 MHz	ECC Decision (13)03 ECC Decision (17)06	2015/750 (EU)
2.1	1920-1980 MHz / 2110-2170 MHz	ECC Decision (06)01	2012/688/EU
2.3	2300-2400 MHz	ECC Decision (14)02	
2.6	2500-2690 MHz	ECC Decision (05)05	2008/477/EC
3.5	3400-3800 MHz	ECC Decision (11)06	2008/411/EC
26	24,25-27,5 GHz	ECC Decision (18)06	2019/784 (EU)

The ECC Decisions cited in Table 1 above designate frequency bands for MFCN either on an exclusive or non-exclusive basis. In most cases, the harmonised MFCN frequency arrangements include common Least Restrictive Technical Conditions (LRTC), in view of achieving the following:

- Facilitated roaming and border coordination to achieve global economies of scale for equipment;

- Spectrum efficiency and high level of flexibility in order to adapt to national circumstances as well as to meet the changing need and demand for capacity in time and geography.

The LRTC implementation relies on the Block Edge Mask (BEM) concept which aims to facilitate the delivery of technology-neutral spectrum rights.

A BEM is an emission mask that is defined in the frequency domain, relative to the edge of a frequency block that is licensed to an operator. It specifies the permitted emission levels in adjacent blocks (transitional region below or above operator block) and non-adjacent blocks in the considered frequency band.

It should ensure coexistence with other MFCN blocks, as well as other services and applications in adjacent bands. Additional measures may also be required at national level to achieve coexistence with other services and applications (e.g. guard bands, coordination with a radio astronomy site or with earth stations of the fixed satellite service…).

In addition, MFCN operators may agree, on a bilateral or multilateral basis, less stringent technical parameters provided that they continue to comply with the technical conditions applicable for the protection of other services, applications or networks and with their cross-border obligations. Administrations should ensure that these less stringent technical parameters can be used, if agreed among all affected parties.

At EU level, the corresponding harmonisation measures that support spectrum requirements for public mobile networks are adopted by the European Commission within the frame of EC Mandates to CEPT. These measures refer to “terrestrial systems capable of providing electronic communications services (ECS) in the Union”.

4.1.2 Frequency allocation vs authorisation process

The conventional approach followed since the early 90’s for most of the frequency bands made available in Europe for public mobile networks has relied on the principle of an exclusive designation of frequency bands for MFCN (700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz).

Those frequencies are, as such, “not shared” with other radiocommunication services and in most cases the administration had to refarm the designated spectrum, i.e. to release it in order to enable the introduction of new mobile services.

National regulatory authorities had also the task to assign the MFCN spectrum to individual stakeholders, taking into account their assessment of the market demand and various policy objectives. In practice, they systematically delivered exclusive spectrum usage rights to those individual mobile network operators, on specific frequency blocks, and applicable throughout a whole national territory.

In addition, it can be noted that CEPT developed the concept of “Licensed Shared Access” (LSA) [9]. LSA was originally intended as a means to unlock access to additional frequency bands for mobile broadband under individual licensed regime. The concept was extended as a spectrum management

tool that aims to facilitate the introduction of new users while maintaining incumbent services in the same frequency band.

LSA relies on the principle of shared spectrum allocation and aims to ensure a certain level of guarantee in terms of spectrum access and protection against harmful interference for both the incumbent(s) and LSA licensees, thus allowing them to provide a predictable quality of service. The LSA concept was also defined at EU level [10].

LSA does not prejudge the modalities of the authorisation process to be set by the Administration taking into account national circumstances.

The band 2300-2400 MHz was harmonised for MFCN at European level (CEPT) in 2014, with reference to LSA as a means to maintain long term incumbent use of the band. The band is however currently sparsely used.

In the case of the band 3400-3800 MHz, which has been identified as the primary band suitable for the introduction of 5G in Europe, the harmonisation measure at CEPT and EU level assumes shared access between mobile broadband and receiving earth stations of the fixed satellite service.

The regulatory framework established for the 26 GHz band also includes several regulatory provisions in support of spectrum sharing with satellite services [11, §. Background].

4.1.3 5G and mmW bands

ECC has recognised in its strategic plan for 2015-2020 the importance of spectrum for wireless broadband and 5G [12].

The 5G focus in the context of WRC-19 preparation and related ITU-R activities was limited to frequency bands above 24 GHz to enable much larger bandwidths than ever before (up to several GHz) and support 5G requirements for very high data rates.

Technical studies have been performed within the frame of agenda item 1.13 of WRC-19 in order to consider possible identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, within the following candidate bands: 24.25-27.5 GHz, 31.8-33.4 GHz, 37-43.5 GHz, 45.5-50.2 GHz, 50.4-52.6 GHz, 66-71 GHz, 71-76 GHz and 81-86 GHz.

At European level, clear priorities have been identified at early stage towards the following frequency bands: 24.25-27.5 GHz, 40.5-43.5 GHz and 66-71 GHz.

Of particular interest in relation with frequencies above 60 GHz, CEPT concluded that the frequency bands 71-76 GHz and 81-86 GHz are not suitable for IMT as they provide an international harmonised duplex frequency arrangement to support 5G backhauling. Therefore fixed link usage at 70/80 GHz is expected to increase in the future. Some studies have also shown that the unwanted emissions of both base station (BS) and user equipment (UE) would need to be limited to protect automotive radars operating in the 76-81 GHz frequency band.

The following action has been identified in "CEPT roadmap for 5G", which was initiated by the 43rd ECC Plenary meeting in Prague, 15-18 November 2016:

- D.4: Ensure least restrictive, flexible and streamlined regulations in the band 57-71 GHz which would accommodate 5G and WiGig technologies and applications, also taking into account Intelligent Transport Systems (ITS) in this frequency range.

Practical regulatory solution to access the 57-71 GHz frequency band is now available as part of SRD regulations (see section 4.3.3.2).

4.2 Fixed Point-to-Point links

4.2.1 Fixed Service (FS) regulatory framework

The Fixed Service (FS) is a key service for telecommunication infrastructure development.

ECC report 173 [13] provides an overview of FS links in Europe. Its last update (27 April 2018) highlights the strategic importance of some frequency bands for the FS: 13 GHz, 15 GHz, 18 GHz, 23 GHz and 38 GHz. The initial growth of the E-band (70/80 GHz) is also mentioned.

Several administrations are open to the use of higher frequencies including W-band (92-114.25 GHz) and D-band (130-174.8 GHz).

Regarding the assignment procedures used for fixed point-to-point links, the most used method remains conventional link-by-link assignment and centralised coordination. However, assignment/auction of frequency blocks in certain bands is also implemented. Light licensed or unlicensed regimes may also be applied in some countries.

In practise, the European FS harmonisation measures consist of a set ECC Recommendations, which propose a harmonised band plan. They provide national administrations with regulatory options, whose implementation is subject to market demand and national spectrum policy.

ECO Report 04 [14] provides information on the national implementation of the FS channel arrangements covered by the ECC/ERC Recommendations, including the related national restrictions.

The regulation in France for fixed point-to-point links is set in Arcep Decision n° 2017-1332 [15]. It provides channel plans in the following frequency bands: 1.4 GHz, 6 GHz, 8 GHz, 11 GHz, 13 GHz, 18 GHz, 23 GHz, 26 GHz, 32 GHz, 38 GHz, 71-76 GHz and 81-86 GHz. In France, FS operation in these bands is subject to individual authorisation.

4.2.2 FS regulations in 70/80 GHz

Within the millimetre-wave frequency range, it is interesting to provide a focus on the 70/80 GHz frequency band, which is promoted worldwide as an international harmonised duplex frequency arrangement to support 5G backhauling.

ECC Recommendation (05)07 [16] provides radio frequency arrangements for FS systems in the bands 71-76 GHz and 81-86 GHz. The recommendation, which was lastly revised in 2009, underlines the increasing interest of mmW spectrum in the range from 70 to 100 GHz to service providers and systems designers because of the favourable propagation, nearly free from O2 absorption attenuation and of the wide bandwidth available for carrying communications. It refers to FS scenarios allowing to reach availability objectives in the order of 99.99% with the average European rain rates for very high capacity (up to 10 Gbit/s) links with some 1-2 km hop lengths (line-of-sight conditions). Longer hops may be implemented with reduced availability objectives.

4.2.2.1 Compatibility with passive services

Compatibility studies between the FS and passive service in the bands 71-76 GHz and 81-86 GHz and in adjacent bands are presented in ECC Report 124 [17].

The unwanted emissions of FS operating in the 70/80 GHz need to be limited in order to protect the passive service in the adjacent band 86-92 GHz, where footnote RR No. 5.340 applies.

The agreed provisions provide adequate protection to the Earth exploration-satellite service (passive) with maximum flexibility for deployment of FS stations. They allow for a sloped decrease of the emission limit from -41 dBW/100 MHz at the lower frequency edge of 86 GHz down to the flat level of -55 dBW/100 MHz, which applies from 87 GHz to 92 GHz. It is consistent with the recommended maximum level specified in Resolution 750 (Rev.WRC-15) of the Radio Regulations.

The emission limit mask applies at the antenna port and to each 100 MHz slot within the passive band, as illustrated in Figure 3.

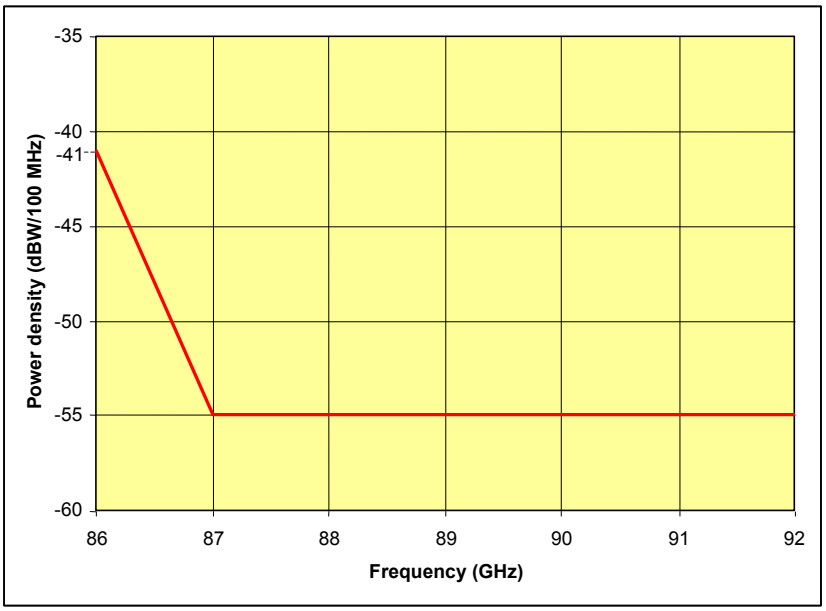

Figure 3 : Unwanted emission power density at the antenna port (as per ECC/REC/(05)07).

The necessary measures to protect the radio astronomy service (RAS) should be defined at national level, taking into account potential cross-border interference scenarios.

ECC Report 124 indicates for instance, with respect to RAS protection in the band 76-77.5 GHz, that an unwanted FS emission power of -40 dBW/100 MHz, associated with a maximum FS antenna gain of 38 dBi, require a separation distance of about 100 km. This separation distance may be reduced when considering a FS station pointing direction that is different from the RAS station direction. An antenna side-lobe rejection factor of 38 dB for a separation azimuth angle >16° will result in a relaxation of the separation distance down to about 20 km. There may also be additional attenuation by shielding, topography or clutter surrounding either the FS station or the RAS station.

ECC Report 124 provides similar consideration for FS/RAS sharing within the band 81-86 GHz; and for RAS protection within 79-81 GHz and 86-92 GHz from unwanted emissions of FS operating in 81-86 GHz.

The calculation of appropriate separation distances should be done on a case-by-case basis by the national administration.

4.2.2.2 Licensing scheme, harmonised standards and equipment coordination

It is worth also noting the potential evolution in terms of frequency assignment in the context of the E-band (70/80 GHz) towards some possible “light licensing” schemes. Indeed, the probability of interference occurrence between two FS links is reduced, compared with lower FS bands, thanks to the highly directional antenna beams and stronger propagation losses.

While the effective frequency assignment scheme is a national decision, Recommendation ECC (05)07 provides some consideration on self-coordination approach to assist the planning of fixed point-to-point links. Such “light licensing” regimes do not mean “licence exempt” use, but rather using a simplified set of conventional licensing mechanisms and attributes within the scope decided by the administration. This planning is delegated to the licensee. Administrations would still intervene for protecting a limited number of sensitive sites while giving greater flexibility elsewhere.

In contrast, the lower 38 GHz band, which was harmonised for FS systems in 1991 (Recommendation T/R 12-01), is essentially assigned to individual users through conventional schemes.

The harmonised standard ETSI EN 302 217-2 V3.1.1 (2017-05) [18], which is published in the Official Journal of the European Union, covers digital point-to-point FS systems operating in frequency bands from 1 GHz to 86 GHz. The standard indicates that, when conventional link-by-link planning is made on the basis of the actual antennas used in each station, the maximum EIRP is defined in the link licence. Alternatively, in bands where link by link planning is not used or is not the unique method of licensing FS links, joint limitation of transmitter (Tx) output power and EIRP and, consequently, also antenna gain, is provided. These limitations are essential for improving, in average, the efficient band usage also in absence of full coordination.

Annex J of ETSI EN 302 217-2 [18] relates to the E-band (70/80 GHz). It specifies a maximum EIRP of +85 dBm and a minimum antenna gain of 38 dBi as baseline requirements. The standard provides less stringent requirements on the antenna gain to achieve a given max EIRP function in case of equipment implementing Automatic Transmit Power Control (ATPC) as a permanent feature.

The standard also makes the following assertion regarding the E-band: ECC Recommendation (05)07 recognizes that, due to the negligible Oxygen absorption attenuation, the conventional link-by-link planning may be profitably applied (typically for FDD only) improving the spectrum usage. However, a number of administrations apply simplified licensing procedures based on self-planning or simple station notification.

4.3 Short Range Devices (SRD)

4.3.1 SRD regulatory framework

The concept of Short Range Device (SRD) refers traditionally to various low-power / short-range / portable / licence-exempt applications such as remote controls, metering devices, alarms or wireless headphones. It encompasses today a wide range of innovative applications in industry, automotive, home automation, logistics or medical field. The Internet of Things has seen the emergence of broad coverage networks - so-called LPWAN (Low Power Wide Area Networks) operating under SRD regulations to meet new usage: smart cities, smart homes, or smart health, for example.

From an international perspective, SRD are not considered as a "radiocommunication service" in the sense of the Radio Regulations. SRD are generally perceived as being authorised by national administrations in derogation of the Table of Frequency Allocations of the RR (RR No. 4.4) and are qualified as operating on a “non-interference/non-protection basis”. The ITU-R maintains Recommendation SM.1896 [19] and Report SM.2153 [20] related to SRD, mainly for information purpose.

Regulatory solutions for SRD in Europe are developed by CEPT, in cooperation with ETSI. ERC Recommendation 70-03 [21] provides a set of regulatory parameters for SRD in various frequency bands for implementation by national administrations within CEPT. Possible restrictions on the national implementation of this recommendation are normally specified in appendix 3 of ERC/REC 70-03.

At EU level, the harmonisation of the radio spectrum for use by short-range devices is supported by the EC Decision 2006/771/CE [22], which is regularly amended (lastly by 2019/1345 [23]) on the basis of CEPT proposals submitted within the frame of a permanent EC mandate to CEPT on SRD. SRD regulations fit under general authorisation regime.

In France, the use of frequencies by SRD is authorised by Decision n° 2014-1263 from Arcep, taking into account its subsequent amendments. Article 3 of the decision stipulates that SRD shall not cause harmful interference to stations of a radiocommunication service operating in accordance with French NTFA and cannot claim any guarantee of protection against harmful interference. The decision is regularly updated in order to account for the evolution of European regulatory framework.

4.3.2 Key principles

CEPT generally supports a number of key principles when developing SRD regulations such as "minimum regulations" and "application and technology neutrality"[2].

Implementing minimum regulations implies that each regulated parameter must be justified by the need to ensure the efficient use of the radio spectrum and the avoidance of harmful interference or the respect of any other public interest requirements.

CEPT favours generic regulations as far as possible. SRD regulations can however be limited to specific applications for instance to ensure protection of a primary service, coexistence between SRD or to possibly achieve greater "quality of service".

SRD regulations available in Europe provide a wide range of regulatory options throughout the spectrum that are able to match various industry/users requirements in terms of performance and deployment scenarios. It should be noted that there is no restrictive definition for the very notion of SRD. A device is authorised to use the spectrum within a national territory as a SRD, as long as it complies with the conditions of use (i.e. regulatory parameters) of the selected SRD regulation. At EU level, the equipment must also comply with the essential requirements of the "Radio Equipment Directive" (RED).

Industry stakeholders require visibility and legal certainty on the availability of frequency bands and associated conditions to support investment. SRD regulations, with associated sharing constraints with primary services when applicable, define a predictable sharing environment for an equal level playing field. Regulations are subject to regular review.

4.3.3 Examples of SRD regulations

Under ERC/REC 70-03, proposed regulations are split in different categories (see annexes of the recommendation). A set of regulatory parameters is applicable to any application that fits within a given category, unless the column 'Notes' in the tables stipulate a more specific application (i.e. other usage restrictions). Some applications supported by a specific SRD regulation may be further described in corresponding ETSI harmonised standard.

Some examples of harmonised SRD regulations at 2.4 GHz and 60 GHz are presented in the following sub-sections for illustration.

4.3.3.1 2.4 GHz band

Different sets of regulatory parameters may be available in the same frequency band to support different applications, as in the case of the 2.4 GHz band, thus offering several options to the industry.

- **Regulatory parameters in ERC/REC 70-03 Annex 1: non-specific SRD**

[2] Some exceptions may remain such as with DECT technology (see ERC/DEC/(94)03 [24])

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements	Modulation/ maximum occupied bandwidth	ECC/ERC deliverable	Notes
i	2400-2483.5 MHz	10 dBm e.i.r.p.	No requirement	Not specified		The frequency band is also identified in Annexes 3 and 6

Corresponding harmonised standard: EN 300 440

The above regulatory provisions are supported by band No 57a in the EC Decision on SRD.

- **Regulatory parameters in ERC/REC 70-03 Annex 3: wideband data transmission systems**

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements	Modulation/ maximum occupied bandwidth	ECC/ERC deliverable	Notes
b	2400-2483.5 MHz	100 dBm e.i.r.p.	Adequate spectrum sharing mechanism (e.g. LBT and DAA) shall be implemented	Not specified		For wideband modulations other than FHSS, the maximum e.i.r.p. density is limited to 10 mW/MHz

Corresponding harmonised standard: EN 300 328

The above regulatory provisions are supported by band No 57c in the EC Decision on SRD.

The most recent version of EN 300 328 is ETSI EN 300 328 V2.2.2 (2019-07) [25], whose reference is subject to publication in the Official Journal of the EU.

Practical implementation of the 'spectrum access and mitigation requirements' is detailed in the standard, which distinguishes the following conformance requirements:

- Requirements for Frequency Hopping (FHSS) equipment;
- Requirements for other types of Wideband Data Transmission equipment (non-FHSS equipment).

4.3.3.2 60 GHz band

- **Regulatory parameters in ERC/REC 70-03 Annex 3: wideband data transmission systems**

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements	Modulation/ maximum occupied bandwidth	ECC/ERC deliverable	Notes
c1	57–71 GHz	40 dBm e.i.r.p., 23 dBm/MHz e.i.r.p. density	Adequate spectrum sharing mechanism shall be implemented	Not specified		Fixed outdoor installations are not allowed.
c2	57-71 GHz	40 dBm e.i.r.p., 23 dBm/MHz e.i.r.p. density and maximum transmit power of 27 dBm at the antenna port or ports	Adequate spectrum sharing mechanism shall be implemented	Not specified	ECC Report 288	

Frequency Band		Power / Magnetic Field	Spectrum access and mitigation requirements	Modulation/ maximum occupied bandwidth	ECC/ERC deliverable	Notes
c3	57-71 GHz	55 dBm e.i.r.p., 38 dBm/MHz e.i.r.p. density and transmit antenna gain ≥ 30 dBi	Adequate spectrum sharing mechanism shall be implemented	Not specified	ECC Report 288	Applies only to fixed outdoor installations

Corresponding harmonised standard:

- EN 302 567 (57-66 GHz) for sub-band c1)
- To be defined for sub-bands c2) and c3)

Band c1) corresponds to the initial regulatory framework developed in 2009 to meet the demand for wireless personal area networks (WPAN), which is mainly for indoor use. The exclusion of fixed outdoor installations was agreed at that time as a means to ensure the protection of fixed service operated in some countries (in accordance with recommendations ECC/REC/(05)02 and ECC/REC/(09)01).

CEPT conducted later studies to review the conditions applicable to the 57-66 GHz band in order to ensure less restrictive, flexible and streamlined regulations for wideband data transmission, while ensuring coexistence with the fixed service and taking into account ITS at 63 GHz. The results are included in ECC Report 288.

The report emphasizes that the adoption of interference mitigation technique such as APC (Adaptive Power Control) / DAA (Detect And Avoid) is also highly beneficial to keep the overall interference probability low enough so that the licence-exempt regulation is attractive enough for 5G application providers, e.g. for fixed wireless access solutions or backhauling and fronthauling to and from small high capacity cells using 5G technology.

The additional regulations finalised in June 2019 would fit separately the spectrum requirements for two different use cases:

- Band c2): Outdoor wireless access solution (e.g. small BS fixed at lamppost);
- Band c3): Wireless backhaul: higher radiated power is permitted, subject to minimum antenna gain.

Finally, CEPT agreed the extension of the new conditions developed for the band 57-66 GHz to the whole of the band 57-71 GHz band when amending Annex 3 of ERC/REC 70-03. This new consolidated licence-exempt regulatory framework provides regulatory solutions that meet the requirements of various fixed and land mobile applications; it also coincides with frequency allocations to the fixed and mobile services in the Radio Regulations.

5 International framework above 90 GHz

The Radio Regulations provide an international framework for the management of radio frequencies up to 3 THz, with agreed frequency allocations stopping at 275 GHz.

5.1 Frequencies within the range 90-275 GHz

Frequency allocations between 90 GHz and 275 GHz were decided at WRC-2000, within the frame of agenda items 1.16 and 1.17. They provide visibility to stakeholders on available frequencies for a large set of radiocommunication services. ITU-R studies performed at that time indicated that sharing between the EESS (passive) and the fixed service is generally possible in frequency bands with high atmospheric absorption but may require constraints to be applied on the fixed service to protect passive space sensors. With respect to the protection of the terrestrial radio astronomy service, it was indicated that national administrations may have to establish coordination zones around millimetre-wave astronomical observatories. Coordination radii in the order of 100 km may be necessary.

Frequencies that may be used by active radio systems are bordered by “passive” bands i.e. bands covered by footnote RR No. 5.340 which prohibits all emissions in dedicated frequency bands. Of relevance to operation within the range 90–275 GHz, the following bands are affected by this footnote: 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 and 250-252 GHz.

In practice, the frequency bands allocated to the fixed and mobile services in the range 90-275 GHz provide a framework for the development of terrestrial wireless communications within this range: 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-164 GHz, 167-174.8 GHz, 191.8-200 GHz, 209-226 GHz, 231.5-235 GHz, 238-241 GHz, 252-275 GHz.

Effective regulatory solutions at European level should be based on RR frequency allocations. Their development and national implementation are driven by market demand. They should define adequate conditions to ensure coexistence with other radiocommunication services and protection of passive services operating in adjacent bands.

Investigations within CEPT based on the requirements expressed by ETSI have led to the publication in 2018 of harmonisation measures for fixed service systems in the frequency ranges 92-114.25 GHz (“W-band”) and 130-174.8 GHz (“D-band”) (see section 6.1).

Under the SRD regulatory approach, one should mention frequency bands 122-123 GHz and 244-246 GHz which are available in Europe in accordance with the technical conditions recommended in annex 1 of ERC/REC 70-03 (see also ETSI EN 305 550).

5.2 Frequencies within the range 275-3000 GHz

Frequencies between 275 GHz and 3000 GHz are not allocated to radiocommunication services, thus there is no international-level obligation for national administrations to protect this spectrum usage.

These frequencies are however subject to footnote RR No. 5.565 which covers distinctively the ranges 275-1000 GHz and 1000-3000 GHz. Several frequency bands within 275-1000 GHz are "identified for use by administrations for passive service applications" (RAS, EESS, SRS), providing as such an international recognition of these frequency bands for scientific purpose.

RR No. 5.565 does not preclude the use of the range 275-1000 GHz by active services but urges administrations wishing to make frequencies within this range available for active service applications to take all practicable steps to protect the identified passive services from harmful interference. All frequencies in the range 1000-3000 GHz may be used by both active and passive services.

Technical studies performed within the frame of agenda item 1.15 of WRC-19 have considered the possible identification of frequency bands for use by administrations for the land mobile and fixed services applications operating in the frequency range 275-450 GHz (see section 7.1).

6 European regulations and ongoing activities above 90 GHz

Only limited regulation is available today in Europe for the use of frequencies above 90 GHz. Information is provided in the following sections on European harmonisation measures related to the fixed service completed in 2018 and ongoing activities related to radiodetermination applications in 120-260 GHz.

6.1 CEPT regulations for the fixed service in frequencies above 90 GHz

CEPT investigations on FS in the frequency ranges 92-114.25 GHz ("W-band") and 130-174.8 GHz ("D band") were completed in 2018 with the publication of the following deliverables:

- ECC Report 282 [26]: Point-to-Point Radio Links in the Frequency Ranges 92-114.25 GHz and 130-174.8 GHz;
- revised ECC Recommendation (14)01 [27]: Radio frequency channel arrangements for fixed service systems operating in the band 92-95 GHz;
- ECC Recommendation (18)01 [28]: Radio frequency channel/block arrangements for Fixed Service systems operating in the bands 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz and 111.8-114.25 GHz;
- ECC Recommendation (18)02 [29]: Radio frequency channel/block arrangements for Fixed Service systems operating in the bands 130-134 GHz, 141-148.5 GHz, 151.5-164 GHz and 167-174.8 GHz.

The main features that are advocated for fixed radio systems operating in this part of the spectrum are highlighted as follows:

- Availability of very wide bandwidths, allowing for the low cost of traffic in multi service provider operation area;
- Feasibility of deploying radio links is much easier in comparison to alternative wire-bound solutions;
- Ability to ensure high security because of low possibility of interference/capture of signals.

The channel arrangements in ECC/REC/(18)01 and ECC/REC/(18)02 account for flexible FDD/TDD deployment, with continuous frequency slot raster of 250 MHz channels, without specifically defining either paired or unpaired use. No strict limitation on the number of aggregate channels (i.e. no limitation on the maximum channel bandwidth) is specified. Bands and Carrier Aggregation (BCA) may also be considered for the W-band and D-band to improve capacity and link availability.

Consideration is given in ECC Report 282 on current high capacity commercial systems in the E-band (71-76 GHz and 81-86 GHz) allowing transport of 1 Gbit/s in a channel size of about 250 MHz, with modulation in the order of 128 QAM. Capacity demand can require aggregating channels for at least 500 MHz to a 2 GHz bandwidth. Indication is also given on maximum specifications and capabilities, (capacity up to 6 Gbit/s using Dual Polarisation Multiplexing and modulation up to 256 QAM), which would however not meet the requirements for the foreseen future applications and use cases.

Around 15 GHz of spectrum is available in the W-band and more than 30 GHz of spectrum is available in the D-band. Optimised trade-off between very wide channels and spectrum efficiency would allow achieving very compact equipment and low power consumption for ultra-high capacity backhauling, front-hauling and possibly fixed wireless access, with up to about 1 km hop lengths in line-of-sight conditions. High density short links under 200 m can be used for 5G mobile backhauling tail link with capacity of over 10 Gbit/s. Indoor application for internal connection of a data centre (inter-server) is also considered with short links in the order of tens of metres, providing capacity around 40 Gbit/s. The report also mentions link capacity in the order of 100 Gbit/s planned in the future.

For D-band systems simulation, ECC Report 282 considers maximum antenna gain of up to 40 dBi and +5 dBm output power.

As for the compatibility with passive services, the conclusions and methodologies in ECC Report 124 (see section 4.2.2.1) have been extrapolated in ECC/REC/(18)01 (D-band) and ECC/REC/(18)02 (W-band) in order to establish the FS unwanted emission mask to ensure protection of EESS (passive). This approach had been already applied to the FS band 92-95 GHz in ECC/REC/(14)01.

The unwanted emissions of FS transmitters that are falling into adjacent passive bands (i.e. bands where footnote RR No. 5.340 applies) should be limited at the FS antenna port according to the same approach with a sloped decrease of the emission limit from -41 dBW/100 MHz at the frequency border between FS and passive services and across 1 GHz of spectrum within the passive band down to the flat level of -55 dBW/100 MHz, which is applied across the remaining of the passive band (see Annex 5 of ECC/REC/(18)01 and Annex 4 of ECC/REC/(18)02).

Radio astronomy service: the calculation of appropriate separation distances between FS transmitters and a radio astronomy site should be done on a case-by-case basis by the national administration.

6.2 Radiodetermination applications in 120-260 GHz

Work has been initiated in 2019 within CEPT to address the spectrum requirements expressed by ETSI on radiodetermination application within the frequency range 120 GHz to 260 GHz, as presented in ETSI TR 103 498 V1.1.1 (2019-02) [30].

The ETSI SRdoc refers to available Ultra-Wideband (UWB) technology and to different measurement applications which cannot be conducted adequately at the moment in the SRD bands 122-123 GHz and 244-246 GHz due to the limited bandwidth. It distinguishes between applications types A, B and C, which vary from applications with potential maximum radiated emissions into the open sky in any direction outside a shielded environment, building or housing (type A) - which would be most critical regarding the generation of harmful interference into radiocommunication services - to applications emitting inside a confined and shielded environment, building or housing (type C).

In terms of regulatory approach, the reference to UWB basically suggests that the possible spectrum regulations to be developed would not be limited within the relevant spectrum allocations of the

Radio Regulations and also that no protection can be granted to these radiodetermination applications. Administrations would have to assess the justification for these requirements, to consider some enforcement aspects in relation with the various specific applications, and also to consider suitable mechanisms to ensure the protection of radiocommunication services e.g. by ensuring that a required geographical separation is met in case of in-vehicle sensor applications.

7 International activity and WRCs

7.1 Agenda item 1.15 of WRC-19

ITU-R activities within the frame of agenda item 1.15 of WRC-19 have considered possible identification of frequency bands for land mobile and fixed service applications operating in the frequency range 275-450 GHz.

Technical and operational characteristics of land mobile service (LMS) and fixed service (FS) applications considered in this context are presented respectively in Report ITU-R M.2417 [31] and Report ITU-R F.2416 [32].

The main FS applications considered in Report ITU-R F.2416 are point-to-point fronthaul and backhaul links for mobile services. High data rates in the order of 100 Gbit/s are provided by simple modulation schemes using wide bandwidths of about 50 GHz. Among baseline radio characteristics, the report refers to maximum Tx output power of 20 dBm in the frequency range 275-325 GHz and 10 dBm in the frequency range 380-445 GHz, with maximum antenna gain of 50 dBi. Maximum power density in 1 GHz is derived from the maximum power by applying a 3 dB reduction factor.

Report ITU-R M.2417 considers LMS applications like "close proximity mobile systems (CPMS)", “wireless links for data centres” and “intra-device communications”, aiming to provide high data rates, in the order of 100 Gbit/s, also with simple modulation schemes using wide bandwidths. The report concludes that a total bandwidth of 50 GHz would be sufficient to provide high-data rate transmissions between CPMS devices for “kiosk” applications, as well as, intra device applications and wireless links for data centres.

Sharing and compatibility studies between land-mobile, fixed and passive services in the frequency range 275-450 GHz performed by the ITU-R during the WRC-19 preparation cycle are presented in Report ITU-R SM.2450 [33].

CEPT analysis of the topic and European proposal to WRC-19 are presented in CEPT Brief on Agenda Item 1.15 [34].

WRC-19 approved a new RR footnote which identifies the frequency bands 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz for the implementation of LMS/FS applications, consistently with the conclusion of the technical studies.

With a total bandwidth of 137 GHz proposed to be identified above 275 GHz, CEPT had noted within the frame of WRC-19 preparation that this conclusion is exceeding the assessed spectrum requirements of 50 GHz for the land mobile and fixed services (with possibility of overlap). In particular, the band 356-450 GHz provides a large contiguous bandwidth of 94 GHz and, with the 23 GHz already allocated to LMS/FS in the lower adjacent band 252-275 GHz, the identification of the band 275-296 GHz also allows for providing a large contiguous bandwidth of 44 GHz.

In addition, WRC-19 concluded that the frequency bands 296-306 GHz, 313-318 GHz, 333-356 GHz may only be used by LMS/FS applications when specific conditions to ensure the protection of Earth

exploration-satellite service (passive) applications are determined in accordance with Resolution 731 (Rev.WRC-19).

In the frequency bands 275-296 GHz, 306-313 GHz, 318- 323 GHz, 327-333 GHz , 356-371 GHz, 388-424 GHz and 426-442 GHz, some specific conditions (e.g. minimum separation distances and/or avoidance angles) may be necessary to ensure protection of radio astronomy sites from LMS/FS applications, on a case-by-case basis.

7.2 Future WRCs

WRC-19 has agreed under its agenda item 10 the agenda for WRC-23, which sets the framework for WRC-23 preparation cycle within the period 2020-2023.

In this context, CEPT was proposing investigation on additional spectrum allocations to the radiolocation service on a co-primary basis in the frequency band 231.5-275 GHz and identification for radiolocation applications in frequency bands in the range 275-700 GHz for millimetre- and sub-millimetre-wave imaging systems.

These ranges are described as being well suited for stand-off detection of concealed objects; with potential significant contribution to public safety, counter-terrorism and the security of high risk/high value assets or areas.

The proposal distinguished between two main configurations: active (radars) and receive-only (radiometers).

The active millimetre- and sub-millimetre-wave imaging systems requires for a frequency bandwidth wider than 30 GHz between 231.5 GHz and 320 GHz, where the atmospheric absorption is relatively low, in order to achieve range resolutions in the order of a one centimetre.

Receive-only imaging systems detect the extremely weak power that is naturally radiated by objects and require much wider frequency bandwidth than active systems to collect enough power for detection. An identification in the range 275-700 GHz is envisaged for these applications.

This proposal related to the radiolocation service was however not considered as a priority for WRC-23 and only agreed as an agenda item in the preliminary agenda for WRC-27. Technical studies may though be initiated within the ITU-R on this basis.

CEPT also proposed for WRC-23 to review frequency allocations for EESS (passive) in the range 231.5-252 GHz and to consider possible adjustment for passive microwave sensors. This proposal was agreed by WRC-19 as an agenda item for WRC-23.

8 Conclusion

The analysis presented in this document emphasizes the importance of spectrum sharing, an essential part in spectrum management which can be achieved in different ways. It also illustrates a possible trend in frequency management towards general authorisation framework for the use of radio frequencies in sub-THz range, given the greater capacity for frequency re-use in higher frequency ranges and taking into account high attenuation from atmospheric gases in specific windows. Specific measures may also be required to ensure the protection of sensitive sites e.g. by imposing a registration mechanism at national level to verify geographic requirements with respect to a radio astronomy site, or possibly by imposing at equipment level an automatic deactivation mechanism in the case of portable/mobile applications.

The radio spectrum above 90 GHz has initially been used by scientific services (e.g. radio astronomy observation, Earth exploration-satellite service, meteorology, etc.). It also offers opportunities allowing huge signal bandwidths in wireless communications. Clear interest is also emerging for radiodetermination applications for accurate measurement or imaging purpose.

Within the range 90-200 GHz, national administrations will have to consider the implementation of European harmonisation measures established for fixed service applications. They offer regulatory solutions within the frequency ranges 92-114.25 GHz (“W-band”) and 130-174.8 GHz (“D-band”) for both ultra-high capacity backhauling/front-hauling in wireless networks and indoor application for internal connection of a data centre. Administrations will also have to consider ways to ensure access to spectrum within these ranges to other applications, including mobile, on an equitable basis.

The decision of WRC-19 under agenda item 1.15 also offers new opportunities for the implementation of land mobile and fixed services applications in the frequency bands 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz.

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