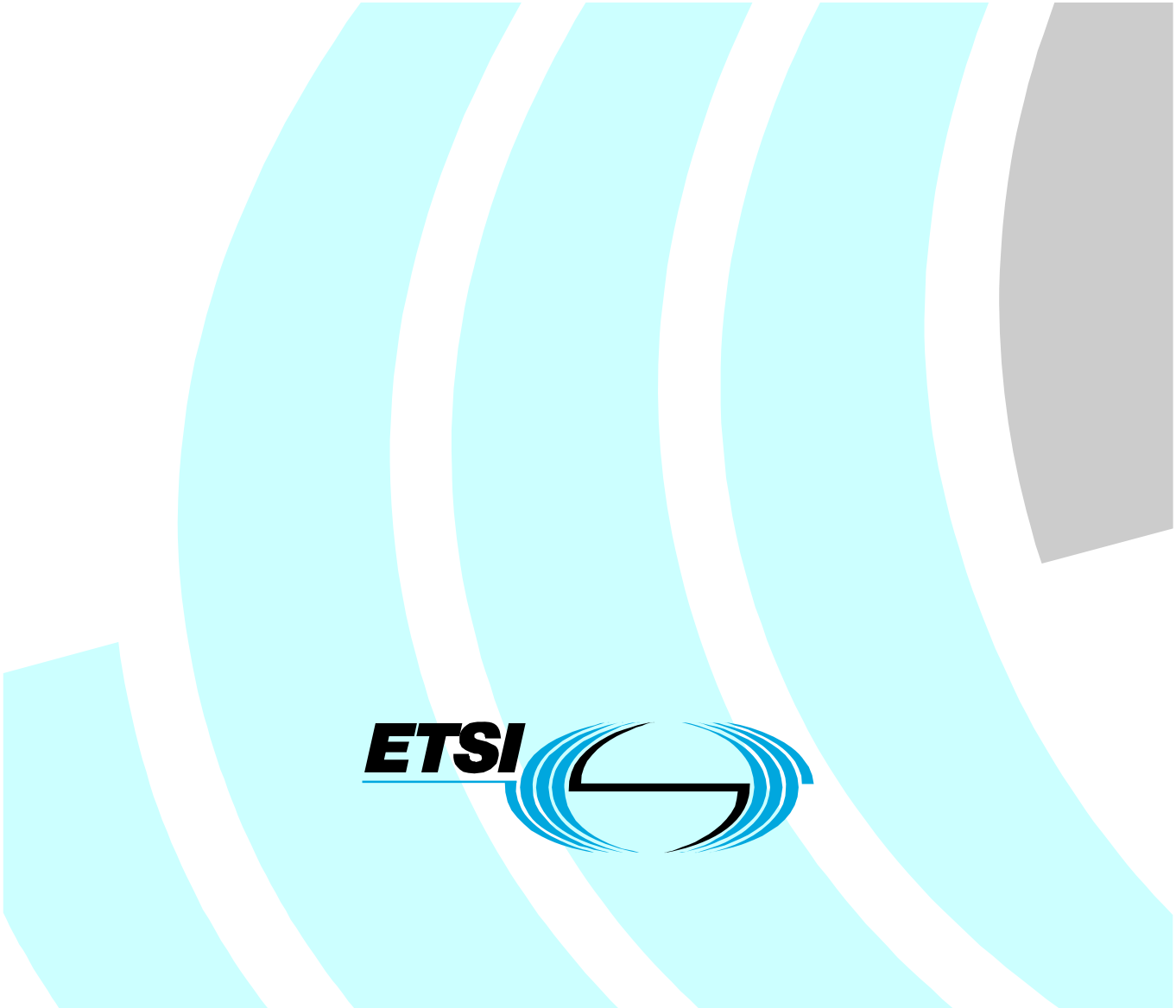
ETSI TR 102 748 V1.1.1 (2008-05)

Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Impact of the trend towards flexibility in spectrum usage on the principles for drafting Harmonized Standards and the ETSI work programme for Harmonized Standards



Reference
DTR/ERM-015

Keywords
radio, regulation

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document handles possible strategies for Harmonized Standards for flexible bands, a concept which may need to be included at a later stage in EG 201 399 [i.1].

Introduction

Introducing flexibility in spectrum management aims at speeding up the process of, and lowering the barriers to, accessing the radio frequency spectrum for new applications and services.

Flexibility in product design is supported by the "new approach Directives", which through essential requirements define the results to be attained, or the hazards to be dealt with, but do not specify or predict the technical solutions for doing so. The technical specifications of products meeting the essential requirements set out in the directives are laid down in Harmonized Standards. This is described in the "Guide to the implementation of directives based on the New Approach and the Global Approach, European Commission" [i.5].

The European Commission has issued two mandates related to flexibility:

- Mandate to CEPT to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS (from DG InfoSoc, 5 July 2006) [i.2].
- M/406 Standardization mandate forwarded to CEN/CENELEC/ETSI for Harmonized Standards for equipment operating in flexible bands (from DG Enterprise) [i.3].

The present document has been prepared as a response to phase 1 of the European Commission Mandate M/406 [i.2]. The mandate consists of two phases; the purpose of the whole mandate is to "establish a set of Harmonized Standards for equipment operating in so-called "flexible bands" to be recognized under Directive 1999/5/EC [i.11] (the R&TTE Directive) giving a presumption of conformity with its requirements".

Therefore, a first question to address is how to organize such a set of standards: the corresponding proposals can be found in clause 6.

The impact of the trend towards flexibility on the design of Harmonized Standards may depend heavily on the underlying scenarios. A method to identify and describe such scenarios is therefore addressed in clause 4.2.

The way in which the standards can be organized internally is addressed in clause 7.

Implications of the work ongoing on flexibility in spectrum usage in CEPT/ECC in this area, on the contents of the standards can be found in various clauses of the present document, in particular in clause 5, where the impact of the various models identified by ECC is addressed.

The ETSI Work Programme is addressed in clause 8.

Finally, drawings, tables and flow charts (see clauses 4 and 5) illustrate the overall processes, the writing of standards are part thereof.

1 Scope

The present document assesses the impact of the trend towards flexibility in spectrum usage on the design of Harmonized Standards and on the corresponding ETSI work programme. It also makes proposals for an update to the ETSI work programme. These cover phase 1 of Mandate M/406 [i.2]. Phase 2 of this mandate is not covered in the present document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI EG 201 399 (V2.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of candidate Harmonized Standards for application under the R&TTE Directive".

[i.2] European Commission mandate to CEPT to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS.

[i.3] European Commission Mandate M/406: "Standardization mandate forwarded to CEN/CENELEC/ETSI for Harmonized Standards for equipment operating in flexible bands".

[i.4] Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive).

[i.5] Guide to the implementation of directives based on the New Approach and the Global Approach, European Commission, 2000.

[i.6] CEPT/ERC Report 068: "Monte-Carlo Radio Simulation Methodology for the use in sharing and compatibility studies between different radio services or systems".

NOTE: http://www.erodocdb.dk/Docs/doc98/official/pdf/REP068.PDF

[i.7] Report ITU-Recommendation SM. 2028-1: "Monte-Carlo Radio simulation methodology for the use in sharing and compatibility studies between different radio services or systems".

[i.8] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[i.9] ETSI EN 301 908 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS), Repeaters and User Equipment (UE) for IMT-2000 Third-Generation cellular networks".

[i.10] ETSI EN 301 489 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services".

[i.11] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.12] ETSI Drafting Rules, version adopted by ETSI Director-General on 11 June 2007 contained in the ETSI Directives.

NOTE: Available at: http://portal.etsi.org/directives/home.asp

[i.13] ETSI EN 302 296 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Transmitting equipment for the digital television broadcast service, Terrestrial (DVB-T); Harmonized EN under article 3.2 of the R&TTE Directive".

[i.14] ETSI EN 300 220-2 (V2.1.2): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".

[i.15] ETSI EN 301 357-2 (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Cordless audio devices in the range 25 MHz to 2 000 MHz; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.16] ETSI EN 300 422-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Wireless microphones in the 25 MHz to 3 GHz frequency range; Part 2: Harmonized EN under article 3.2 of the R&TTE Directive".

[i.17] ETSI EN 302 208-2 (V1.1.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W; Part 2: Harmonized EN under article 3.2 of the R&TTE Directive".

[i.18] ETSI EN 301 502: "Harmonized EN for Global System for Mobile communications (GSM); Base Station and Repeater equipment covering essential requirements under article 3.2 of the R&TTE directive (GSM 13.21 version 8.1.2 Release 1999)".

[i.19] ETSI EN 301 511 (V9.0.2): "Global System for Mobile communications (GSM); Harmonized EN for mobile stations in the GSM 900 and GSM 1800 bands covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC)".

[i.20] ETSI EN 301 419 "Digital cellular telecommunications system (Phase 2) (GSM); Attachment requirements for Global System for Mobile communications (GSM)".

[i.21] ETSI EN 302 544 (all parts): "Broadband Data Transmission Systems operating in the 2 500 MHz to 2 690 MHz frequency band".

[i.22] ETSI EN 302 326-3 (V1.2.2): "Fixed Radio Systems; Multipoint Equipment and Antennas; Part 3: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive for Multipoint Radio Antennas".

[i.23] CEPT Report 019: "Report from CEPT to the European Commission in response to EC Mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS".

[i.24] Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorization of electronic communications networks and services (Authorization Directive).

[i.25] ETSI TR 102 742: "Broadband Radio Access Networks (BRAN); Consideration of requirements for Mobile Terminal Station (TS) in Broadband Wireless Access Systems (BWA) in the 3 400 MHz to 3 800 MHz Frequency Band".

[i.26] ETSI EN 301 997 (all parts): "Transmission and Multiplexing (TM); Multipoint equipment; Radio equipment for use in Multimedia Wireless Systems (MWS) in the frequency band 40,5 GHz to 43,5 GHz".

[i.27] CEPT/ECC Recommendation (01)04: "Recommended guidelines for the accommodation and assignment of Multimedia Wireless Systems (MWS) in the frequency band 40.5 - 43.5 GHz".

[i.28] CEPT/ECC Decision (99)15: "ERC Decision of 1 June 1999 on the designation of the harmonised frequency band 40.5 to 43.5 GHz for the introduction of Multimedia Wireless Systems (MWS) including Multipoint Video Distribution Systems (MVDS)".

[i.29] CEPT/ECC Recommendation (04)05: "Guidelines for accommodation and assignment of Multipoint Fixed Wireless systems in frequency bands 3.4-3-6 GHz and 3.6-3-8 GHz".

[i.30] CEPT/ECC Report 33: "The analysis of the coexistence of Point-to-Multipoint FWS cells in the 3.4 - 3.8 GHz band".

[i.31] ECC Decision of 30 March 2007 on availability of frequency bands between 3400-3800 MHz for the harmonised implementation of Broadband Wireless Access systems (BWA).

[i.32] Radio Spectrum Committee: "BWA in the band 3.4 - 3.8 GHz - revised draft proposal for a Commission Decision".

NOTE: Available at: http://ec.europa.eu/information_society/policy/radio_spectrum/docs/ref_docs/rsc21_public_docs/rscom07_59rev2_bwa.pdf

[i.33] "Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations".

[i.34] ITU Radio Regulations.

[i.35] COMMISSION DECISIONof 9 November 2006 on harmonisation of the radio spectrum for use by short-range devices (notified under document number C(2006)5304) (Text with EEA relevance) (2006/771/EC).

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

application: collection of user tasks which require processing, storage and communications functions to carry them out

block: spectrum assigned to an operator

classes: sets of objects that can be handled in the same way

electronic communications: are defined in Article 2 of Directive 2002/21/EC [i.4] under two different angles:

- "electronic communications network" means transmission systems and, where applicable, switching or routing equipment and other resources which permit the conveyance of signals by wire, by radio, by optical or by other electromagnetic means, including satellite networks, fixed (circuit- and packet-switched, including Internet) and mobile terrestrial networks, electricity cable systems, to the extent that they are used for the purpose of transmitting signals, networks used for radio and television broadcasting, and cable television networks, irrespective of the type of information conveyed;

- "electronic communications service" means a service normally provided for remuneration which consists wholly or mainly in the conveyance of signals on electronic communications networks, including telecommunications services and transmission services in networks used for broadcasting, but exclude services providing, or exercising editorial control over, content transmitted using electronic communications networks and services; it does not include information society services, as defined in Article 1 of Directive 98/34/EC [i.33], which do not consist wholly or mainly in the conveyance.

flexibility (in relation to authorization): "minimal conditions attached to the authorization of the use of spectrum" as stated in draft report 019 of CEPT [i.23]

flexibility (in relation to the essential requirements): results to be attained or the hazards to be dealt with are defined through the essential requirements but not the technical solution for doing so

flexible frequency band: frequency band with minimal conditions attached to the authorization of the use of spectrum

general authorization: is defined in Article 2.2(a) of Directive 2002/20/EC [i.24]:

- "general authorization. means a legal framework established by the Member State ensuring rights for the provision of electronic communications networks or services and laying down sector specific obligations that may apply to all or to specific types of electronic communications networks and services, in accordance with this Directive".

individual rights of use for radio frequencies: is defined in Article 5.2 of Directive 2002/20/EC [i.24]:

- "Where it is necessary to grant individual rights of use for radio frequencies and numbers, Member States shall grant such rights, upon request, to any undertaking providing or using networks or services under the general authorization, subject to the provisions of Articles 6, 7 and 11(1)(c) of this Directive and any other rules ensuring the efficient use of those resources in accordance with Directive 2002/21/EC [i.4] (Framework Directive)".

inheritance: typical property related to the concept of classes: when building a new derived class it will inherit properties from one or more previously-defined base classes, while possibly allowing for redefining or adding new properties

NOTE: This creates a hierarchy of classes.

licence exempt: commonly used term in the regulatory bodies, including CEPT, stating the case where the Directive 2002/20/EC [i.24] (i.e. "Whereas 5") does not apply. This is the case related to the self-use of radio terminal equipment, based on the non-exclusive use of specific radio frequencies by a user. Such use is covered by the Directive 1999/5/EC [i.11].

operating band: one or more frequency ranges that are defined with a specific set of technical conditions, in which a type of equipment can operate

NOTE: For an operating band under individual license, operators can be granted exclusive rights to use a frequency block being a part of an operating band, or be granted shared rights to use an operating band. Another option is general authorization bands. Radio equipment is usually designed to operate in one or more complete operating band(s).

service neutrality: neutrality is not explicitly defined in Article 2 of Directive 2002/21/EC [i.4]. However the "neutrality" is addressed in recitals 11, 18, 22 and 31 of that Directive, and in Article 8.1 as well.

technologically neutral regulation: regulation which neither imposes nor discriminates in favour of the use of a particular type of technology (source: Directive 2002/21/EC [i.4], whereas 18).

3.2 Symbols

For the purposes of the present document, the following symbols apply:

h_i	Reference to the status i (= 1, 2, ...) of the spectrum of any system to which a particular combination of a situation at the time of introduction, and expected chronological sequence of events applies.
l_j	Reference to the type of license j (= 1, 2, ...) of any system to which a particular combination of licensing regime, application and type of right applies.
t_k	Reference to technical issues k (= 1, 2, ...) that are relevant to a particular system.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AFA	Adaptive Frequency Agility
BEM	Block Edge Mask
BS	Base Station
BWA	Broadband Wireless Access
CEPT	European Conference of Postal and Telecommunications
CB	Citizen's Band radio
DAA	Detect And Avoid
DFS	Dynamic Frequency Selection
EC	European Commission
ECC	Electronic Communications Committee
ECS	Electronic Communication Service
EIRP	Equivalent Isotropically Radiated Power
EMC	Electro Magnetic Compatibility
ERP	Effective Radiated Power
FDD	Frequency Division Duplex
HS	Harmonized Standard
IMT	International Mobile Telecommunications
LBT	Listen Before Talk
MS	Mobile Station
MWS	Multimedia Wireless Systems
PFD	Power Flux Density
PMR	Professional Mobile Radio
PSD	Power Spectral Density
R&TTE	Radio and Telecommunications Terminal Equipment
SEM	Spectrum Emission Mask
SRD	Short Range Device
TB	Technical Body
TDD	Time Division Duplex
TX	Transmitter
UE	User Equipment
WAPECS	Wireless Access Policy for Electronic Communication Services

4 Requirements on the HS development process and classification of scenarios

4.1 General

In the current European frequency regulatory and HS development process, the following are needed:

- Identification of appropriate spectrum in the European table of frequency allocations and utilizations.
- Requirements to avoid harmful interference and facilitate effective use of spectrum.
- Other requirements (for example EMC, safety).

The identification of appropriate spectrum in the European frequency allocation table contains the definition of the frequency range in addition to other information such as the application (e.g. satellite), uplink/downlink, etc.

The focus in mandate M/406 is on the first two points above, therefore the other requirements, such as EMC, are not included in the discussion below.

The requirements to avoid harmful interference and facilitate effective use of spectrum can be further divided into requirements on the equipment and requirements on the operator or user. Exactly where the division takes place depends on the application/technology. For example, for Short Range Devices, there are typically no requirements on the user (only in exceptional cases).

This is depicted in figure 1.

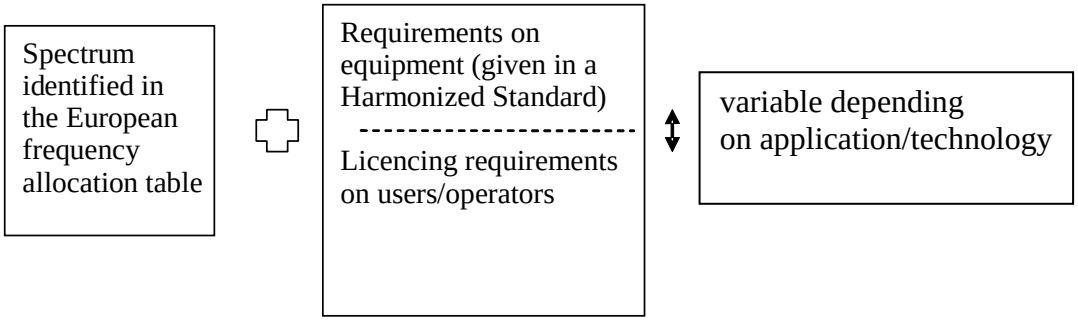


Figure 1: Illustration of the current European frequency regulatory and HS development process to avoid harmful interference and facilitate effective use of spectrum

4.2 Description of scenarios

The impact of an increase in flexibility in the use of spectrum on the design of Harmonized Standards may depend upon the scenario (or conditions) being considered. Some tables are provided in the present document in order to describe the scenarios. At a later stage, the tables may be amended, and other criteria may be developed.

Some tables in this clause have an empty column, which may be used at the time of drafting the corresponding standard (phase 2 of the mandate M/406 [i.2]).

4.2.1 Status of the Spectrum Considered

The status of the frequency band considered, including history and expected chronological sequence of events relating to it, is a criterion to classify the scenarios. Table 1 summarizes typical situations. In the table, "h" plus a subscript is used to identify each entry.

This criterion relates to the box "Spectrum identified in the European frequency allocation table" in figure 1.

Table 1: Status of the spectrum

Ref.	Situation at the time of introduction of a new technology	HS in relation to the expected chronological sequence of events	Intended policy for evolution of the HS
h_1	Green field	HS written for that particular spectrum and frozen	See for example clause 6.2.2
h_2		HS written for that particular spectrum and expected to evolve/adapt	See for example clause 6.2.2
h_3		HS written for that particular spectrum based on equipment expected for that band	
h_4	Spectrum with existing users	HS written for that particular spectrum based on equipment expected for that band	

A Harmonized Standard is written at a certain time taking into account the entry corresponding to a particular frequency band in the European frequency allocation table. If the regulators make a particular frequency band with existing users more non-specific (case h_4 in table 1), there may be effects on already existing Harmonized Standards in that band. In such a case, coordination between regulators and ETSI may be required.

4.2.2 License types and regulatory regimes

The type of license is another criterion to classify the scenarios.

Table 2 shows the license types and their relations with typical applications and type of rights. In the table, "l" plus a subscript is used to identify each license type.

Table 2: Type of license

Ref.	License type	Applications	Type of rights
l_1	General Authorization	Ad-hoc	shared
l_2		Terminals associated to networks	shared
l_3		Underlay technologies over a wide frequency range	shared
l_4		Non-specific	shared
l_5	License exempt	Ad-hoc	shared
l_6		Terminals associated to networks	shared
l_7		Underlay technologies over a wide frequency range	shared
l_8		Non-specific	shared
l_9	Individual Rights of use for radio frequencies	Ad-hoc	exclusive
l_{10}		Terminals associated to networks	shared

The license type and the regulatory regime have an important impact on Harmonized Standards, as described below.

A regulatory authorization regime could be either general or individual.

Thus it follows that the Authorization Directive 2002/20/EC [i.24] defines the specific instruments (license type/model) that supports those regimes. These instruments are respectively the "General Authorization" (as defined in Article 2.2(a)) and the "Individual Rights of use for radio frequencies" (as defined in Article 5.2).

The Authorization Directive 2002/20/EC [i.24] also excludes some types of radio terminal equipment from its provisions (i.e. whereas 5). This equipment falls under the general regulatory authorization regime but not requiring any registration and/or notification (just opposite to the "General Authorization"), however this case is still subject to some (light) regulatory conditions for spectrum use. This situation is commonly known as "license exempt".

According to the ITU Radio Regulations [i.34], an authorization regime without regulatory conditions to use spectrum does not exist. Even in a license exempt regime, some regulatory conditions to use spectrum are in force.

Explanations, supported by actual examples, are given below.

4.2.2.1 Equipment operating in shared spectrum subject to general regulatory authorization regime

The Directive 2002/20/EC [i.24] (i.e. "whereas 4 and 5") covers both ECS and non-ECS cases.

EXAMPLE 1 (ECS case): Public operated WiFi, BWA (5,8 GHz), etc.

The Directive 2002/20/EC [i.24] (Authorization Directive) applies (see article 5.1 and annex "A" condition 17), therefore an Operator will have to apply for a "General Authorization". The obligation to avoid harmful interference and promote effective use of spectrum applies both to equipment and to the Operator. The requirements are mostly on equipment side and defined in the relevant HS while for Operators some (few) requirements may be contained in the "General Authorization". This means that the dashed line in the right hand box of figure 1 is located nearly at the bottom of the box. In other words, that box almost or entirely consists of requirements on equipment.

EXAMPLE 2 (non-ECS case): SRD, private WiFi, CB, etc.

The Directive 2002/20/EC [i.24] (Authorization Directive) do not apply (see "Whereas 5"). Instead the Directive 1999/5/EC [i.11] applies. In this case the general regulatory authorization regime does not include any provision for registration and/or notification. Some regulatory provisions for spectrum use are put in force through a light regulation, for example the EC Decision on Short Range Devices 2006/771/EC [i.35]. This situation is commonly known as "license exempt".

The obligation to avoid harmful interference and promote effective use of spectrum applies to the equipment.

The requirements to avoid harmful interference and promote effective use of spectrum are defined in the relevant HS. This means that the dashed line in the right hand box of figure 1 is located at the bottom of the box. In other words, that box entirely consists of requirements on equipment.

For the equipment in the two examples above, Harmonized Standards play a crucial role to the effective use of spectrum. This is further elevated in the case of introducing flexibility in a piece of spectrum, meanwhile ensuring cohabitation of different technologies.

For these equipment (examples 1 and 2) the spectrum (co-ordination) management is supported by the (light) regulatory deliverables and Harmonized Standards playing both an important role together.

The minimum constraints would be expected to be brought in line in both the Harmonized Standards' essential parameters, and the spectrum management requirements in the regulatory deliverables (i.e. EC Decision, ECC Decision/Recommendation, National Regulations).

Both consistent with spectrum sharing analysis/studies.

4.2.2.2 Equipment operating in exclusive spectrum subject to individual regulatory regime

The Directive 2002/20/EC [i.24] (i.e. "whereas 4 ") covers both ECS(example-1-) and non-ECS(example-2-) cases.

The obligation to avoid harmful interference and promote effective use of spectrum applies both to equipment and to the license holder. The requirements on equipment are defined in the relevant HS while for the license holder (e.g. Operator) they are contained in the (license) "Individual Rights of use for radio frequencies" .

EXAMPLE 1(ECS case):

GSM. The Directive 2002/20/EC [i.24] (Authorization Directive) applies (see article 5.2). The Operator will have to apply for an *"Individual* Rights of use for radio frequencies", commonly known as "individual license"

EXAMPLE 2 (non-ECS case):

> *PMR.* The Directive 2002/20/EC [i.24] (Authorization Directive) applies (see article 5.2 and "Whereas 4"). The PMR holder will have to apply for an *"Individual* Rights of use for radio frequencies", commonly known as "individual license".

For these equipment (example 1 and 2) the spectrum (co-ordination) management is supported by the Authority responsible for license issuance and the Harmonized Standards that have an important role together with the licensing conditions.

The minimum constraints would be expected to be brought in line in both:

(a) the Harmonized Standards' essential parameters; and

(b) the spectrum management requirements in the regulatory deliverables (i.e. EC Decision, ECC Decision/Recommendation, National Regulations); for example: both consistent with spectrum sharing analysis/studies.

4.2.3 Technical issues

Technical issues are another criterion to classify the scenarios. They have impact on the parameters in the HS (which are primarily a subject for phase 2 of Mandate M/406 [i.2]) and possibly on the licensing requirements. Table 3 provides typical technical aspects. In the table, "t" plus a subscript is used to identify each entry.

This criterion relates to the right hand box in figure 1.

Table 3: Technical issues

Ref.	Technical aspect	Network architecture and coverage	Implications	Comments and notes
t_1	Organization of the network and/or its links	Point to point		
t_2		Point to multipoint		
t_3	Coverage	Coverages intended to be continuous		For example cellular
t_4		Coverages not intended to be continuous		

Examples of technical parameters to avoid harmful interference and ensure the efficient use and effective management of the radio spectrum are:

- Limits on Maximum EIRP.
- Maximum PSD/MHz or kHz etc. based on max EIRP value.
- Spectrum access/Mitigation techniques (DFS, LBT, AFA, DAA, duty cycle etc.).
- Channel plans or rasters (frequency ranges, uplink/downlink/unpaired designation etc.).

4.2.4 Graphical presentation

The criteria to describe the scenarios are presented in a tabular form (in tables 1 to 3) in clauses 4.2.1 to 4.2.3.

Another way to present the same information is to combine them into a graphical presentation, as shown in figure 2. In the figure, each of the criteria corresponds to an axis. Therefore, each particular scenario corresponds to a point in this 3D space.

If more criteria are developed in the future, then the graphical presentation would correspond to some hyperspace, where each scenario would correspond to a point of the hyper-cube. An example of a criterion that may be developed in the future is "marketing considerations".

While each scenario corresponds to a particular point, there may be points that do not correspond to a (realistic) scenario.

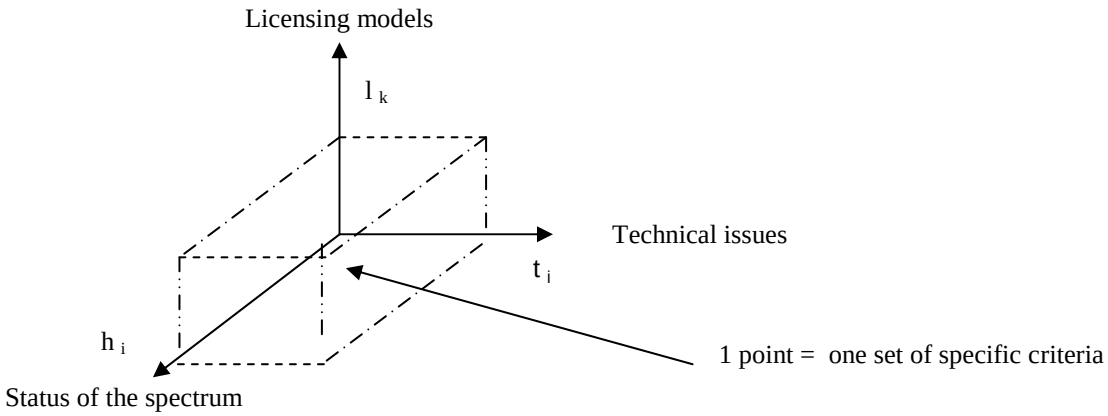


Figure 2: Cube showing 3 criteria used for the description of scenarios

Using this methodology, a set (l_k, h_i, t_j) identifies in a unique manner, each of the scenarios handled in the classification.

At a later stage, views and conclusions may be common to several scenarios (i.e. relating to several sets of points in the (hyper)cube).

5 Impact of flexibility in spectrum management on the process relevant to the development of Harmonized Standards

Flexibility in spectrum management will likely lead to changes in the process relevant to the development of Harmonized Standards. At this moment it is not precisely known what the future process will look like. In any case, the future process will need to satisfy a number of requirements. Clause 5.1 gives an overview of such requirements.

The impact of flexibility in spectrum management on the process relevant to the development of Harmonized Standards can be estimated by comparing a possible future process with the current process (see figure 3). This is done in clause 5.2.

5.1 Requirements on the future process for flexible bands

The following requirements on the processes relevant to the development of Harmonized Standards could be used to test whether future processes are satisfactory:

- The process must allow for innovation by evolution of existing technologies and inclusion of new technologies.
- The process should allow for easy addition of innovations in the member technologies of the Harmonized Standard and the introduction of new member technologies.
- The process should produce Harmonized Standards which cover the essential requirements of the R&TTE Directive.
- The process should consider the inclusion of requirements for both transmitter and receiver, depending on the type of equipment and the equipment attributes (see also EG 201 399 [i.1]).

5.2 Process relevant to the development of Harmonized Standards

The flow diagram in figure 3 describes a possible process including the development of Harmonized Standards. The diagram is a generic process description and is not intended to focus on any particular frequency band. Tables are used to compare the current system with a possible future system which facilitates more flexible frequency usage.

Figure 3: Flow chart of a possible overall process

The parameters which are proposed for a new or modified system should be complete enough in order to study compatibility/sharing with other systems, although it needs to be recognized that some characteristics may be implementation or deployment specific, and therefore "typical" or "anticipated" values may be given. For example, the following may be provided in order to calculate the probability of interference: proposed set of transmitter parameters, a proposed set of receiver parameters, and possibly the selection of a specific protocol and its parameters (such as for channel occupation). See references [i.6] and [i.7] for the exact equations.

The information for compatibility/sharing studies could be made more visible, for example, by including a reference in the European table of frequency allocations and utilizations to relevant documentation on compatibility/sharing assumptions.

NOTE: CEPT adopted a harmonised European table of frequency allocations and utilisations (in frequency range 9 kHz to 1 000 GHz). This table (see the European Allocation database) http://apps.ero.dk/ECA/) is annually updated by CEPT frequency management working group to reflect the regulatory changes that have been made the previous year.
Such table includes among others references: frequency band, European common allocation, major utilisation, ECC/ERC deliverables (see http://www.erodocdb.dk/), and standards.
Moreover, ERO is providing a European Frequency Information System (European spectrum information portal) in order to harmonise the availability of information on the use of radio spectrum among CEPT members. The European Commission adopted a Decision 2007/344/EC on harmonised availability of information regarding spectrum use within the Community. According to such Decision, Member States shall use the ERO Frequency Information System (EFIS see : http://www.efis.dk/search/general) as a common access point, in order to make comparable information regarding the use of spectrum in each Member State available to the public via the Internet.
Currently there is an ongoing investigation, at EU level, for a possible EFIS update in order to include spectrum usage rights information provided by EU member States.

Some differences between the current and possible future flexible system are given in table 4:

Table 4: Comparison of current system and flexible system

Aspect	Current system	Flexible system
Need for spectrum requests		The number of spectrum requests may be lower due to broadened authorization conditions in a particular flexible frequency band.
Information on technical parameters for compatibility studies	Some information is readily available (e.g. from Harmonized Standards, ECC/ERC documents, national radio interfaces), however the information is not always complete enough to perform compatibility/sharing studies.	The availability of information for compatibility/sharing studies may need to be improved.
Technical definitions of harmful interference	There seems to be a technical definition of harmful interference which is used in the CEPT during the assessment of the results of compatibility studies.	The technical definition(s) of harmful interference may need to be made more visible so that the results of the compatibility/sharing study can be easily assessed.
Organizing frequency bands	When the timing of requests for spectrum is independent, it may be more difficult to formulate a policy to efficiently fill the spectrum.	The organization of the band may be based on information about possible technologies solution at that time, but should as much as possible allow for future innovation and evolution within the band.

Some basic regulatory measures incorporated in the technical conditions for an operating band may facilitate efficient use of spectrum: these basic measures may vary depending upon the licensing model that may be selected to manage interference. Possible measures to facilitate efficient use of spectrum may include items such as:

- allowing systems using different duplex options (FDD and TDD), whilst ensuring that there is adequate separation (either in frequency or geography) between such systems;
- avoiding simultaneous up- and downlink transmissions of medium and high power in the same frequency band or in close adjacent bands, unless the appropriate measures are taken to ensure that interference does not occur;
- great care should be taken when deploying technologies with dis-similar properties co-frequency or at adjacent frequencies in the same operating band, for example low power (e.g. short range devices) and medium/high power equipments.

In the case of Individual Rights for use for Frequencies, some of these measures cannot be solved by the design of Harmonized Standards, but should be addressed on a regulatory level, see also annex A for further discussion. The corresponding Harmonized Standards should be able to take regulatory technical conditions as input, being a set of boundary conditions that can be incorporated in the scope of the standard.

5.3 Impact of models to define least restrictive technical conditions on the design of Harmonized Standards

CEPT report 019 [i.23] describes several models (see clause 4.4.7, in particular its table 1) which can be used to define the least restrictive technical conditions. Although the Block Edge Mask was chosen as the model to be used for the 2 500 MHz to 2 690 MHz and 3,4 GHz to 3,8 GHz bands, other models may be useful for other frequency bands to be addressed in the future.

This clause lists all models and elaborates on them where appropriate.

NOTE: At the moment of writing the present document, ECC has not finished the work on the various models. Hence the difference in size between the various clauses below.

5.3.1 Traditional compatibility and sharing analysis method

This is the method that has been often used to derive the various technical parameters ensuring co-existence between systems.

It has led to a significant number of Harmonized Standards.

It can be considered that it has been widely validated (by experience).

This method has been used directly, or implemented in simulation tools. Direct results and simulation results may complement each other.

5.3.2 The Block Edge Mask (BEM) approach to define spectrum usage rights (SUR)

5.3.2.1 Relationship between the BEM and Harmonized Standards for equipment in shared frequency bands subject to "General Authorization"

In some situations a flexible band may be occupied by a range of very different equipment.

At the time of writing this report it has not been thoroughly investigated whether a BEM could be a useful regulatory requirement for equipment subject to General Authorization i.e. shared spectrum.

Equipment under the category may operate in a shared band that readily conform to defined channel plans. In such a case there may be an opportunity to use BEMs making useful contribution towards more efficient use of the spectrum. Such an arrangement, for example, might allow co-existence between one equipment type that requires use of the whole band while another equipment that might require only a small portion of the band.

In comparison to the regulatory requirements for individually licensed bands it is likely that the shared bands may have an extra requirement that covers the sharing mechanism. The sharing mechanism may be contained in the technology specification or in the HS, in any case the HS must establish that the sharing mechanism is operating.

In order to establish if satisfactory co-existence between equipment is possible, it may be necessary to conduct compatibility studies. Based on the outcome of the study, the necessary conditions to ensure compatibility will be included within the Harmonized Standard as relevant.

5.3.2.2 Relationship between the BEM and Harmonized Standards for equipment in shared frequency bands subject to "Licence Exempt"

In some situations a shared flexible band may be occupied by a range of very different equipment, such as the case with SRDs.

As opposed to the above case (i.e. clause 5.3.2.1) and to equipment in frequency bands subject to Individual Rights of Use for radio frequencies, the shared frequency bands for "licence exempt" equipment are in general not organized into rigid channels. This allows a very high level of spectrum flexibility to be achieved.

Since BEMs are identified on the basis that a block of spectrum is assigned to a particular user/licence holder (for details see clause 5.3.2.3), it does not seem possible to apply BEMs across flexible sub-bands occupied by **licence exempt** equipment" such as SRDs, but work on this is still ongoing.

To work effectively the concept of BEMs requires scenarios in which the parameters of equipment using the flexible band are defined. (e.g. compatibility between different modulation techniques, channel arrangements, etc.) This does not apply to SRDs which can operate in many different ways.

Practically speaking the implementation of BEM limits within the band may be very difficult due to the large numbers of different equipment types that may be operating in the same geographic space, with different modulation schemes, operational channel bandwidth etc. This is further complicated by the fact that it is impossible to know the parameters of the neighbouring equipment. It therefore seems unlikely that the flexible band concept as proposed in the present document can provide any benefits to "licence exempt bands" used under very flexible conditions by equipment such as SRDs.

At present co-existence between SRDs with widely different parameters is well and flexibly achieved within ETSI by agreement on few core parameters such as suitable emission limits, spectrum masks and appropriate spectrum access and mitigation techniques. These parameters are incorporated within Harmonized Standards. These arrangements have led to optimum use of the spectrum

In order to establish if satisfactory co-existence between equipment is possible, it may be necessary to conduct compatibility studies. Based on the outcome of the study, the necessary conditions to ensure compatibility will be included within the Harmonized Standard as relevant.

An example of where such a process is applied is in the band 863 MHz to 870 MHz, which is used by a wide variety of SRDs (that also means spectrum technology neutrality).

5.3.2.3 Relationship between the Block Edge Mask and Harmonized Standards for equipment in bands subject to "Individual rights of use"

The CEPT/ECC Project Team SE42 has developed technology neutral least restrictive technical licensing conditions for frequency bands addressed in the context of WAPECS in draft CEPT report 019 [i.23].

It states: "Block edge masks control interference between radio systems …". It also states: "The technical parameters shall be applied as an essential component of conditions necessary to ensure co-existence in the absence of bilateral or multilateral agreements (see note) between operators of networks in adjacent blocks and areas (i.e. frequency and geography), …". Regarding spurious emissions, the draft report states: "The BEM requirements should be applied without prejudice to any other requirements e.g. R&TTE directive including spurious emission domain limitation. Emissions limits in the spurious domain and requirements in relation to the R&TTE Directive also apply."

NOTE: It is recognised that there will be cases where co-operation will still be needed.

The Block edge mask covers part of the requirements to prevent harmful interference. This is depicted in figure 4. The sizes of the requirements on the left hand side of the box are arbitrary. The position of the dashed line separating equipment requirements and user/operator requirements for the BEM situation is under discussion.

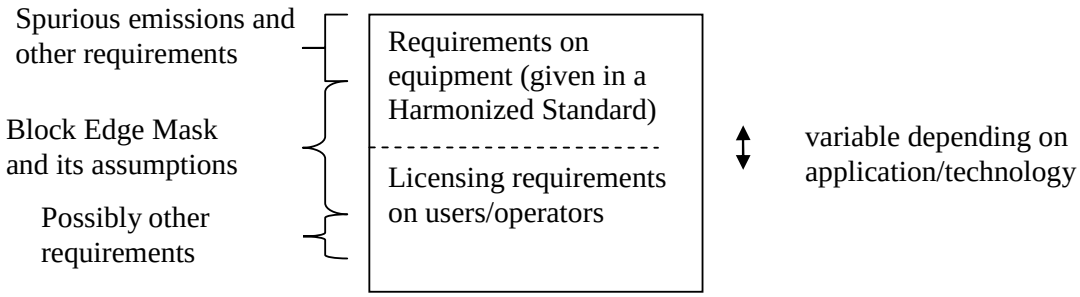


Figure 4: Division of requirements to avoid harmful interference and facilitate efficient use of spectrum

The least restrictive technical conditions for frequency bands 2 500 MHz to 2 690 MHz and 3,4 GHz to 3,8 GHz are based upon the concept of a Block Edge Mask (BEM), a requirement set in relation to the edge of each spectrum block assigned to a particular user (operator), to be met by the equipment operating in that license block.

5.3.2.3.1 Difference between spectrum emission mask and BEM

In the current approach to Harmonized Standards for frequency bands subject to Individual rights of use, equipment specific spectrum emission masks (SEM) apply to individual radio equipment and are developed to ensure both intra system and inter-system compatibility. They are usually expressed in terms of conducted power at the antenna connector of the equipment and therefore do not explicitly deal with the antennas that may be attached to the equipment. These emission masks are related to the specific transmitter characteristics and channel arrangement of the technology concerned so different technologies may have different equipment spectrum emission masks. The emission mask limits are usually set relative to the transmitted carrier (centre or carrier edge).

Block Edge Masks, on the other hand, apply to the entire block of spectrum that is assigned to an operator, irrespective of the number of channels occupied by the chosen technology that any operator may deploy in their allocated block. In the CEPT report [i.23], these masks can be specified in terms of absolute radiated power (EIRP BEM) or transmitted power (Tx power BEM). Depending on the specific deployment scenarios (e.g. compatibility between FDD and TDD), which may need different coexistence requirements with the neighbouring operator, different BEMs may apply. These

masks are intended to form part of some national authorization regimes for spectrum usage. The BEM limits are set relative to the license block of an operator.

CEPT report [i.23] proposes EIRP BEM limits and makes a point of the flexibility that can be achieved with the BEM concept , in terms of the freedom of the operators to choose and adjust several parameters to meet the BEM. These are:

1) The EIRP level (transmit power level plus antenna gain).

2) The minimum frequency separation from the block edge of outermost channels.

3) The transmit spectrum mask attenuation enhancements (additional filters, BS only).

Since EIRP is a combination of two parameters, this gives *four* parameters, of which only one (additional filters) is provided by the manufacturer, while the other three are under the control of the operator and can thus be adjusted to meet the BEM limits when deploying the equipment.

5.3.2.3.2 Impact of BEM on Harmonized Standards

The Harmonized Standard sets technical requirement that are used to demonstrate conformity with the R&TTE Directive [i.11] when placing a product such as Base Station or a Mobile Station (or User Equipment) on the market. This is demonstrated through a set of test suites in a laboratory environment. The technical requirements will include emission limits for the transmitter under test, such as spectrum emission masks and/or ACLR.

It would not be possible to directly demonstrate conformance with an EIRP Block Edge Mask in a lab environment, since the BEM limits the emissions of the deployed Base Station or Mobile Station relative to an operator license block, and not on the emissions relative to the transmitted signal at the antenna connector. The EIRP emissions of the deployed system will obviously depend on the conducted spectrum emissions of the transmitter, but they will in addition depend on transmitter power dynamics and frequency settings, chosen antenna gain, site configuration and additional attenuation enhancements provided by the manufacturer (e.g. additional BS filter) that may be implemented by the equipment or at the site.

For a Base Station, the site dependent characteristics cannot be directly part of the technical requirements of a Harmonized Standard, since in general the HS sets requirement at the antenna connector on the BS cabinet, under a set of pre-specified test conditions that are not directly related to any specific deployment. This is also the case for the MS/UE, where such parameters are also under operator control through general network presettings.

On the other hand, it would be nearly impossible to demonstrate compliance (whichever its legal relationship to R&TTE or license conditions) to the BS BEM "on site" because this would require very difficult "far field" radiated tests.

However, it might be possible to derive from the BEM limits specific test suites intended for assessing the equipment capability and its optional attenuation enhancements (e.g. block filters) in the "worst deployment situations" foreseen by the manufacturer through specific design. For example it might be possible to test that the BS spectrum mask can match the BEM (upper or lower edge) EIRP requirement under well defined conditions (declared by the manufacturer). For example the following, and others, might be considered:

- Specific power level setting(s);
- Maximum allowable antenna gain (including other losses, cables, etc.);
- Additional attenuation enhancements (e.g. block filter(s)) added;
- Minimum/maximum block size covered by those optional attenuation enhancements;
- Minimum distance from the carrier to the block edge(s).

If appropriate, under the responsibility and expertise of the relevant ETSI TB, such tests, might be considered, among other "conventional" ones, when producing a HS for radio systems in flexible bands. This approach (dedicated test and manufacturer declaration of "worst deployment conditions") might significantly reduce the possibility of "harmful interference", at least under the deployment assumptions used in the studies that have led to the BEM definition.

An example of this approach may already be found, for the MWS band 40,5 GHz to 43,5 GHz, in EN 301 997 [i.26], described in clause 5.3.2.2.4.

It will in the end be under the discretion of the license holder (operator) to set the deployment parameters in such a way that the BEM limits are met (implementing the available mitigation offered by the equipment/system flexibility) or signing specific coordination agreements (if permitted within the licensing provision) with neighbouring operators.

One possibility however is to *indirectly* reference BEM limits in a Harmonized Standard, by relating them to a spectrum emission mask that is defined at the antenna connector. Together with a manufacturer's declaration of transmitter frequency offset from a Block Edge, suitable transmitter power dynamics and usable antenna gain, conformance to the SEM requirement can be related to meeting the BEM limits. The information about the relation between BEM limits, the assumed deployment parameters and the SEM specified in the HS would be of great use to a license holder (operator) when deploying the equipment.

The details of how the SEM/BEM relationship is documented in a Harmonized Standard and whether it is informative or normative, would have to be investigated on a case-by-case basis.

5.3.2.3.3 Example 1: impact of the BEM on Harmonized Standards for the band 3,4 GHz to 3,8 GHz

The requirements to the future process of developing HSs are changing at least to the effect that can be observed in the draft EC Decision on BWA in the 3,4 GHz to 3,8 GHz band [i.32]. The requirements for this band are now expressed in e.i.r.p as a Block Edge Mask (BEM).

The basic principles of compliance have been established for BWA in the 3,4 GHz to 3,8 GHz in the following way:

1) The technical parameters (as included in the annex of the draft EC Decision [i.32]) called Block Edge Mask (BEM) are an essential component of conditions necessary to ensure co-existence in the absence of bilateral or multilateral agreements between neighbouring networks. (Establishes the "benchmark" minimum entry to the market requirement).

2) Less stringent technical parameters, if agreed among the operators of such networks, can also be used. (Allows for equipment to be used/operated that do not meet the limits set out by the Block Edge Mask and without the need for a technical file or a new HS).

3) Equipment operating in this band may also make use of e.i.r.p. limits other than those set out by the Block Edge Mask provided that appropriate mitigation techniques are applied which comply with Directive 1999/5/EC [i.11] and which offer at least an equivalent level of protection to that provided by these technical parameters. (Other deviations that may be allowed using either a different HS or a technical file route).

The overall requirements are the benchmark under 1) including the tables in the annex of the draft EC Decision [i.32] these requirements have to be translated into measurable requirements taking into account of a representative installation of a station. These measurable requirements are then developed into test cases that are taken to define the essential tests required to with a good degree of certainty prove conformance to the overall requirements. See also the discussion in clause 5.3.2.2.2 regarding the impact of BEM.

A practical approach to develop the corresponding Harmonized Standard for a particular band is by direct translation of the BEM curve into a dBc curve. The equipment would be tested at its antenna connector at its declared maximum, medium and minimum power, the roll-off curves dependency on the equipments output power is recorded. This approach will allow for the maximum technology neutrality possible provided by the BEMs and provide the users/operators with the information required to deploy the equipment in compliance with the BEMs for the band.

Depending on the subsequent market development there may be a case to either modify the Benchmark HS (see bullet 1) or to develop a new HS (see bullet 3) being representative of a modified set of requirements that has gained general market acceptance.

This approach will allow technology neutrality for this particular frequency band defined BEMs.

5.3.2.3.4 Example 2: existing ETSI Standards reflecting flexibility

In 2001 ECC Recommendation (01)04 [i.27] was published. It recommended guidelines for the accommodation and assignment of Multimedia Wireless Systems (MWS) in the 40,5 GHz to 43,5 GHz band. The anticipated characteristics of MWS systems were drawn from a number of technology standards and therefore required a flexible frequency assignment plan to account for several system types and applications including a potential mix of FDD and TDD techniques in adjacent licence blocks. In order to control emissions into neighbouring licence blocks a BEM was

developed and is detailed in annex 3 of the Recommendation. This BEM identifies in-block EIRP spectral density, block edge transition EIRP spectral density and out of block EIRP spectral density.

In 2002/2003, ETSI published EN 301 997 [i.26] with Part 2 as the Harmonized Standard covering the essential requirements of the R&TTE Directive [i.11].

This standard was developed in a manner consistent with the BEM and other elements detailed in the ECC Recommendation (01)04 [i.27] consequent to the ECC Decision (99)15 [i.28] and therefore already provides an example of an ETSI Harmonized Standard developed with flexible spectrum use in mind.

The standard reflects the expected transmitting and receiving phenomena derived based upon the ETSI guidance material for the production of Harmonized Standards but some aspects were adapted to account for the flexible spectrum use.

Notably, channel emission masks, whilst a normative requirement for standard compliance were not deemed essential requirements for the R&TTE Directive [i.11] conformity (and therefore appear only in Part 1 of EN 301 997).

There is an essential requirement in Part 2 of EN 301 997, "Block Edge minimum frequency spacing", that requires the manufacturer to characterize the equipment compliance with the BEM. The specific text is copied below.

The following is extracted from clause 4.5.3.2 of EN 301 997-2 [i.26]:

- "The manufacturer or person responsible for placing the apparatus on the market shall declare the minimum frequency spacing from the block edge(s) of each proposed type of transmitting channel, operating at maximum power, in order to fulfil the requirements referred to in EN 301 997-1 [i.26], clause 5.5.4.2."

5.3.3 BEM with Tx power

One practical difficulty with the BEM approach as defined in clause 5.3.2, is that a driving parameter of this model is ERP/EIRP, which in many cases, is not addressed directly in Harmonized Standards.

As many Harmonized Standards, to date, address conducted power, a model based on this parameter could seem more easy to relate to.

One very clear difference between conducted and radiated methods of measurement, besides the cost and complexity of the measurement, is the corresponding measurement uncertainty (by far higher in the case of radiated methods of measurement).

High measurement uncertainties may result in higher safety margins, hence sub-optimal use of spectrum.

The ECC-SE42 study leading to the CEPT Report 19 [i.23] (Response to the EC Mandate on WAPECS bands) discussed the pro and contras of having BEM limits in terms of either TX power density or EIRP density.

In principle, the EIRP BEM method is more "regulatory oriented" while TX Power BEM method is more "equipment oriented".

Being the two options which are linearly scalable through the antenna gain (including the possible additional "site losses"), the only difference lays on the coexistence assumptions which are often sensitive to the mix between TX power and antenna gain/directivity (at the same EIRP, a higher antenna directivity obviously results in less interference probability in neighbouring areas).

The CEPT Report 19 [i.23] describes BEM in term of EIRP for the 2,5 GHz to 2,69 GHz band and in term of TX power for the 3,4 GHz to 3,8 GHz band (directly derived from the ECC REC 04-05 [i.29]); however, the draft EC Decision on WAPECS, just for commonality, translates the latter into EIRP values by adding the antenna gain assumed by the relevant ECC coexistence studies (ECC Report 33 [i.30] and CEPT Report 019 [i.23]); possibly, the relationship with the antenna gain assumption would remain through cross-reference to ECC REC 04-05 [i.29].

From the ETSI EN point of view, both options might be managed, either directly (TX power BEM) or indirectly (EIRP BEM) as described in clause 5.3.2.2.2.

5.3.4 PFD masks - aggregate PFD approach

At the moment of writing the present document, ECC has not finished the work on this model.

It might be of more interest in the case of SRDs and/or l_1 to l_4 or l_g scenarios (as defined in clause 4.2).

5.3.5 Aggregate PSD Transmitter masks

At the moment of writing the present document, ECC has not finished the work on this model.

It might be of more interest in the case of SRDs and/or l_1 to l_4 or l_g scenarios (as defined in clause 4.2).

5.3.6 The hybrid approach

At the moment of writing the present document, ECC has not finished the work on this model.

5.3.7 Space centric management

At the moment of writing the present document, ECC has not finished the work on this model.

6 Impact of more non-specific designations of frequency bands on Harmonized Standards and hierarchy of standards

In the discussions on flexible use of spectrum, there is a tendency towards more non-specific designations of frequency bands.

This may imply more extensive use of co-existence protocols, and may be supported by a clear and well defined hierarchy of standards.

Such hierarchies have been extensively used in particular in ITU-T.

The model proposed in clause 6.2 is based in concepts and terminology very popular in the field of object oriented languages.

6.1 Coexistence protocols in "licence exempt" shared bands

More non-specific designations may mean that very different equipment is using the same frequency band. This may lead to an increased need for coexistence protocols in Harmonized Standards (e.g. Listen before talk, Dynamic Frequency Selection, Adaptive Frequency Agility, etc.).

Such protocols to be effective, have to be non-predatory.

6.2 Towards a hierarchy of standards based on "Classes of equipment"

One way to write/organize a set of standards supporting more flexibility (and WAPECS) may be based on concepts and terminology widely spread out, in particular in the context of object oriented languages.

In fact, this approach can be seen as an extension of modular approaches currently used by ETSI for drafting Harmonized Standards. It can be helpful, as it allows independent drafting of standards addressing the various classes.

Such drafting (that can be performed in parallel, and possibly by different teams) could be started as soon as agreement is reached on the way to organize the various classes and on the requirements on a particular class.

Examples (see clause 6.2.2) show that to a certain extent, this approach can also be used and has somewhat been used in Standards that have been already published by ETSI.

Generalizing this approach and using a more appropriate terminology could support an extended flexibility, while keeping the amount of extra work load under control.

6.2.1 General concepts

A number of concepts used in object oriented programming languages, for example C + + may be found useful both in the radio frequency world as well as, when drafting standards.

Families of radio equipment and families of standards may be thought of in terms of classes. The corresponding relations and properties can be found in table 5.

NOTE: The term of "class" has been used in the present document, as it is the term used, in general, in conjunction with object oriented languages. However, it is reminded that the term "class" is also being used in relation with the R&TTE Directive, with a very specific meaning. In order to avoid any possible confusion in the future, it should be considered to use the term "category", instead.

Table 5: Classes, their inter-relations and how they apply in the context of standards for radio equipment

Typical concepts (using the traditional terminology)	Proposed usage in the context of radio standards	Comment
Base Class	In the context of standards for radio equipment, in particular in a flexible context, would correspond to the basic requirements for the corresponding frequency band, valid for all those in the band, e.g. frequency and channelization, if any.	See, in particular CEPT/ERC Recommendation 70-03 [i.8], where some frequency bands are defined so that they are used in a particular way.
Class	Standards or parts of standards covering one particular class would cover the characteristics of particular subsets of the Base Class (e.g. high powers or low powers or underlay/overlay).	
Inheritance	Property: Equipment shall fulfil the requirements set in all the standards of the hierarchy that apply (concept of multiple inheritance).	This is a very fundamental mechanism. It provides one of the major benefits brought by this approach.
Members	A member could be one particular technology or one set of technologies.	
Derived Class	The term "derived" can be used to express the relationship in terms of hierarchy.	

As a standard (or a part there of) would correspond to a class, it would address a number of requirements to be complied with by some family of equipment, operating in a specific band, this would ensure the relation between classes, standards and technical characteristics.

6.2.2 Examples of current usage of classes

6.2.2.1 Example 1: EN 301 908

EN 301 908 [i.9] can be described as corresponding to the following structure:

- Base Class: = IMT 2000
  Part 1 of the Harmonized Standard EN 301 908 [i.9] covers all the members of the IMT 2000 family.

- Derived Classes: = the various technologies (UTRA FDD, cdma2000, etc.);
  one or more parts of the Harmonized Standard EN 301 908 [i.9] is dedicated to a particular technology

A member of a derived class could be the network of a particular operator.

Compliance with the Harmonized Standard EN 301 908 [i.9] means compliance with PART 1 **AND** with the dedicated part (example of implementation of the principle of inheritance).

A more complete hierarchy allowing to cover several systems in the same frequency band could be depicted as follows (see figure 5):

- class <frequency band>;
- derived classes IMT 2000 (EN 301 908 [i.9] adapted) AND class A … class N;
- derived class IMT2000 would have further derived classes, as is the case now (e.g. UTRA FDD)
  derived class A would/could have also further derived classes;
- "derived classes" of UTRA FDD could be "base stations", "user equipment" and "repeaters".

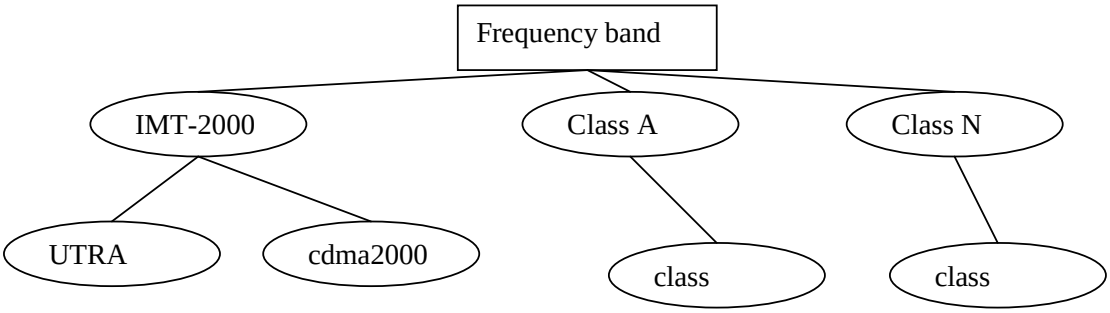


Figure 5: Example of a hierarchy in a particular frequency band

6.2.2.2 Example 2: mobile communications and broadcast

WAPECS bands could encompass, amongst others, both mobile communications and broadcast. The corresponding hierarchy might be defined as:

- Class <frequency band>
- derived class A → high powers
  derived class B → low powers
- Derived classes A and B could be further developed in turn, into derived classes, in order to accept further zooming in.

6.2.2.3 Further comments

To some extent, this approach has already been used in the context of EMC standards, where a hierarchy of standards has been used (basic/generic standards, etc.) and in the EN 301 489 series [i.10], where there is a common part together with parts dedicated to specific technologies.

In the case where a particular frequency band is not dedicated, it could, for example, support one or more classes [of equipment].

At the moment, the so called "GSM band" hosts, in reality traditional GSM, but also EDGE, GPRS, etc. This could be modelled using the Class concept.

The entries of technical criteria in table 3 could be used as classes.

6.2.3 Usage of the hierarchy as proposed above

The classification of the systems can be done taking into account the compatibility between the different systems.

With regard to compliance with standards, as it is today in the case concerning EN 301 908 [i.9], complying with the requirements set by ETSI in Harmonized Standards using the concept of classes, would mean complying with the requirements included:

- in the standard (or parts thereof) corresponding to the higher level class e.g. the base class (in the case of IMT 2000, part 1 of EN 301 908 [i.9]);
- in the standard (or parts thereof) corresponding to the appropriate intermediate class(es);
- in the standard (or parts thereof) corresponding to the dedicated lower level class.

Obviously, tracking these applicable bits and pieces may be difficult, in particular when names of services and technologies are not to be highlighted in titles (or in keywords).

Corresponding EMC standards are to be applied also (and introduces the difficulty of name matching and finding the right standard(s)).

6.2.4 Assembling Standards and parts thereof

The next question is of how to assemble material relating to the various Classes (and derived Classes) i.e. standards and parts hereof.

It may deserve further attention, just as in an everyday programming activity, the choice of how to merge code corresponding to the various Classes into files may be critical.

Experience has shown that questions such as the handling of dated references in Harmonized Standards may also be of prime relevance.

7 Impact of flexibility on the design of Harmonized Standards in flexible bands (including WAPECS) or bands where flexible usage is introduced

7.1 General requirements on the Harmonized Standard

This clause lists some general requirements on the Harmonized Standard.

The R&TTE Directive [i.11] includes the following requirements:

- ETSI shall ensure that the Harmonized Standards are appropriately updated;
- the Harmonized Standards shall be drafted in a way which allows for unambiguous interpretation.

The EC mandates to the European Standards Organizations include the further requirement that the Harmonized Standard shall be drafted to give presumption of conformity with the essential requirements in the R&TTE Directive.

ETSI has approval procedures for Harmonized Standards in the ETSI Technical Working Procedures and drafting rules in the ETSI Drafting Rules (part of the ETSI Directives).

One general requirement is that the Harmonized Standard and the corresponding technical specifications should be well aligned, in order to avoid duplication of testing.

7.2 Structure of Harmonized Standards

This clause describes a way in which a Harmonized Standard could be structured as a multi-part modular standard, taking into account the essential parameters, technical requirements, and corresponding test suites for different technologies.

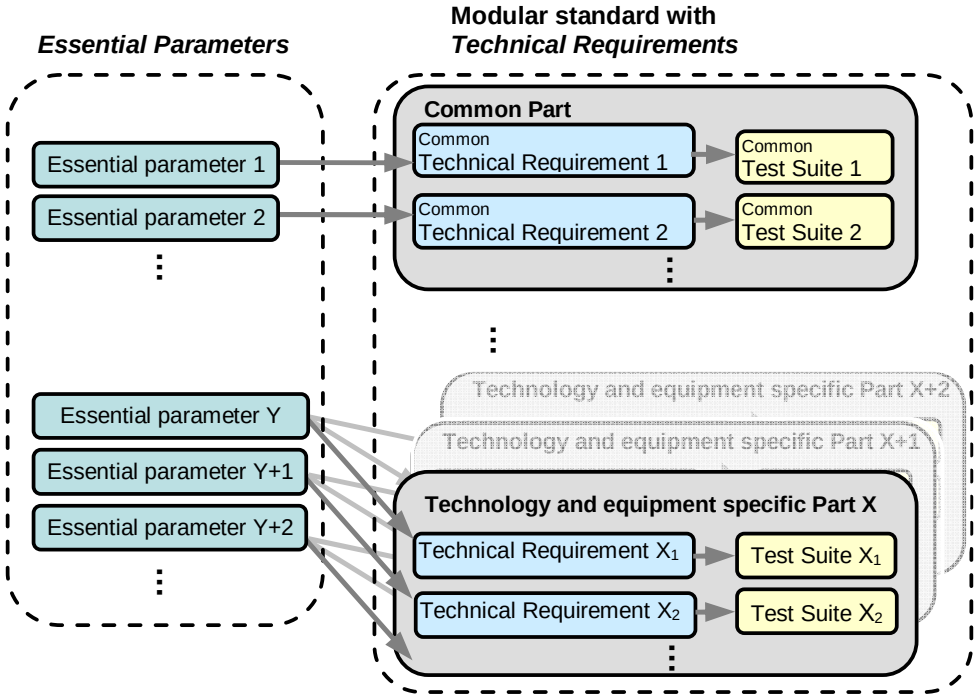
The following methodology is recommended for specifying the limits for each piece of equipment:

- First a common set of essential parameters is determined independently of the various technologies.
- Then each essential parameter is further defined by a technical requirement and the corresponding test suite.

Technical requirements and test suites that are completely common to all member technologies of the standard are put in the Common Part. As much as possible should be placed in the common part (even if the test procedures have to be given in subsequent specific parts).

If a requirement cannot be defined as common between different member technologies and/or equipment types for some reason, it is put in a specific standard part for each member technology and/or equipment type. Receiver parameter measurements as well as many other transmitter parameters are often technology specific and therefore will not fall in the set of common elements.

This methodology is depicted in figure 6.



NOTE: Each test suite is either essential or non-essential.

Figure 6: Methodology for organizing the technical requirements and test suites in a multipart standard, based on a set of essential parameters

There may need to be separate parts addressing the Base Stations and, Mobile Stations (and Repeater Stations, if appropriate).

When introducing individually licensed flexible (WAPECS inclusive) or general authorization bands or licence exempt flexible spectrum use bands, more than one technology/solution could be provided for a particular frequency band. The advantage of using a modular structure is that it easily allows modification of a single specific part or addition of a new specific part, without the need to revise other parts as well.

7.3 Content of a Harmonized Standard for equipment operating in flexible bands (including WAPECS) or bands with flexible usage

This clause only addresses elements of Harmonized Standards where the approach differs from the usual approach as a result of introducing individually licensed flexible (WAPECS inclusive) or general authorization bands or authorization-free flexible spectrum use bands.

7.3.1 Title

Currently the title for the ETSI Harmonized Standard includes the name of the ETSI Technical Body, a short description of the content, and a phrase indicating that the Harmonized Standard is under article 3.<n> of the R&TTE Directive [i.11]. Traditionally, standards addressing a particular technology would include the name of the technology in the title.

In a technology neutral (and service neutral) scenario, the link between various standards for the equipment may not be obvious anymore when using the title of the standards. Therefore it is necessary to address explicitly methods allowing the creation of links between standards in the case when titles do not include words of technologies, that can be used as keywords in a search. Searching, in any case, should be user-friendly, practical and non-ambiguous.

One possibility would be to include, in the title, the appropriate point in the hypercube presented in clause 4. An example of a title is: "... equipment to be operated in <Fresh Spectrum | ... | > for <point to point | ... | > equipment , expected to be used on shared channels under <individual | ...| > licensed regime, in the band < > MHz ... and expected to < >".

7.3.2 Scope

The ETSI Drafting Rules [i.12] require that the scope "define without ambiguity the subject of the ETSI deliverable and the aspect(s) covered, thereby indicating the limits of applicability of the ETSI deliverable or particular parts of it".

For technology-specific Harmonized Standards, it is relatively straightforward to write the scope.

For multi-technology Harmonized Standards described in general terms (without reference to specific technologies), it may be challenging to unambiguously define the subject of the ETSI deliverable, and therefore it may be difficult to write the scope. If the scope is not defined well, there could possibly be misuse of the standard to show conformity with the essential requirements of the R&TTE Directive.

In writing the scope the following elements should be taken into account:

- assumptions made should be documented (may include assumed environment);
- the scope of the standard should limit its application to the frequency band(s), taking into account the technical conditions set out for the band(s) by regulation.

The scope and the rest of the Harmonized Standard need to be clear enough so that any equipment falling within the scope and passing the requirements indeed fulfils the essential requirement article 3.2 of the R&TTE Directive.

In any case, there should be a good correspondence between the contents of the Harmonized Standard and the technical solution tested in the compatibility/sharing study.

7.4 Traceability

Manufacturers often prefer that the corresponding technical specifications and the Harmonized Standard are well aligned, in order to avoid duplication of testing. Technical specifications which are related to the Harmonized Standards may be written by standardization organizations other than ETSI. There is no change expected in this task with the introduction of more flexibility.

Additionally the conditions/assumptions of the original compatibility/sharing study are important to document. The importance of executing this task may increase with the introduction of more flexibility since there may be more scenarios to evaluate.

The exact format for the important information to be documented could be further discussed.

7.5 Coordination between Technical Bodies working on Harmonized Standards that fall within the same flexible bands (including WAPECS) or bands with flexible usage

There may be the case that the optimal (modular structure) solution as described in clause 7.2. could not be implemented.

This is the case when there are different Harmonized Standards in the same band produced by more than one Technical Body.

This can be defined as the "Harmonized Standards bouquet" case that requires high care of coordination between the involved Technical Bodies, including spectrum compatibility studies (see ETSI System Reference Document procedure) and finally a proper unambiguity and cross-correlation between the Title (see clause 7.3.1) and Scope (see clause 7.3.2) of the various Harmonized Standards falling in the same band.

This may be taken into account when the hierarchy of standards (see clause 6) will be further elaborated.

8 ETSI Work Programme for Harmonized Standards

8.1 Existing Harmonized Standards in possible future flexible bands (including WAPECS) or bands with flexible usage

Table 6 gives an overview of the existing ETSI Harmonized Standards under article 3.2 of the R&TTE Directive in possible future flexible bands.

Table 6: Overview of existing ETSI Harmonized Standards in possible future flexible bands (including WAPECS) or bands with flexible usage

Frequency band	Harmonized Standards	ETSI Group
470 MHz to 862 MHz	At the moment only Harmonized Standards for broadcast services as well as for secondary usage such as professional radio microphone usage. The broadcast Harmonized Standard is also in principle usable for e.g. DVB-H (follows EN 302 296 DVB-T [i.13]) for RF conformance.	ETSI ERM TG17
863 MHz to 870 MHz (licence exempt with flexible usage)	EN 300 220-2 [i.14] for Generic SRD plus social alarms	ETSI ERM TG28
	EN 301 357-2 [i.15]/EN 300 422-2 [i.16] for radio microphones and wireless audio	ETSI ERM TG17
	EN 302 208-2 [i.17] for RFID in the 865 MHz to 868 MHz band	ETSI ERM TG34
880 MHz to 915 MHz/925 MHz to 960 MHz (900 MHz bands)	EN 301 502 [i.18]/EN 301 511 [i.19]/ EN 301 419 [i.20] for GSM	*ETSI MSG GSM*
	EN 301 908 series for IMT-2000 [i.9]	ETSI ERM/MSG-TFES
1 710 MHz to1 785 MHz/1 805 MHz to 1 880 MHz (1 800 MHz bands)	EN 301 502 [i.18]/ EN 301 511 [i.19]/ EN 301 419 [i.20] for GSM	*ETSI MSG GSM*
	EN 301 908 series for IMT-2000 [i.9]	ETSI ERM/MSG-TFES
1 800 MHz to 1 805 MHz	No standard with regard to context of the mandate yet	-
1 900 MHz to 1 980 MHz/2 010 MHz to 2 025 MHz/2 110 MHz to 2 170 MHz (2 GHz bands)	EN 301 908 series for IMT-2000 [i.9]	ETSI ERM/MSG-TFES
2 500 MHz to 2 690 MHz	EN 301 908 series for IMT-2000 [i.9]	ETSI ERM/MSG-TFES
	Draft EN 302 544 for Personal Broadband Data Transmission Systems [i.21]	ETSI BRAN
3,4 GHz to 3,8 GHz	EN 302 326 [i.22] for Fixed Wireless Access	ETSI ATTM-TM4
	TR 102 742 [i.25] New work item for Harmonized Standard for mobile terminals that would communicate with the base stations complying with EN 302 326 [i.22]	ETSI BRAN
57 GHz to 59 GHz		

8.2 Proposals to update the ETSI Work Programme for Harmonized Standards

8.2.1 Possible future flexible spectrum use subject to "individual rights of use"

8.2.1.1 3,4 GHz to 3,8 GHz

Among possible future "individual rights of use" flex bands, 3 400 MHz to 3 800 MHz is the most appropriate band for ETSI to start with the update of its Work Program for the Harmonized Standards. The following facts and developments justify this approach.

According to table 8, there already exists the ETSI Harmonized Standard EN 302 326 [i.22] for Fixed Wireless Access. This includes both the central/base station and the terminal station. Based on the ECC Decision ECC/DEC/(07)02 "on availability of frequency bands between 3 400 MHz to 3 800 MHz for the harmonized implementation of Broadband Wireless Access systems (BWA)" [i.31], a new work item is approved within ETSI to create a Harmonized Standard for mobile terminals that would communicate with the base stations complying with EN 302 326 [i.22]. In parallel, the European Commission is in the process of developing a decision "on the harmonization of the frequency band 3 400 MHz to 3 800 MHz for terrestrial systems capable of providing electronic communications services in the

Community". In addition, WRC-07 has identified the Band 3 400 MHz to 3 600 MHz for IMT systems and ECC has mandated ECC PT1 to develop ECC deliverables addressing the frequency arrangement for this band. Due to the fact that the band 3 600 MHz to 3 800 MHz has been designated for BWA, ECC PT1 may consider this band as well even if this band is not identified for IMT by WRC-07. Also 3GPP has created a work item for developing specifications for Long Term Evolution (LTE) as one of the IMT technologies in the 3 400 MHz to 3 800 MHz band. The final 3GPP specifications will require corresponding Harmonized Standards to be created by ETSI ERM/MSG TFES.

8.2.1.2 2 500 MHz to 2 690 MHz

2 500 MHz to 2 690 MHz is another candidate for the update of the ETSI Work Program for Harmonized Standards. Given the Harmonized Standard deliverables for this band within ETSI, namely the EN 301 908 series for IMT-2000 [i.9] and EN 302 544 for Personal Broadband Data Transmission Systems [i.21], there may be a need for a careful assessment of the developments in this band, e.g. potential EC Decisions, current and future updates of ECC Decisions and national licensing regimes, before the ETSI Work Program for Harmonized Standards in this band can be updated.

8.2.1.3 880 MHz to 915 MHz/925 MHz to 960 MHz (900 MHz), 1 710 MHz to 1 785 MHz/1 805 MHz to 1 880 MHz (1 800 MHz), 1 900 MHz to 1 980 MHz/2 010 MHz to 2 025 MHz/2 110 MHz to 2 170 MHz (2 GHz)

It is too early to consider the update of the ETSI Work Program for the Harmonized Standards for the possible future flex bands 880 MHz to 915 MHz/925 MHz to 960 MHz (900 MHz), 1 710 MHz to 1 785 MHz/1 805 MHz to 1 880 MHz (1 800 MHz) and 1 900 MHz to 1 980 MHz/2 010 MHz to 2 025 MHz/2 110 MHz to 2 170 MHz (2GHz). For this purpose, it would be required to await the results of future work on these bands within European Commission and ECC.

8.2.2 Possible future flexible spectrum "licence exempt"

8.2.2.1 862 MHz to 870 MHz

A Work Programme (REN/ERM-TG28-0420-1 & -2) is in progress to further update the EN 300 220 [i.14] Harmonized Standard for Generic Short Range Devices: this has special relevance to equipment subject to licence exempt in the 862 MHz to 870 MHz band. The publication in April 2006 of EN 300 220 V2.1.1 implemented the key concept of "modular structure" for introducing "flexible spectrum use".

However, in order to implement the revised template for Harmonized Standards, a new version is being produced. This will include tables specifying operating frequency bands within 25 MHz to 1 000 MHz switching range, and the associated essential requirements (including those that are also constraints in regulatory terms) of power limits and duty cycle/LBT/AFA or equivalent techniques.

Special attention will be given to the flexible spectrum usage 862 MHz to 870 MHz band in order to clarify those essential requirements associated with the various possible choices of technologies, while ensuring "spectrum technology neutrality" and "Generic-Flexible Spectrum Use" use.

This will result in the generic standard EN 300 220 [i.14] being unambiguous and complete.

9 Conclusions

As a consequence of the trend towards flexibility in spectrum management, the current barriers to accessing the spectrum for different technologies and applications will be lowered (according to ECC report 19 [i.23]). To complement this approach, the equipment standardization process in ETSI needs to accommodate the production of harmonized standards, in a timely manner, that are appropriate for the more flexible environment. The current standards aim to provide manufacturers with a set of objective technical requirements, where compliance with the standard raises a presumption of conformity with Article 3(2) of the R&TTE Directive (avoidance of harmful interference).

In the case of individually licensed equipment, avoidance of harmful interference is not addressed solely by Harmonized Standards but also relies on the conditions attached to authorizations. In the future more flexible environment, a possible impact would be a change in the relationship between the harmonized standard and the conditions attached to authorizations. The future process must allow for innovation by evolution of existing

technologies and inclusion of new technologies, both in existing and new frequency bands. On the other hand the process is expected to ensure that no harmful interference is caused to existing services in the same flex band or neighbouring bands.

Harmonized Standards for new and evolved technologies should be made available in a timely manner. It should be noted that national conditions or requirements cannot be included in Harmonized Standards. Flexible bands should be authorized with a minimal set of conditions, as excessive requirements may reduce the flexibility. However, some conditions are required if maximum flexibility is to be obtained.

It is not fully clear yet what impact, if any, the introduction of flexible band will have on Harmonized Standards for General Authorization or License Exempt (e.g. SRD bands). At the moment of writing the present document, the CEPT/ECC work on this is not progressed to a level where it is possible to draw final conclusions.

For new technologies that do not fall within a previously defined flexible framework, the availability of information for compatibility/sharing studies will continue to be required.

For the flexible bands, a technology neutral Harmonized Standard may be developed in the first instance, and if required be supplemented with a family Harmonized Standard to cover multiple related technologies that can operate in the band. This may facilitate the inclusion of new related technologies as well as *evolution of existing technologies.* Technical requirements and the corresponding test suites should be expressed in a generic way and collected in the common part of a standard, while requirements and/or test suites that cannot be expressed in a generic format would be collected in standard parts specific to each technology (and/or equipment type).

At the time of developing an EC Decision on spectrum usage for the so called flexible or WAPECS bands, there should be a process which enables the industry, e.g. through ECC and ETSI, to work on establishing a consistency between the technical requirements of a relevant future Harmonized Standard and the technical conditions in the EC Decision under development. This can facilitate ETSI to develop in a later stage equivalent technical requirements in the relevant Harmonized Standard consistent with the EC Decision. These equivalent technical requirements could be presented as required in either a generic, or a frequency dependent or, an application specific or a technology specific Harmonized standard. ETSI will need to take into account the needs of the marketplace when considering the most appropriate working arrangements for developing a Harmonized Standard. Furthermore, it should be recognized that there may be more than one Technical Body with an interest in drafting a Harmonized Standard for a particular frequency band, and therefore co-ordination within ETSI will be required.

The use of Block Edge Masks (BEM) is proposed by EC/ECC as a technical requirement for some licensed bands (WAPECS). Since several system parameters under control of the operator will directly impact how a BEM limit is met, it may not be possible to include the BEM as such in a Harmonized Standard that defines requirements on the equipment. However, it might be possible to indirectly reference BEM limits in a Harmonized Standard, through a combination of spectrum emission limits to show conformance and a manufacturer's declaration of suitable deployment parameters. The exact solution for each HS and type of equipment needs to be investigated on a case-by-case basis.

There is no direct change in the general requirements on the Harmonized Standard with the introduction of flexibility in spectrum usage; however, in the case of the BEM for individually licensed spectrum (see CEPT Report 19), there is a change in responsibility for meeting the radiated unwanted emissions requirements of an equipment. Currently, if a piece of equipment meets the requirements of the relevant HS, an operator or licensee/user can deploy the equipment without any further considerations to radiated unwanted emissions. However, with the introduction of BEM, the operator or licensee (and to some extent also a user) is responsible for keeping the radiated unwanted emissions below the requirement of the BEM, in a similar way as it currently is for the radiated wanted power from the transmitter. In other words a direct link is established between radiated wanted power and radiated unwanted emissions.

In order to handle flexible bands in an efficient way for the industry, the established cooperation between EC, ETSI and CEPT will continue to be of high importance.

Annex A:
Some technical issues related to flexibility in bands under individual licence

A.1 Technical conditions for an operating band (individual licence)

For an operating band under an individual licence regime, the licensing authority will facilitate spectrum management by setting technical conditions for using the spectrum. Some examples of such conditions are given in clause 4 of the present document and include channel plan and raster, spectrum access and mitigation techniques. Other examples of technical conditions are Block Edge Masks and EIRP limits as proposed in the CEPT Report 19 [i.23], which are also further discussed in clause 5.3 of the present document.

The technology implemented under the licence in the operating band must operate within the technical conditions, but apart from this there should be flexibility to choose different technologies and modes of operation. Any Harmonized Standard developed for equipment intended to operate in an individually licensed operating band should have its scope and technical requirements aligned with the technical conditions set out for that operating band.

It is also highly desirable that technical conditions for bands are to a large extent harmonized. This is especially important for bands with mobile and/or nomadic use, since harmonization facilitates roaming between the coverage areas of licence holders. Harmonized Standards are in this respect also very useful tools, especially in combination with harmonized technical conditions.

The choice of technical conditions for an operating band can have a substantial effect for facilitating efficient use of spectrum. In this respect, the most important technical conditions are:

- Duplexing scheme and/or duplex direction.
- Power levels and/or PSD.

The choice of duplexing scheme as a technical condition is further discussed below.

A.2 Duplexing scheme and direction

Since the early days of radio communication, the multiple access problem has been a main driver for the evolution of radio technology. Multiple communication links are fundamentally separated through the use of narrowband transmissions separated in frequency, where the receiver selects the relevant signal with the use of receiver filters. This is still the case in modern digital communication systems, but the frequency division is often complemented with time division, code division, etc.

For any two-way communication, there is also a need for duplex separation. While many traditional system use a single communication link that is shared in time, duplex separation over two frequencies has also been implemented since early times.

The next problem to solve is communication over long distances without everyone having to use bulky high power transmitters that potentially drown everyone else in interference. This is where the cellular concept is implemented - communication is trunked through high power base stations that provide coverage over a limited area, allowing communication from and between lower power equipment located almost anywhere. The links to and from the BS are here called uplink and downlink. Separation of uplink and downlink communication is facilitated either through duplexing in the frequency (FDD) or time domain (TDD).

The bottom line is that also today's state-of-the art digital communication systems are designed to solve the same basic problems of selectivity between multiple users (multiple access), two-way communication (duplexing) and ubiquitous coverage (high power/multiple cells). The fundamental schemes to solve the problems are the same today as in the early days, while implemented with more advanced technology. Any technical conditions for an operating band must be defined with this in mind: Multiple access, duplexing and ubiquitous coverage should not be unnecessarily constrained.

The two fundamental schemes for duplexing are FDD and TDD. Both have their merits and shortcomings:

FDD relies on an a band pair dedicated to uplink and downlink operation respectively:

- Very good duplex isolation is made possible through fixed band specific duplex filters.
- Good uplink/downlink isolation is given also at high power levels and does not rely on two systems adjacent in frequency being of the same type.
- Implementation is simplified since no further filtering to separate duplex directions is needed inside the operating band. Filter costs can also be kept low by economy of scale for harmonized bands.
- Wide area coverage operation with high power transmitters is facilitated by the good duplex isolation.
- Requires a paired operating band with designated uplink and downlink parts that have some separation in frequency. Uplink/downlink capacity is fixed through the licence.
- FDD is used globally in a number of mobile/nomadic/fixed systems for wide area coverage, usually operated under individual licences with exclusive rights.

TDD relies on isolation in time (synchronization):

- Very good duplex isolation is given through strict time separation of uplink and downlink.
- Cannot give good isolation between two systems adjacent in frequency that are of different type or that are not completely synchronized.
- Implementation is simplified since no duplex filter is needed. Blocking filters are needed that give some isolation towards adjacent frequencies, but cannot give full duplex isolation.
- Local area/lower power operation is optimal, since adjacent channel interference can be more easily controlled in that case. High power, large coverage operation is more difficult due to potential adjacent channel interference.
- Can operate on a single operating band with some flexibility in terms of uplink/downlink capacity.
- TDD is used globally in a number of systems for local area/limited coverage, both for individual licence operation use with exclusive rights and for general authorization.

As is shown above, both FDD and TDD operation have their own merits and there should be operating bands with technical conditions that allow for both FDD and TDD. However, in order to have effective use of the spectrum and to avoid harmful interference between systems, there must be a fundamental separation of transmitters (aggressors) and receivers (victims) either in frequency, space and/or time. This has to be assured through the licence conditions supported by and the requirements set out in the harmonized standards.

Since FDD systems rely on frequency separation and TDD systems on time separation of uplink and downlink, there are challenges associated with mixing them in the same operating band. When a frequency band is arranged into blocks of spectrum than can form operating band(s), a block should be identified as intended to be used for either FDD or TDD. Separate frequency blocks may provide a solution and the technical conditions need to define how the FDD and TDD blocks are isolated, through e.g. specific transmitter emission limits. Separation into different operating blocks allows FDD and TDD to be deployed and function in the most efficient way. Three types of band arrangements can be defined although the specific designation would need to be evaluated against the objectives of flexibility in the licensing process:

- Uplink bands, paired for FDD operation.
- Downlink bands, paired for FDD operation.
- Unpaired bands, for TDD operation.

Frequency blocks for both TDD systems and FDD systems can be allowed within a frequency range, provided that appropriate spectrum engineering measures are taken and co-existence criteria can be met.

NOTE: For example: ECC Recommendation (04)05 for BWA in the range 3 400 MHz to 3 800 MHz.

Because of the potential for interference between FDD and TDD systems, the frequencies closest to a border between FDD and TDD can not be used with full efficiency. It is therefore desirable that the number of such FDD/TDD border areas is kept as low as possible.

History

Document history		
V1.1.1	May 2008	Publication