Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

ENHANCING HARMONISATION AND INTRODUCING FLEXIBILITY IN THE SPECTRUM REGULATORY FRAMEWORK

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0 EXECUTIVE SUMMARY

This Report has been developed by the CEPT as a preliminary investigation into the issues of harmonisation and flexibility and the current regulatory framework for spectrum management. It is intended to inform and assist CEPT members, operators, manufacturers and other interested parties and presents proposals for further work to be undertaken by ECC and its Working Groups.

1 SCOPE OF THE WORK

The radio spectrum is a key resource for electronic communication systems. Its effective management is essential for economic growth and welfare[1]. Over the years the current framework of frequency management has in general enabled timely responses to the changing technological and market requirements and in many areas improvements have been introduced. However, the question has arisen whether the current framework needs to be adapted further in the light of rapid technological evolution, changing user demand, and service convergence. Recent years have seen more frequent discussions on this issue at all levels: national, European (EU and CEPT) and international (ITU-R). The Report considers the scope for enhancing flexibility at each of these levels.

2 HARMONISATION AND FLEXIBILITY

Harmonisation is the process of defining measures at the European or international level to ensure that the utilisation of the spectrum will have sufficient commonalities. ***Flexibility*** can be understood as the ability of the spectrum regulatory framework to facilitate and adapt, in a timely manner, to user requirements and technological innovation by reducing constraints on the use of spectrum and barriers to access spectrum. Because all spectrum stakeholders legitimately wish to maximise the degree of flexibility that is given to them, the term "flexibility" may be understood differently by various stakeholders.

Harmonisation may be achieved in different ways. From a spectrum management point of view, harmonisation currently relates primarily to ***de jure spectrum*** **harmonisation**, *i.e.* to mandatory measures facilitating the coexistence of the different equipment or networks. ***De facto*** **harmonisation** may occur when, for instance, in response to market forces or perceptions of economic or commercial advantage, service providers and equipment manufacturers adopt similar usages in a given frequency band.

It should be noted that the underlying technical assumptions made during the spectrum management decision-making process also affect flexibility and therefore need to be taken into consideration.

De jure harmonisation and flexibility each deliver benefits but can also impose costs. They may therefore need to be balanced although they are not intrinsically incompatible. Introducing flexibility in harmonisation can result either in a high degree of uniformity of spectrum usage through *de facto* mechanisms or in a loss of harmonisation that may be detrimental to the development of the market and to the end-consumer. To achieve the optimal outcome, it will be necessary for the regulator to assess and weigh the relative advantages and disadvantages in each particular case.

There are different possible balances between *de jure* harmonisation and flexibility ranging from **full harmonisation to full flexibility.** There are occasions when full exclusive harmonisation is justified. This kind of intervention needs to be carefully considered, justified and proportionate. Full flexibility means that the regulator does not mandate application or technology. However, technical provisions to ensure that there will not be harmful interference remain necessary. There are intermediate levels between the two extremes that provide a greater degree of flexibility than full exclusive harmonisation while still enabling harmonisation to occur.

As indicated by industry representatives such as ETNO, the standardisation of radiocommunication equipment and the harmonisation of radio spectrum is considered as the basis for successful development and placing on the market. Nevertheless, ETNO underlined that a more flexible use of radio spectrum could facilitate a more efficient radio spectrum use.

[1] The Report deals with management of the spectrum in its entirety. However most of the issues (e.g. licensing) discussed in this report apply only to commercially used spectrum and in some cases only to terrestrial commercially used spectrum.

Trends

Technological trends, convergence of telecommunications, broadcasting and internet, strong demand for radio services, sharing techniques and globalisation are combining and make it necessary to increase flexibility in order to be able to respond quickly to new technological and commercial developments, to make optimal use of the radio spectrum and to promote European competitiveness. Making spectrum available for new services and technologies is crucial to this goal.

3 HARMONISATION, FLEXIBILITY, AND WAYS OF ENHANCEMENT ON DIFFERENT FREQUENCY MANAGEMENT LEVELS

The Report discusses the experience obtained with the current system, the possibilities of improvement of frequency management in order to enhance harmonisation and how greater flexibility might be introduced at each of the three levels of spectrum management: global, regional and national.

3.1 ITU level

The worldwide allocation level is determined by the ITU Radio Regulations, which allocate the various parts of the spectrum to specific services. Decisions to modify the Radio Regulations are taken by WRCs on the basis of consensus and are binding on all countries. The Radio Regulations reflect, at a given time, an allocation level which provides for flexibility for all countries. There may however be scope for seeking additional flexibility by amending the RR in general terms, for example by trying to widen the definition of services or to allocate more services in a given frequency band. These issues are currently being taken up again in the ITU by ITU-R Study Group I following the adoption of Resolution 951 at (WRC-03).

3.2 Regional level

3.2.1 CEPT

In recent years European harmonisation has become more dynamic. At the CEPT level, it was agreed in 2004 to review ECC Decisions every three years from date of adoption to determine the extent of implementation and take-up of use in the designated frequency bands. As a consequence of this review the ECC will decide whether to maintain, revise or abrogate existing Decisions. The main areas of further potential improvement relate to: basing harmonisation on demonstrable benefits and giving appropriate focus to spectrum designation by removing restrictions that are not necessary or proportionate and making harmonising measures technology-neutral except where justified otherwise.

ECC Decisions provide administrations with the possibility to benefit from harmonisation by committing to them. This type of harmonisation therefore leaves flexibility to individual administrations. In addition, European countries work together on long-term planning, through voluntary endeavours such as ERC Report 25, the European Common Allocation table. This provides spectrum users with clarity over the long-term future of spectrum use**.**

ECC Decisions should not include restrictions that are unnecessary or disproportionate, and should be technology-neutral and flexible except where justified otherwise.

Applications which have been subject to harmonisation measures by CEPT are not always successful. It is important that the European regulatory framework (CEPT and EU) is sufficiently effective, by being sufficiently reactive to adjust to such situations, by suppressing or amending existing Decisions/directives as necessary or by introducing less prescriptive means of regulating spectrum use.

3.2.2 European Union

Harmonisation of frequency usage conditions (based on proposals from CEPT in response to an EC mandate) may be imposed on administrations that are member states of the European Union in situations where this is considered necessary. The EU Spectrum Decision adopted in 2002 introduced a new framework for spectrum harmonisation measures, which enables the European Commission to adopt specific Commission Decisions on the basis of the comitology procedure.

EC Decisions currently define the type of service and application to be used in a given frequency band, and the associated technical, operational and regulatory provisions under which spectrum is to be used. They should be easy to adapt and should preferably contain an end date, after which they expire so that they do not stand in the way of flexibility introduced by the CEPT.

The R&TTE Directive which is the legal basis for the creation of the single market for radio products in the EU determines the requirements that products must meet (most notably the obligation to avoid interference), and the procedures manufacturers must apply in order to place such products on the EU market.

Although harmonised standards set the normal rule, the Directive offers the possibility for manufacturers to bring innovative products to the market that do not meet the standard, but nonetheless meet the requirements of the Directive. Thereby it inherently introduces elements of flexibility by allowing for innovation, albeit within an existing spectrum allocation framework

3.2.3 Basing harmonisation on demonstrable benefits

It is becoming increasingly important to move towards a frequency management regime that does not sterilise spectrum unnecessarily and is both flexible and dynamic. Harmonisation can, by making spectrum available on an assured basis, promote confidence for equipment manufacturers and service providers to invest. It can generate economies of scale, although these have to be quantified on a case-by-case basis. It also provides opportunities for consumers and users to use their equipment throughout the Community. At the European level, cross-border coordination is particularly critical. Harmonisation is clearly even more necessary where there is an operational necessity for the same frequencies to be made available on a multi-national basis. However, it is necessary to ensure that harmonisation does not increase spectrum scarcity, which may prevent services and technologies that are different from the harmonised application from accessing spectrum.

European harmonisation of a frequency band may also lead to increased refarming/reallocation cost at a national level. Therefore, CEPT should endeavour to base harmonisation measures on justified need following a cost-benefit evaluation. This could take different forms, quantitative estimates, qualitative assessments or risk analyses, taking into account the uncertainty related with market predictions. Such a cost benefit analysis should not take the form of an ECC deliverable and should not block the development of a new Decision.

3.2.4 Technology neutrality

According to the 'New Regulatory Framework for electronic communications infrastructure and associate services' of the EU, member states have to ensure that SMAs take the utmost care to make regulation technology neutral, i.e. it should neither impose the use of a particular type of technology nor discriminate against it. This does not preclude proportionate steps to promote specific services where justified.

At the same time, harmonisation of the European market and of standards is another essential requirement of the European Community.

The Framework Directive requires member states to provide effective management of radio frequencies for services. One of the conditions mentioned in the Authorisation Directive is the "Designation of service or type of network or technology for which the rights of use for the frequency has been granted". The concept of technology neutrality is therefore not in contradiction with the identification of any type of technology.

In any case, it is clearly not a task for SMAs to predict which technologies will best meet consumers' and business users' needs and so succeed commercially. This is better left to industry, standardisation bodies and market forces.

With regard to 'technology neutrality', the ECC has adopted an amendment to its Rules of Procedures that ECC Decisions should neither impose nor discriminate in favour of the use of a particular type of technology, although this does not preclude the taking of proportionate steps to promote certain specific services where this is justified. CEPT should therefore pay particular attention to the definition of application for which a frequency band is designated, and justify cases where harmonisation objectives may lead to the restriction to a particular type of technology.

3.2.5 Application definition

The ECC harmonisation process works through the designation of frequency bands for particular "applications". The list of applications currently used in ECC Decisions is described in the EFIS database.

It should also be noted that the designation of a frequency band for an application does not mean that the band is reserved exclusively for that application or technology. The definition of the word "**designation**" relies on the interpretation at a national level of the "market demand" for the application or type of technology for which a frequency band is designated. This definition does not prohibit CEPT members committed to the Decision from

conducting an auction or using other competitive procedures in which bids may be invited for the designated applications as well as for other applications or from using spectrum trading as a tool to assess market demand.

CEPT may also consider it appropriate to adopt a Decision harmonising an application in a frequency band which has already been designated for another application.

3.2.6 Ways of enhancing the regional spectrum harmonisation process

The CEPT process for designating frequency spectrum has sometimes been criticised for being too slow. Some Decisions have required more than two or three years to be finalised, reflecting on the one hand the difficult debate between different interest groups and on the other hand, the difficulty of solving complex compatibility issues resulting from the initial choice of a frequency band for operation.

The most important issue for industry is to obtain a certain degree of certainty in the process. Currently no timescales and milestones have been specified in the process starting with the System Reference Document and ending with an ECC Decision allowing the system or service. Due to the diversity of requests from ETSI, it seems difficult to adopt a single timescale valid for all requests, but CEPT could, on a case-by-case basis, indicate whether the deliverable can be expected within "one year", "two years" or "in an unpredictable timeframe".

This would result in a more responsive frequency management system which could take account of industry needs and concerns of other spectrum users and deliver harmonised frequency management solutions with regulatory certainty, all in a timely manner.

3.3 National level

3.3.1 Spectrum management

The national frequency authority has a responsibility to draw up a National Frequency Allocation Table. This Table is in many countries adopted at a rather high level. The higher the level of approval of the Table, the more stability and force it has, which also means that it takes more time and effort to modify it, hence reducing reactivity and flexibility. A degree of stability is important, however, to provide the certainty necessary for industry to make substantial and long-term investments. The National Frequency Allocation Table also reflects the specific choices made in a country. Most frequency bands are shared between various terrestrial and space services, in a way which enables the users of both services to co-exist in the same bands and in the same geographic areas with limited constraints. As a result of increased spectrum congestion, it is expected that new sharing schemes will continue to appear to enable such co-existence between services.

3.3.2 National institutional structure

It is essential that the institutional framework provides for a structure to facilitate discussions between spectrum users, government departments/agencies and independent regulatory authorities so that they can negotiate any changes to the Allocation Table, taking into account their respective spectrum requirements. Industry, operators and end-users are consulted and may provide input to this process. Such a structure should preferably be permanent and independent. Decisions should be reached by consensus. This structure has the ability to facilitate or complicate the negotiations and therefore has a significant impact on the flexibility of the spectrum regulatory framework in a country**.**

3.3.3 Role and current tools of the administrations

Monitoring

In order to ensure that transmitters are operated in accordance with licence conditions (and that harmful interference is promptly eliminated when it occurs), administrations have established monitoring facilities which require important resources, but are essential to guarantee the rights or spectrum users, in particular in terms of protection from harmful interference. Spectrum monitoring data may also provide valuable information on the actual use of frequencies.

Resolving harmful interference after it happens is therefore very costly and time-consuming and it is generally unsatisfactory for all parties involved. All possible efforts should be made *a priori* to define the conditions that avoid harmful interference and to check regularly that spectrum is used in conformity with regulations and licence conditions and, when this is not the case, to take appropriate enforcement measures.

Introduction of secondary spectrum trading and liberalisation is expected to increase the need for spectrum monitoring.

Role of SMA as trusted third party

The existence of a trusted third party is an essential element in the field of frequency management in order to bring about the necessary confidence for the emergence of new markets. Until now, administrations have successfully discharged this function. One of the main reasons for this is that changes to the spectrum regulatory framework often require access to confidential information. In particular, the fact that commercial bands are used or are likely to be used by government applications in exceptional cases imposes strong constraints in terms of frequency management.

The trusted third party also has a role to play in checking or certifying compatibility studies between systems, especially when they are subject to confidentiality. In the absence of the kind of confidence provided by administrations acting as trusted third parties, many deals between different government users and between government users and civil users that are necessary to relocate spectrum or modify sharing constraints would not be possible and flexibility would be less.

Spectrum refarming

Changing market or technical requirements may require the administration to change the Allocation Table in the public interest, for example to introduce commons, or to transfer bands from government to commercial services. Such changes are facilitated by a national decisional structure which is matched to the situation and provides financial incentives for the incumbents to move out of the band or make the necessary adjustments to allow new entrants.

Allocation fees

Optimum allocation between users may be facilitated by the use of allocation fees, encouraging these users to release spectrum to others when its retention is no longer justified. Depending on the level of the allocation fees, this approach may also make it easier to avoid spectrum hoarding and reduce inefficient use of spectrum.

Licensing methods

Licences may be granted to spectrum users through various approaches, which should be based on objective, transparent, non-discriminatory and proportionate criteria. These approaches are first-come-first-served, beauty contest or auction

Once granted, the rights and obligations associated with these licences may be transferred fully or partly from one spectrum user to another through secondary markets, where trading has been introduced.

It would be interesting to study the scope for increasing flexibility in the process of licensing.

- ***Licence conditions***

Rights and obligations attached to licences for the right of use of frequencies as defined in the Authorisation Directive are subject to certain limitations. The rights relate to the use of a given part of the spectrum to provide a given radiocommunication service, under certain conditions/limitations. It is for the SMA to decide on the level of protection to be given to radio services within its territory. In so doing it has to take into account all relevant international obligations.

In any case, spectrum is a part of the public domain and licences are granted on a revocable basis even if the licence is given to an operator for a number of years. Regulatory authorities may impose obligations to share spectrum with other services and networks, to use spectrum efficiently and to limit interference. Regulatory bodies/administrations may also impose obligations to promote competition, to contribute to the development of the internal market and to promote public interest.

More flexibility may be sought by reducing obligations, in particular in relation to the type of services that may be provided within the scope of the licence, and in relation to the associated technical parameters. This flexibility however, has to be exercised by the regulatory authority within the limits negotiated in the National Allocation Table. Any change in the terms of a licence to allow other services or relaxed technical parameters may therefore require a new negotiation at national level, and in many cases at regional or worldwide level.

Duration

Duration of use in frequency allocations may range from very short term such as for temporary use for experiments to long-term such as for GSM/UMTS. The type of services concerned, the types of use or markets addressed and the

level of investment needed to develop those services have determined the type of duration chosen by licensors when establishing licence conditions.

Operators who have to invest large amounts of money in order to develop 3G networks, for instance, need certainty and security of tenure. By granting long-term licences, spectrum managers reduce their flexibility to take back the spectrum awarded for different purposes. Shorter term durations therefore provide greater flexibility for spectrum management. On the other hand, longer licence duration provides increased flexibility to operators, in particular in the framework of a secondary market as the higher resale value enhances the opportunities to sell spectrum rights in the secondary market.

Rolling-term licences balance these considerations.

- ***Transfers of licences***

Transfers of licences have been limited in scope up to now and have mostly meant transfer in the sense of change of ownership of a company that had been granted rights of use, or modifications of existing licences.

In some cases, transfer of licences has taken place via barter or limited market mechanisms, with effective implementation upon the regulator's approval. This has provided increased flexibility in ensuring timely response to operator's/user's requirements, with allocation fees providing an economic incentive to release underused spectrum**.**

The additional benefits that may be achieved in terms of flexibility by implementing spectrum trading have been considered by RSPG in its opinion to the EC.

Modifications of licences

In the past, modifications of licences have always been possible after negotiations between the licensing authority and all affected interested parties. This will continue to apply with the introduction of spectrum trading, where prior agreement of the licensing authority will be requested before authorising change of use beyond the terms of the existing licence. If additional flexibility is requested the regulator will have to respond on a case-by-case basis to allow a change of use beyond the terms of the original licence or to make the licence more generically flexible so as to authorise a wider range of applications within the licence conditions.

If the SMA agrees to a request to modify a licence to allow a change of use, this may result in an increase in interference. An important criterion for judging the possibility of change of use is the quality of spectrum for reception. The issue for the SMA is how to provide assurance to users and transparency about the spectrum quality they can expect. In general, a decision to modify licence conditions will require a compatibility analysis, which might be complex.

Another way forward is to publish spectrum quality indicators based on present planning criteria and to allow users to negotiate variations between themselves, as long as they do not unduly affect third parties. Publication of spectrum quality indicators will ensure transparency and engender user and market confidence. However, the choice and definition of such indicators remain a challenge, given the wide range of possibility of change of use requests and the difficulty of formulating reliable and precise indicators correctly reflecting the real impact on the receiver.

Further work on developing and validating the concept of such indicators is necessary before they can be considered as a tool to allow greater flexibility in spectrum use.

3.4 Scenarios for flexibility in spectrum management

Frequency regulation is a complex matter in which technical, social, regulatory and market aspects are closely interrelated. Changes in individual sub-areas can hence cause the entire structure to shake unless the effects on other sub-areas are investigated in detail. Furthermore, both the telecommunications markets and the frequency usage in the CEPT countries vary considerably so that a certain measure intended to render frequency regulation more flexible may have a totally different impact in different countries.

Nonetheless an attempt is made to present various scenarios on the subject of "introducing flexibility in the spectrum regulatory framework". The scenarios are based on the orthogonal axes of "market flexibility" and "technology flexibility".

- Low market flexibility is characterised by investment certainty, high entry barriers, strict market and service definitions, oligopolistic markets and restrictive service and market definitions.

- High market flexibility is characterised by free competition in services, low entry barriers, no service and market definitions.
- Low technology flexibility is characterised by investment certainty, spectrum scarcity, many restrictions, technology harmonisation, consensus-driven decision process, non-interference basis, longer and more complex process for change
- High technology flexibility is characterised by minimal restrictions, boundary conditions, change of technology, reconfiguration, lower harmonisation and higher probability of interference.

The secondary market is also part of market flexibility. However, secondary market can also be introduced with low market and/or low technology flexibility.

The four scenarios thereby defined are:
prescriptive conditions, *technical flexibility*, *market approach* and *liberalised markets.* These represent different views of how to manage spectrum. The different scenarios all have benefits, drawbacks and impacts on the market. One scenario should not be considered to be applicable to all frequency bands but would rather be applicable on a case by case basis.

The scenarios for future spectrum management depict a situation where different bands, applications and spectrum management regimes can be presented and the potential for increased flexibility can be assessed. The scenarios aim at identifying the possibilities to increase the level of flexibility in spectrum management in cases and frequency bands where it would help drive innovation and foster competition. All scenarios would benefit from being introduced in a harmonised way.

3.5 Models for increasing the level of flexibility

There are already some well-known and developed models for increasing flexibility such as the “pure commons” model. Their relative advantages and disadvantages need to be determined on a case-by-case basis as they depend on national circumstances and the characteristics of the frequency band in question.

3.5.1 Flexible bands

This model is based on individual licences with minimal technical constraints and no market constraints. A flexible band may be defined as a band in which licenses are technology neutral and can be used to offer any electronic communications service, subject to conditions for the protection of services operating in neighbouring bands and ensuring safety while omitting any further parameters for the use of the band as such.

A prerequisite to such an approach would be the definition of minimum requirements for compatibility ensuring a compatible and efficient coexistence of flexible bands and conventional bands. There may still be a need for ‘site clearance’ procedures.

These frequency bands should be harmonised at European level. In addition, minimal framework conditions would need to be defined. These conditions need to ensure compatible coexistence with conventional bands.

A few possible topics for discussion are listed below without further evaluation:

- number of licence holders
- conditions for efficient band usage
- radio interface descriptions
- coexistence conditions and dispute resolution framework
- conditions for duration of band usage
- spectrum mask (radiated power, maximum interference power at the band edges)

To ensure maximum freedom for the development of a new technology, usage conditions for the protection of neighbouring frequency bands should also be restricted to a necessary minimum.

The concept will require further study to develop it further and it is recommended that CEPT should undertake work in this area.

The transition of a frequency band into a flexible band may be facilitated by spectrum trading and interference trading where the different operators negotiate coexistence conditions including possible compensation payments on commercial terms. In some geographical areas, bordering with neighbouring countries, which do not use particular

bands as flexible bands, additional regulations shall be implied, to ensure compatible coexistence of services used in those neighbouring countries. Such specific conditions will reduce benefits of flexible bands and therefore it is necessary to encourage and endeavour that, as far as possible, countries use a flexible band model.

3.5.2 Light Licensing Regime

A 'light licensing regime" is a combination of licence-exempt use and protection of users of spectrum. This model has a "first come first served" feature where the user notifies the regulator with the position and characteristics of the stations. The database of installed stations containing appropriate technical parameters (location, frequency, power, antenna etc.) is publicly available and should be consulted before installing new stations. If the transmitter can be installed without affecting stations already registered the new station can be recorded in the database. New entrants should be able to reach an agreement with existing users in case interference criteria are exceeded. The regime can enable the SMA to protect a limited number of sensitive sites while giving greater flexibility elsewhere than could be allowed without the geographical limitation.

4 TECHNICAL ASSUMPTIONS AND DEVELOPMENTS AFFECTING SPECTRUM MANAGEMENT

4.1 Basic technical assumptions in spectrum management

Experience has also shown that additional sharing possibilities between different users/systems/services have been made feasible through the introduction of new technical concepts. This can be illustrated for example with RLAN and the DFS concept, NGSO system and the epfd limits, SRD and duty cycle or listen before talk limitations. In this respect, it is striking that the concept of promoting underlay services and systems needs to be coupled with rigid requirements. Through these examples it can be seen that introducing more flexibility in the management of a particular frequency band generally results in imposing new constraints on the systems in that band i.e. limiting their flexibility in using spectrum.

4.2 New sharing approaches

The Report discusses the potential of various approaches to the sharing of spectrum by different services.

4.2.1 Interference Noise Temperature

Interference Noise Temperature is not in itself a new sharing approach, but could be seen as a means to facilitate the implementation of a new sharing approach. The basic idea behind this concept is that one of the most objective ways to gauge the impact of interference on a system is to assess the increase of noise caused by the interferer or rather "by interference". As a corollary, any system should include in its design (e.g. in its budget link), some allowance for external interference.

However, the FCC has recognised the difficulty in implementing this concept and it is now not expected to find practical application**.**

4.2.2 Cognitive Radio

The Cognitive Radio concept increases the 'intelligence' in a radio system to provide it with the functionality to adapt to its environment. Such behaviour could facilitate more efficient use of shared frequency bands and lead to new models of spectrum management.

Although the feasibility of cognitive radio is still under debate, the concept deserves to be further investigated.

4.2.3 Underlay service

The main objective of the interference noise temperature concept was to enable the definition of "underlay rights" based on interference temperature in order to increase spectrum usage and efficiency.

4.2.3.1 Real-time adaptive radio

One possible way to allow operation of underlay systems is to rely on real-time adaptive radio such as Radio LAN in the 5 GHz band.

The use of the interference temperature concept as described in the NPRM FCC 03-289 would require, in order to function effectively on an adaptive or real-time basis, a system to measure the "interference temperature" in the band and communicate that information to devices subject to the limit. A response process would also be needed to restrict

the operation of devices so as to maintain the interference temperature at or below the level of the limit. Propagation conditions have such a wide impact on interference received that it is almost impossible for a potential interferer to assess the interference it may cause on others.

Three different ways to implement such a concept are described:

- **DFS-like mechanism** : "In the simplest case, the entire process would take place within an individual device. That is, the device would measure the interference temperature at its location and make a transmit/not transmit decision based on this measurement plus the device's own contribution of RF energy. If the result of this analysis were below the interference temperature limit set for that location, the device would transmit."
- **Victim-Interferer cooperation:** "another approach would be for the receive sites of a licensed service to measure the temperature and communicate those measurements to a central site, where the interference temperature profile for the region would be computed. A message could then be broadcasted indicating the temperature values over that region."
- **Real-Time Ubiquitous Monitoring :** "A third more general case, might be to establish a grid of monitoring stations that would continuously examine the RF energy levels in specified bands, process that data to derive interference temperatures, and then broadcast that data to subject transmitters on a dedicated frequency, again perhaps with instructions how to respond."

The **third implementation option** seems to be unrealistic since it assumes costly solutions. Furthermore, making the link between interference noise temperature measured at some geographical points and the requested change of parameters of the underlay system would be very complex.

The **second implementation option** is somewhat less unrealistic but assumes a very rigid sharing scheme with consequences for both the design of the underlay system and the primary operating system.

Therefore, real-time adaptive radio is, in practice, equivalent to **Dynamic Frequency Selection**. The question is therefore about the possible extension of such a concept to other bands and other sharing scenarios.

4.2.3.2 Dynamic Frequency Selection

The DFS was originally developed within CEPT, in cooperation with ETSI, to enable the use of the 5 GHz band by RLAN in sharing with radars. This concept was subsequently endorsed at the international level through WRC-03 decisions.

With regard to generalising the DFS functionality to other cases, one has to recognise that a lot of work was required to specify DFS characteristics for RLAN. In other frequency bands and sharing scenarios, the set of conditions, or perhaps others, could also make the introduction of a new service or a new application possible. However, it has to be studied and determined on a case-by-case basis and any attempt at an overall generalisation of the DFS concept would inevitably fail.

CEPT has already started to identify other cases where techniques similar to DFS would improve the sharing situation. For example, ECC Report 37 recommends the application of this technique ("Listen Before Talk (LBT)") to facilitate sharing between different categories of Short Range Device applications in the band 863-870 MHz.

Therefore, DFS is an interesting sharing approach, but it cannot be extended without careful case-by-case studies.

4.2.3.3 Practical implementation example of a cognitive underlay radio

A generalised approach is to develop a radio that is able to sense the spectral environment over a wide available band and use the spectrum only if communication does not interfere with primary (licensed) users. These unlicensed low priority **Secondary Users (SU)** would thus be using **Cognitive Radio (CR)** techniques, to ensure non-interfering co-existence with higher priority users. The "cognitive" part of such a system will have to ensure that a secondary system is only allowed to transmit if it has predicted with an agreed high reliability that it would not intolerably degrade the reception of signals for a primary (licensed) owner. One challenge for CR implementation is how to tackle the "hidden terminal" problem, i.e. how CR could avoid interfering to the close-by primary receivers, if CR can not sense the corresponding primary transmitter e.g. due to a propagation obstacle (e.g. hill). Assuming that these difficulties are solved Cognitive Radio discovers unused capacity and creates out of this unused capacity a "virtual unlicensed spectrum" to be used in a way not constraining the licensed owner.

4.2.3.4 UWB

Another possibility to allow for underlay systems is to limit the power density of such systems to a level which would not increase significantly the interference noise temperature and therefore ensure the protection of other services and systems. However, in order to have sufficient capacity and range, such systems would have to operate over a very large bandwidth. This is the concept of Ultra-Wide Band (UWB) systems which are currently under study in regulatory and standardisation bodies.

The initial results show a contradiction between the power density limits which would be necessary to protect other radio services and those which would be necessary to enable the development of a mass-market for UWB. This area is under intensive study in Europe with a view to developing a harmonised pan-European framework for the introduction of UWB.

4.2.4 New geographical or time sharing opportunities

Geographical and, to a lesser extent, time separation have always been identified as ways to make sharing between different systems possible.

There have been many examples in the past of geographical sharing. Mesh networks could in the future provide such sharing solutions.

The possibility to allow for interruptible systems in bands where a primary service would not need to operate in a given area except for a limited duration has been envisaged. This would require detailed arrangements regarding the obligation of the interruptible system. The merit of such a solution would then highly depend on the possibility to design and market such a system under such stringent obligations.

4.2.5 Software Defined Radio / Reconfigurable Radio

The progressive miniaturisation of radios, growing computing power, and integration of communication and computing capabilities on the same chip provide the technological basis for reduced costs and increased interoperability. Radio equipment becomes increasingly re-configurable by software, and the encoding of information in signals will become more and more flexible.

Software Defined Radio is defined as a radio in which the RF operating parameters including *inter alia* frequency range, modulation type, and/or output power can be set or altered by software, or the technique by which this is achieved. In its most basic form, software defined radio may be viewed simply as an implementation technique in which signal processing hardware is replaced by programmable devices. In the broader perspective, software defined radio is a collection of hardware and software technologies that make reconfigurable wireless infrastructure and user terminals possible.

SDR technology may facilitate flexibility, through reconfigurability. However, it does not eliminate the need for radio standards or harmonised or ‘quasi-harmonised’ frequency arrangements, nor reduce the need for spectrum policy, but it may ease the frequency allocation process by allowing faster evolution and reconfiguration of radio interface, roaming facilities and easier implementation of sharing solutions.

The implementation of this technology in terminal radio equipment is a crucial issue. Indeed, SDR for networks equipment does not raise major problems insofar as it stays under the network operator’s control. But when the end user is permitted to freely install different versions of signal processing software and/or protocol stacks in a terminal, the network integrity may be at risk either by incorrect use or by an illegal act. Security as well as privacy-related problems are a key concern for operators. These issues also raise regulatory concerns under the R&TTE Directive that need to be considered further when SDR is introduced. From the end user’s point of view, SDR is expected to alleviate problems (e.g. in case of software bugs or of roaming problems) but it should not cause additional complexity in the terminal handling and should therefore preferably be invisible to the user of the terminal.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions on harmonisation and flexibility

- The changing spectrum management environment and the increasing pace of change require improvement of the spectrum management system, including increased flexibility, in order to be able to respond quickly to new technological and commercial developments so as to make optimal use of the radio spectrum and promote European competitiveness.
- The aim of the SMA should be to secure technical and economic efficiency in use of the radio spectrum. Harmonisation of the appropriate type can contribute to this.
- Demand for spectrum is expected to grow, especially in the most sought-after part of the spectrum between 300 MHz and 6 GHz. Meeting this demand will become increasingly challenging.
- Regulators cannot be sure about which applications or technologies will succeed in the market place. This is better left to standardisation bodies, industry and market forces. The role of the regulatory authorities is to adapt dynamically to industry and market requirements while taking account of the desirability of promoting a sufficient level of confidence for the market.
- Introducing more flexibility in the spectrum regulatory framework can be understood as increasing the ability of the spectrum regulatory framework to facilitate and adapt, in a timely manner, to user requirements and technological innovation by reducing constraints on the use of spectrum and barriers to access spectrum.
- Flexibility and harmonisation are not incompatible.
- A high degree of uniformity in spectrum usage can in some cases for some applications be achieved *de facto* on an industry-led basis without the need for exclusive harmonisation.
- Harmonisation in the sense of making spectrum available for designated applications or technologies to a specified timescale is generally beneficial. However costs and benefits need to be assessed in each case.
- CEPT should continue to promote publicly available standards harmonised worldwide for the benefit of the market and customers in certain markets (e.g. in the core IMT-2000 bands for 3G) and also take a positive stance *vis-à-vis* the development of other solutions (e.g. WLAN, BWA).
- Standardisation should be encouraged. and is not an activity that regulators need to lead or in which they should necessarily be heavily involved.
- Sharing is one of the main sources of flexibility in spectrum management for satisfying new requirements. New sharing techniques can be expected to enhance spectrum efficiency and provide added scope for different applications to co-exist.

5.2 Conclusion on the ITU level

Although the ITU Radio Regulations already provide for a high level of flexibility, i.e. more and more allocations are made in all parts of the spectrum, in a way that enables each country to select, for each frequency band, the specific services it wants to implement in the band, subject to coordination with its neighbours, and to certain constraints arising from sharing with space services, studies in response to Resolution 951 are supported.

5.3 Conclusions on the European level

- Pace of change, development of competing technologies and uncertainty about the future of convergence make it necessary to review spectrum management policies to strengthen innovation and European competitiveness.
- For experience to be gathered of new approaches to spectrum management, greater flexibility in harmonising measures should be allowed in appropriate cases.
- It is for SMAs to decide in the light of national circumstances whether to rely on market mechanisms to comply with ECC Decisions. Rules of Procedure and Working Methods do not preclude use of market mechanisms by those SMAs that have introduced them.

5.4 Recommendations on the European level

- To improve spectrum management at the CEPT and European level, frequency allocation and harmonisation measures should be based on the designation of frequency bands for a particular application, as a result of the following process:

  - CEPT should base harmonisation measures on demonstrated need following an evaluation of operational need, cross-border mobility, interoperability, competition (operators, networks,terminals etc.), market demand, economies of scale, effect on innovation and possible impact of limiting spectrum access for other applications.

  - CEPT should then pay particular attention to :
    - the definition of the application to which the harmonisation applies, taking into account the impact of convergence;
    - technology neutrality, which should be restricted only in specific cases where harmonisation justifies the restriction to a particular type of technology;
    - specification of the minimum necessary technical characteristics to achieve effective and efficient use of spectrum through prevention of harmful interference. In some instances limitations on technology may be justified for reasons of spectrum efficiency.

  - When CEPT has adopted a harmonisation measure, all CEPT administrations are encouraged to implement it so that the harmonised application fully benefits from a European-wide market, without prejudice to their discretion to decide whether or not to commit to the Decision. Isolated actions taken by CEPT members regardless of the European Allocation Table would have a negative impact on achieving the objectives which have been sought through harmonisation efforts. Any step in this direction should therefore be carefully considered.

CEPT has decided to regularly review harmonisation measures and to decide whether they need to be maintained, modified or withdrawn. This is an element that increases flexibility. EC Decisions should be easy to adapt and should preferably contain an end date, after which they expire. If the EC agrees on including a sunset clause in its decisions, the sunset clause of the EC decision should coincide with the first review date of the ECC Decision on which it is based. EC decisions should be drafted so as not to stand in the way of flexibility which may be introduced in the CEPT.

5.5 Conclusions on the national level

- Administrations have a number of tools at their disposal to enhance flexibility, ranging from use of regulation to refarm spectrum to market mechanisms, including incentive pricing to encourage efficiency, auctions and spectrum trading to transfer rights of use.

- Flexibility may be increased by removing unnecessary restrictions from licences, either through case-by-case variation to permit change of use or by making licences generically more flexible. In so doing, care needs to be taken not to increase interference to an unacceptable degree and to the impact on harmonisation.

- Introduction of spectrum trading is likely to add to the tasks and responsibilities of SMAs, e.g. in terms of preventing interference and observance of competition rules, while relieving them of the responsibility to select which users will generate greatest value from the spectrum.

- The scenarios for future spectrum management in section 3.5 aim at identifying the possibilities to increase the level of flexibility in spectrum management in cases and frequency bands where it would help drive innovation and foster competition for the benefit of end users and consumers. All four scenarios presented here would benefit greatly from being introduced in a harmonised way.

- Two licensing models have been described in this Report which may present interesting solutions for additional flexibility:
  - Flexible bands, where licensing conditions are laid down only for the protection of neighbouring bands whilst omitting any restrictions on services or technologies. These frequency bands should be harmonised at European level. Actions have been initiated at the CEPT level to find adequate

frequency bands for such flexible bands and for defining the minimum requirements for compatibility. This work should be proactively pursued with high priority.

- Light licensing regime, where the position and characteristics of the stations are recorded on a database on a first-come first-served basis, with responsibility for subsequent users to ensure the compatibility with previously notified stations.

5.6 Conclusions on new sharing approaches

- New sharing approaches that over time may become available on the market range from the concept of cognitive radio to underlay services and may be enabled through real time adaptive radio, Dynamic Frequency Selection or UWB, geographical and time sharing or Software Defined Radio.

- The implementation of SDR in terminal radio equipment is a crucial issue. Indeed, SDR for networks equipment does not raise major problems insofar as it stays under the network operator's control. But when the end user is permitted to freely install different versions of signal processing software and/or protocol stacks in a terminal, the network integrity may be at risk either by incorrect use or by an illegal act. Security as well as privacy-related problems are a key concern for operators. These issues should be considered before SDR is introduced. Moreover, to avoid confusing complexity of the terminal handling SDR should preferably not be perceivable by the terminal user. SDR can be seen as an appropriate means to correct software bugs in terminals or to enhance in a controlled way the terminal capabilities. The downloading of entire new terminal software packets might raise additional commercial and technical issues.

- tThe introduction of SDR will not happen as a regulatory act, but will be initiated by the manufacturers in accordance with technological capabilities and market requirements. The interest of the regulator will probably be restricted to the conformity assessment procedures and in particular the definition of responsibilities of e.g. manufacturers in case of resulting malfunction.

5.7 Areas for further study within the ECC

Areas of further study could include:

1. Study the technical and regulatory implications of the introduction of flexible bands **(Section 3.6.1)**
2. Investigate in which bands light licensing regimes could be introduced **(Section 3.6.2)**
3. Study the practical implications of the described scenarios **(Section 3.5)**
4. Study further the increased sharing opportunities mentioned in Section **4.2.**

6 STRUCTURE OF THIS REPORT

- Section 1 introduces the report.
- Section 2 discusses the concepts of flexibility and harmonisation and their relationship.
- Section 3 considers how flexibility may be enhanced at the global, European and national levels.
- Section 4 discusses technical assumptions and developments.
- Section 5 gathers together the recommendations and conclusions contained in the Report and proposes areas for further study within the ECC.

E**nhancing harmonisation and introducing flexibility in the spectrum regulatory framework**

1 INTRODUCTION

1.1 Scope of the work

The radio spectrum is a key resource for electronic communication systems. Its effective management is essential for economic growth and welfare[2].

Over the years the current framework of frequency management has in general enabled timely responses to the changing technological and market requirements and in many areas improvements have been introduced, such as accommodating new services and systems through innovative sharing approaches, or identifying globally harmonised bands for emerging services (IMT-2000, PPDR).

However, the question arises whether the current regulatory framework has to be adapted in order to cope with the rapid technological evolution, changing user demand, as well as service convergence as these increasingly occur nowadays.

In this respect, CEPT and national administrations are facing an increasing number of challenges as illustrated by the following examples:

- Some GSM licences will expire in the near future and this will lead to a debate on the renewal procedures and conditions. GSM licensees are requesting the flexibility to be able to migrate from GSM to IMT-2000 in the GSM bands . In some administrations, current regulations do not allow this flexibility.
- Some administrations are considering allowing fixed nomadic and mobile broadband wireless access technologies in the same band.
- There has been significant debate on the introduction of wideband PMR/PAMR and possible overlapping with the 3G market.

Recent years have seen more frequent discussions on the enhancement of spectrum policy, allocation principles and the introduction of spectrum trading. This debate takes place at all levels: national, European (EU and CEPT) and international (ITU-R).

At the EU level, the Council has considered in its Resolution of December 2004 on “Looking into the future of Information Communication Technologies” that the assessment of spectrum management models was relevant for European ICT policies.

More precisely, the Council considered it relevant “to continue assessing different spectrum management models with a view to a more flexible and efficient use of spectrum at European and global level, taking into account the development of new and innovative technologies as well as the methodologies which make use of market mechanisms”.

In this context, ECC Project Team 8 (ECC/PT8) on ‘Enhancing harmonisation and introducing flexibility in spectrum management’ has been tasked to:

- Conduct a study on the overall direction of harmonisation policy, bearing in mind that harmonising measures should be technology neutral, flexible and include review stages
- Investigate ways and possibilities of establishing a more flexible regulatory structure for spectrum management to better enable the introduction of new radio technologies and adapt to the changing market demand
- Study additional opportunities of spectrum sharing, including sharing on the basis of geographical area(s), time and service, as well as the possible introduction of a flexible “noise temperature limit”.

Possible changes to the spectrum regulatory framework in order to increase flexibility may relate to any of the following levels of this framework:

- ITU allocation level

[2] The Report deals with management of the spectrum in its entirety. However most of the issues (e.g. licensing) discussed in this report apply only to commercially used spectrum and in some cases only to terrestrial commercially used spectrum

- CEPT/EU allocation level
- National allocation level
- National licensing level

This ECC Report, which has been drafted in response to the above task, will investigate all levels in seeking possibilities for further flexibility in spectrum management

The Report is not advocating wholesale change to an approach that has been generally, though not universally, successful. However, it is time to review whether there are ways in which existing European policy needs to be updated in the light of current circumstances and challenges, such as a growing demand for spectrum and the emergence of new technologies. It is important to ensure that any enhancements are applied systematically and consistently in order to make harmonisation work better. The Report proposes a synthesis of the demand for flexibility and the enhancement of measures regarding the harmonisation process to meet the above challenges.

The Radio Spectrum Policy Group has already adopted an opinion on spectrum trading which addresses pros and cons of spectrum trading and the approach which should be followed by administrations to implement spectrum trading. This opinion refers to the work of ECC/PT8 on flexibility and harmonisation.

2 BACKGROUND

This section discusses the concept of harmonisation and flexibility and their relationship.

2.1 Harmonisation

Harmonisation is the term used in this Report to refer to the process of defining measures at the European or international level to ensure that the utilisation of the spectrum will have sufficient commonalities in order to avoid interference, ensure efficient use of the spectrum, promote investment, reduce cross-border coordination requirements, ensure roaming facilities and promote economies of scale. The level of commonalities, i.e. the degree of harmonisation, will vary depending on the objectives that harmonisation measures are aimed to meet.

Harmonisation may be regarded as either process or outcome. The process of harmonisation refers to the measures, such as ECC Decisions, that set conditions on which spectrum is made available throughout Europe. The outcome, on the other hand, refers to the extent to which spectrum usage is uniform throughout Europe in the sense that spectrum is used for the same application or technology and is arguably more significant.

Harmonisation may be achieved in different ways. From a spectrum management point of view, harmonisation currently relates primarily to *de jure spectrum harmonisation, i.e.* to mandatory measures facilitating the coexistence of the different equipment or networks which are part of the application to which the band is designated (power, antenna characteristics, channelling arrangements, coexistence parameters…). In some justified cases, the harmonisation measure may also address interoperability and technology requirements. *De facto* harmonisation relates to cases where, in response to market forces or perceptions of economic or commercial advantage, service providers and equipment manufacturers adopt similar usages in a given frequency band within a flexible framework, without this usage being imposed by regulators.

There are different degrees of spectrum harmonisation. For example, in some cases ECC Decisions specify only maximum power, e.i.r.p or output power, and in some other cases they specify detailed characteristics such as channelling arrangements.

Standardisation aims at *harmonising technology* by ensuring that the equipment used meets the technical requirements specified in technical *product standards* or specifications in order to provide market advantage in terms of better coexistence or interoperability, cross-border roaming, economies of scale etc. These standards are produced in bodies such as ETSI and are normally not mandated by regulation.

In the context of the introduction of market mechanisms, users of spectrum can acquire spectrum for harmonised application or technology through an auction or through trading. It is to be expected that they will do so, as the harmonised use will be of a higher value than the alternatives, taking into account transaction and refarming costs.

However, this “de facto” harmonisation model would not apply satisfactorily in all circumstances and cases due to the following reasons.

- The existence of constraints derived from public sector or governmental use or from international obligations means that administrations are better placed in these respects to identify and negotiate frequency bands with the greatest potential for harmonisation.
- Excessive transaction and refarming costs and complexity imply in some cases the need for regulatory intervention to ensure beneficial harmonisation.
- The process of identifying spectrum is closely related to the definition of the technical conditions that allow the new application to operate while protecting other spectrum users from excessive interference, particularly when a new application or technology is radically different from existing applications.

As a general rule, *de facto* harmonisation is more likely to be effective in cases in which the new standard or application is not too far removed technically from those already existing and where spectrum is already available on a harmonised basis throughout Europe.

In EEA countries, conformity of radio equipment is subject to a Declaration of Conformity pursuant to the provisions of the R&TTE Directive (1999/5/EC) rather than the Framework and Authorisation Directives. In this regard, "*Harmonised Standards*" are a specific category of standards which assume conformity to the essential requirements of the R&TTE Directive and therefore facilitate the placing of equipment on the market. As standardisation does not need to be tied to the use of particular frequencies, "Harmonised Standards" are also prepared for equipment operating in non-harmonised frequency bands. Furthermore, *harmonised standards* do not address technology and interoperability requirement and are completely distinct from *product standards.* Therefore "Harmonised Standards" are not necessarily linked to the harmonised use of radio spectrum and to the harmonisation of technology.

The *regulatory radio interface* is the technical specification imposed by an SMA on radio equipment that is allowed to be used on its territory. In accordance with the provisions of Article 7.2 of the R&TTE Directive, the SMA may restrict the right to put into service certain categories of equipment complying with the requirements of the R&TTE Directive. This provides a link between the R&TTE Directive and spectrum licensing. The term *radio interface* more generally applies to the physical layer of a radiocommunication system.

The overall harmonisation that exists in a frequency band is therefore a combination of *de jure* harmonisation (e.g. the object of an ECC or an EC Decision), which defines the minimum regulatory requirement to achieve the harmonisation objective, and the *de facto* harmonisation (success of a product standards, market development etc.). The coexistence between different equipment and networks is based on the compliance with the R&TTE essential requirements and with harmonised standards, together with spectrum use requirements as specified in the licence conditions.

2.2 Flexibility

Although the idea of the need for more flexibility in the spectrum management area is much debated, there does not seem to be any clear or common understanding of what this should cover. In fact, the term flexibility itself is a rather vague and broad term, which refers to the capacity to undergo modification or to adapt. This modification or adaptation may be in response to technical innovation, changes in user requirements or market demand. Introducing more flexibility in the spectrum regulatory framework can therefore be understood as ***increasing the ability of the spectrum regulatory framework to facilitate and adapt, in a timely manner, to user requirements and technological innovation by reducing constraints on the use of spectrum and barriers to access spectrum.***

The spectrum regulatory framework has undergone various changes over the years with the aim to be capable of adapting to evolving conditions. It has shown some flexibility in the sense of the above definition. However, the expected rise in demand for spectrum and the pace of new technological developments call for a review of the current regulatory framework and the level of flexibility it currently achieves, with a view to identifying possible areas of improvement. It is also to be noted that there is a difference between flexibility in radio spectrum management at the allocation level and flexibility in radio spectrum utilisation.

It should be noted that the above definition of the concept of flexibility applied to the spectrum regulatory framework may be in contradiction with flexibility as understood by the various stakeholders in this field. Because all spectrum stakeholders legitimately wish to maximize the degree of flexibility that is given to them, they will tend to use the term "flexibility" to support contradictory objectives. For example:

- Maximum flexibility for incumbent operators is achieved by minimising constraints on their operations, whether they arise from the same or adjacent bands, in particular when no other spectrum user is allowed to share the same band.

- Maximum flexibility for new entrants is obtained at the cost of minimising that of incumbents, in particular by maximising sharing constraints on the incumbents.
- Maximum flexibility for manufacturers is to be able to market in any country radio equipment which may have been designed for the particular regulatory framework of one country or even disregarding any particular regulatory framework, at the potential detriment of all current spectrum users in the same or adjacent bands.
- Maximum flexibility for the national body in charge of licensing is reached by maximising the spectrum available for licensing, by keeping its available spectrum and claiming more frequencies from other assigning entities or by promoting sharing.
- Maximum flexibility for the national body in charge of allocation, which is subject to particular international constraints (ITU RR, ECC Decisions, cross-border co-ordination etc.) is obtained by requesting other countries to accept more constraints in order to satisfy the requirements of new entrants, or to prevent other countries to introduce new services/applications in order to protect their own incumbent services.

In other words, any actor may tend to shift the burden of being more flexible to the others and consider that maximum flexibility is achieved by him being totally inflexible. Such contradictory objectives are normally resolved through negotiations (including in some cases through market mechanisms) among the stakeholders at local, national, bi-lateral, sub-regional, regional or global level.

Although increasing flexibility of the European regulatory framework is an important objective, care must be exercised to balance potential negative impact on:

- Harmonisation
- Confidence of the industry to develop equipment and networks
- Policy goals (coverage, broadband access etc.)
- Spectrum efficiency and protection against interference
- Existing applications and existing technologies**.**

Last, but not least, it should be noted that the underlying technical assumptions made during the spectrum management decision-making process (allocation, designation of spectrum, frequency arrangements, definition of conditions of use) also affect flexibility and therefore need to be taken into consideration.

2.3 Interrelation between harmonisation and flexibility

The relationship between harmonisation and flexibility is complex. Harmonisation itself can be more or less flexible and introducing flexibility in harmonisation can result either in a high degree of uniformity of spectrum usage through *de facto* mechanisms or in a loss of harmonisation that may be detrimental to the development of the market and to the end-consumer. *De jure* harmonisation and flexibility each deliver benefits but can also impose costs. They may therefore need to be balanced although, as discussed elsewhere in this Report, they are not intrinsically incompatible. To achieve the optimal outcome, it will be necessary for the regulator to assess and weigh the relative advantages and disadvantages in each particular case.

It is also necessary to balance conflicting interests when lifting restrictions on spectrum use. As illustrated in section 2.2, an increase in flexibility for one stakeholder might adversely affect other stakeholders' use of spectrum and may require additional technical constraints to be imposed in order to avoid harmful or unacceptable interference. Where this balance is struck will depend on the current rights and future legitimate expectations of the respective parties.

The need for balance applies at different levels. For example:

- Harmonisation for an application at the European level provides general benefits in terms of access to market and free circulation of equipment, but may limit the flexibility of national administrations to provide for an application for which they have specific need.
- Harmonisation of technology may help market development and foster competition, but should not prevent innovation and evolution of technologies.
- Harmonisation of spectrum use such as channelling arrangement provides a means to limit interference, but may limit flexibility by excluding some category of technology (e.g. FDD vs. TDD).
- Harmonisation of characteristics of stations such as unwanted emissions facilitates coexistence in adjacent blocks, but puts constraints on possible technologies, thereby reducing flexibility.

There are different possible balances between *de jure* harmonisation and flexibility ranging from full harmonisation to full flexibility. There are occasions when full harmonisation is justified, for example to ensure a harmonised approach to spectrum for safety-related services or possibly for those implying European or global deployment or for other policy reasons. This kind of intervention needs to be carefully considered, justified and proportionate. Full flexibility means that the regulator does not mandate application nor technology. However, technical provisions to ensure that there will not be harmful interference remain necessary. The interrelation between harmonisation and flexibility depends – as regards spectrum utilisation - on the specific conditions in a given frequency band.

Figure 1 below illustrates schematically the balance between different types of harmonisation and flexibility.

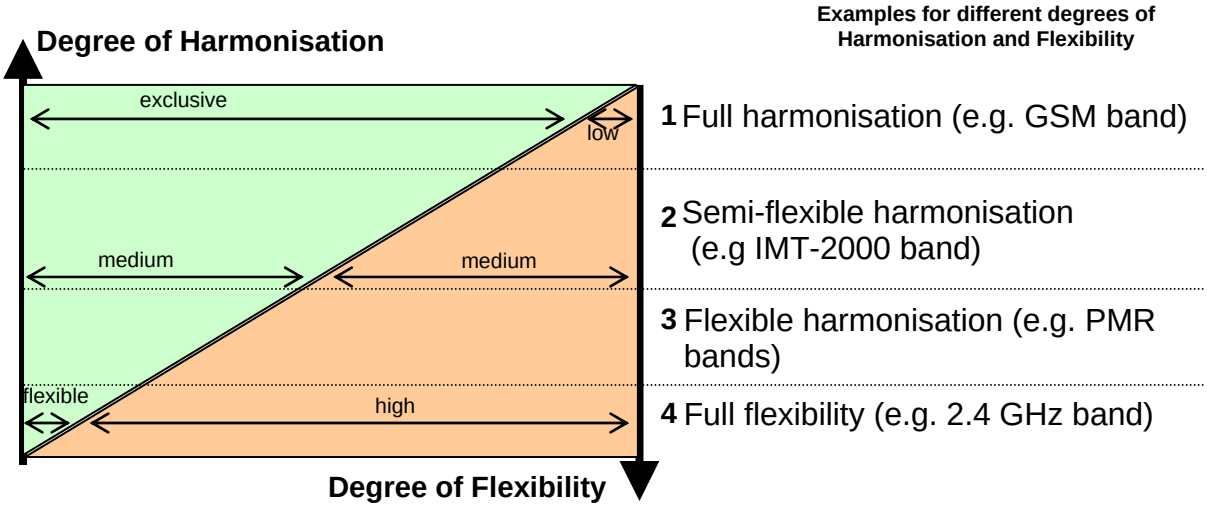

Figure 1: Harmonisation and flexibility

It should be noted that "harmonisation" here refers to *de jure* harmonisation. In practice, flexibility does not exclude *de facto* harmonisation.

Both *de jure* harmonisation and flexibility should be viewed as a means to achieve the spectrum managers' objectives, which may be defined by national or European legislation, rather than as ends to be pursued for their own sakes. In particular it is recommended to evaluate the appropriateness of *de jure* harmonisation and flexibility for each application on a case-by-case basis.

As indicated by industry representatives such as ETNO (see **Annex 9**), the standardisation of radiocommunication equipment and the harmonisation of radio spectrum is considered as the basis for successful development and placing on the market. Nevertheless, ETNO underlined that a more flexible use of radio spectrum could facilitate a more efficient radio spectrum use.

Therefore sufficient experience has to be gained before appropriate regulation modifications can take place and a careful and progressive approach is favoured. The EC and the CEPT should be involved in order to adopt a common approach.

2.4 Trends

The changing spectrum management environment and the increasing pace of change require improvement of the spectrum management system, including increased flexibility, in order to be able to respond quickly to new technological and commercial developments so as to make optimal use of the radio spectrum and promote European competitiveness. Making spectrum available for new services and technologies is crucial to this goal.

Five main factors underlie the need to adapt spectrum management policy and methodology:

a) Technological trends;
b) Convergence of telecommunications, broadcasting and internet;
c) Strong demand for radio services
d) Sharing techniques
e) Globalisation

These are considered in the following paragraphs.

2.4.1 Technological trends

In the key mobile sector, wireless technologies are being developed not just under the ITU-R umbrella (IMT-2000 family) but also in standardisation bodies such as IEEE. Proprietary technologies are also emerging and need to be taken into consideration. New standards are being developed at a quicker pace. The task of making spectrum available for these new technologies is presenting new challenges. As technological innovation happens in both forms, development of new technologies and further evolution of existing technologies, spectrum management has also to take account of further evolution of already existing technologies. The different aspects of innovation by development of new technologies and further evolution of existing technologies are given in **Fig. 2** below. Further aspects related to 3GPP and IEEE-standard development are outlined in **Annex 1.**

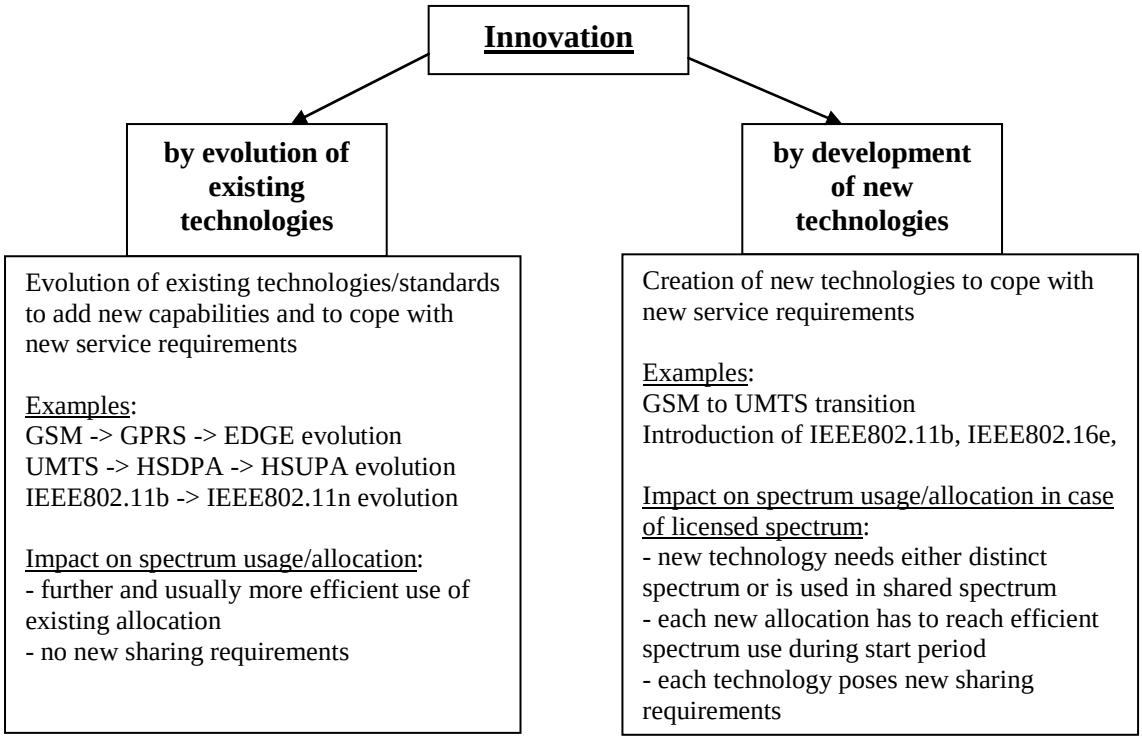

Figure 2: Types of innovation and their impact on spectrum usage/allocation

In this context, CEPT should continue to promote publicly available standards harmonised worldwide for the benefit of the market and customers in certain markets (e.g. in the core IMT-2000 bands for 3G) while also taking a positive stance *vis-à-vis* the development of other solutions (e.g. WLAN, BWA).

Some of the mobile technologies developed in IEEE and mentioned in **Annex 1** may address a similar market as IMT-2000 technologies, i.e. full mobility radio interface. At the same time, 3GPP and 3GPP2 are studying the merit of an evolution of IMT-2000 which would include similar technologies (e.g. IP over mobile, new modulation schemes such as OFDM). Although it is unclear what the situation will be in few years the task of administrations in this context should be limited to ensuring that IMT-2000 will evolve in a harmonised framework.

It is not a task for regulatory authorities to predict which technologies and applications will best meet consumers' and business users' needs and so succeed commercially. This is better left to industry, standardisation bodies and market forces. The role of the regulatory authorities is to adapt dynamically to industry and market requirements while taking account of the desirability of promoting a sufficient level of confidence for the market.

2.4.2 Convergence of telecommunications, broadcasting and internet

Convergence, the 'coming together' of hitherto separate contents and platforms driven by digitisation and Internet standardisation, adds to the dynamics of the present situation.

Telecommunication markets are increasingly converging. The 'explosion' of Internet plays an important role in this trend and IP is a driver everywhere. The borderlines between vertically integrated solutions are getting blurred. Operators start to compete on each other's 'territories':

The trend towards mobile broadcasting receivers (even integrated in mobile telephones) will as a next step lead to fully integrated terminals that can offer video and sound with broadcasting quality combined with all facilities of future public mobile telecom networks and their voice and Internet capabilities.

Digital broadcasting technologies are spectrally significantly more efficient than analogue technologies. Therefore, after completion of the transition from analogue to digital services, the current broadcasting service could be provided using less spectrum. This would allow the introduction of other applications and systems in the remaining spectrum. This is commonly called the "digital dividend".

The digital dividend may be used in various ways which may partially overlap given the technical convergence:

- more broadcasting services (e.g. increase in the number of channels, regional programming);
- new applications within broadcasting services (e.g. HDTV, portable or mobile reception);
- communication services other than broadcasting.

Similar services are increasingly provided through different technologies which operate in bands allocated to different services. For example, broadcast content can already be provided to handsets through 3G, W-LANs or DVB-H technologies. Furthermore, FWA technologies can be used in a nomadic, and potentially mobile, mode. Mobile technologies have also been used for broadband wireless access for years. New converged products appear almost daily and this process can be expected to continue and accelerate over the coming years. In the light of this, designation of spectrum for applications that are too specific would be too restrictive and hold back innovation. As far as the Radio Regulations are concerned, the present framework is considerably flexible, although it remains to be seen whether this flexibility is sufficient to allow for desirable future developments. .

It is impossible to predict how markets will develop in the future and the impact that convergence will have on spectrum use. There are diverging views about the types of converged services that may emerge, each leading to different conclusions on the level of spectrum demand.. Consequently, it is clear that the CEPT spectrum management framework needs to be sufficiently flexible and dynamic to respond to convergence developments, if it is to promote maximum benefits for consumers and European competitiveness.

The issue of convergence is also addressed in the development of the WAPECS (Wireless Access Policy for Electronic Communications Services)[3] concept within RSPG. The RSPG Opinion on WAPECS provides insights into how harmonisation policies will need to adapt to the phenomenon of convergence so that spectrum may be made available on a service, application and technology neutral basis.

2.4.3 Strong spectrum demand for radio services

The development of radio services over the last decade, particularly mobile services, SRDs and access technologies, has led to a massive increase in demand particularly in the 300MHz - 6GHz range since this offers the optimum combination of mobility, data capacity and range. Special care is needed to avoid blocking desirable innovation by denying access to this valuable spectrum.

[3] The main objective is to develop policy approaches ensuring that spectrum issues related to the growing and evolving variety of radio access platforms for public wireless communications comply with the overall policy goal to develop the EU internal market and European competitiveness, by ensuring an innovation-friendly and consistent regulatory environment which facilitates rapid access to spectrum for new technologies and leads to the provision of a wide variety of wireless services and applications. The objective will be fostered by the introduction of more flexibility in the conditions of use of spectrum resources for wireless electronic communications, while maintaining harmonisation where necessary within a coherent and spectrally efficient frequency management scheme, noting that there is a large variety of services and a large number of wireless access platforms potentially operating in various frequency bands, but which target similar mass markets. Adapting regulation to the long-term functional convergence of markets and services is therefore essential.

2.4.4 Sharing techniques

Sharing is a key instrument in spectrum management, which is used in a systematic way to enable different technologies and radiocommunication services to coexist in the same band in the same timeframe, rather than phasing out incumbents to accommodate new users.

Shared use is based on geographical, time or frequency separation or combinations thereof. In practice, sharing is generally ensured either by operating different services/systems in different locations or at a different time (e.g. in different countries, different parts of a country or in rural/urban areas etc.), or in future by using new sharing techniques such as cognitive radio.

Since spectrum is limited, sharing will continue to be used to accommodate new requirements, with an increasing variety of approaches, taking advantage in particular of time or geographical factors as implemented in the DFS (dynamic frequency selection) feature specified in the 5 GHz RLANs (See Decision ECC/DEC/(04)08[4]) or in the epfd limits for sharing between NGSO and GSO satellite systems.

Sharing is therefore one of the main sources of flexibility in spectrum management for satisfying new requirements.

Chapter 4 of this Report discusses new approaches to sharing.

2.4.5 Globalisation

Due to globalisation, people around the globe are more connected to each other than before. Information and money flow more quickly than ever. Goods and services produced in one part of the world are increasingly available in all parts of the world.

This trend has an impact on spectrum management. Equipment developed in one region, especially equipment that does not require network connection (SRR, SRD, UWB), will increasingly be used in other regions (possibly causing interference) and lead to pressure on frequency managers to make the relevant spectrum available. Recent examples are FM transmitters and some SRDs.

Manufacturers produce more and more for global markets, which makes worldwide harmonisation processes essential for them and in some cases calls for more detailed harmonisation. This was recently illustrated by the considerable mobilisation from industry to support CEPT in obtaining mobile allocation in the 5GHz range for wireless access systems including RLAN, at WRC-03.

Therefore, spectrum management has to be sufficiently responsive to this requirement for worldwide harmonisation and market globalisation.

In the above context of convergence, globalisation and increased demand for spectrum, it is necessary to analyse at each level of the existing spectrum framework how harmonisation goals can be pursued and flexibility improved so as to allow for the deployment of innovative services while ensuring the most efficient use of spectrum. This is the scope of the following Chapter.

2.5 Conclusions

- The changing spectrum management environment and the increasing pace of change require improvement of the spectrum management system, including increased flexibility, in order to be able to respond quickly to new technological and commercial developments so as to make optimal use of the radio spectrum and promote European competitiveness.
- The aim of the SMA should be to secure technical and economic efficiency in use of the radio spectrum. Harmonisation of the appropriate type can contribute to this.
- Demand for spectrum is expected to grow, especially in the most sought-after part of the spectrum between 300 MHz and 6 GHz. Meeting this demand will become increasingly challenging.
- Regulators cannot be sure about which applications or technologies will succeed in the market place. This is better left to standardisation bodies, industry and market forces. The role of the regulatory authorities is to adapt dynamically to industry and market requirements while taking account of the desirability of promoting a sufficient level of confidence for the market.

[4] ECC/DEC/(04)08 of 9 July 2004 on the harmonised use of the 5 GHz frequency bands for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs)

- Introducing more flexibility in the spectrum regulatory framework can be understood as increasing the ability of the spectrum regulatory framework to facilitate and adapt, in a timely manner, to user requirements and technological innovation by reducing constraints on the use of spectrum and barriers to access spectrum.
- Flexibility and harmonisation are not incompatible.
- A high degree of uniformity in spectrum usage can in some cases for some applications be achieved *de facto* on an industry-led basis without the need for exclusive harmonisation.
- Harmonisation in the sense of making spectrum available for designated applications or technologies to a specified timescale is generally beneficial. However costs and benefits need to be assessed in each case.
- CEPT should continue to promote publicly available standards harmonised worldwide for the benefit of the market and customers in certain markets (e.g. in the core IMT-2000 bands for 3G) and also take a positive stance *vis-a-vis* the development of other solutions (e.g. WLAN, BWA).
- Standardisation should be encouraged and is not an activity that regulators need to lead or in which they should necessarily be heavily involved.
- Sharing is one of the main sources of flexibility in spectrum management for satisfying new requirements. New sharing techniques can be expected to enhance spectrum efficiency and provide added scope for different applications to co-exist.

3 HARMONISATION, FLEXIBILITY AND WAYS OF ENHANCEMENT ON DIFFERENT FREQUENCY MANAGEMENT LEVELS

3.1 Background

The previous section discussed the concepts of harmonisation and flexibility. This section considers how the conclusions of the previous section may be applied to the three different levels of spectrum management: global, regional and national. It also discusses how we might introduce greater flexibility.

The radiocommunication sector is organised internationally within the framework of the International Telecommunication Union (ITU), which provides the basic technical and regulatory framework for the global coordination and management of the radio-frequency spectrum.

Between ITU and national frequency management, regional organisations establish common positions in preparation for ITU decisions, to harmonise national frequency allocations within the relatively flexible framework set by the ITU. The aim is to allow for the coordinated introduction of new services in existing frequency allocations and to harmonise standards and procedures to allow free circulation and use of radiocommunication terminals in the countries concerned.

It must be emphasised that only a few frequency bands are allocated exclusively to a single radiocommunication service. In most cases frequency bands are shared by many radiocommunication services; the sharing conditions are regulated by technical compatibility rules decided after extensive studies and discussions between administrations and adopted by World Radiocommunications Conferences (WRC) as part of amendments to the ITU Radio Regulations (RR). Administrations are bound by the RR, which have the status of an international treaty.

Regional organisations active in frequency management are:

- The European Conference of Postal and Telecommunications Administrations (CEPT), which deals mainly with spectrum management, spectrum engineering and regulatory questions through working groups of the Electronic Communications Committee (ECC). The objective is to harmonise frequency use in Europe in conformity with the RR, based on the principle of equitable access to frequencies for all administrations and the efficient use of frequencies. ECC Recommendations and Decisions are usually adopted by consensus.
- The European Union (EU) which has established a regulatory framework for strategic planning and harmonisation of spectrum use within the Union with the objective of ensuring availability of radio spectrum. In particular, the EU Radio Spectrum Decision on “a regulatory framework for radio spectrum policy in the European Community” establishes a cooperation mechanism which allows the EC to issue mandates to CEPT on the harmonisation of frequency use and to make the resulting ECC Decisions mandatory for all EU member countries. Directive 2002/21/CE on a common regulatory framework for electronic communications networks and services (the Framework Directive) and Directive 2002/20/CE on the authorisation of electronic communications networks and

services (the Authorisation Directive) establish a set of rules on frequency assignment procedures and introduce the concept of secondary trading. Directive 1999/5/EC on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE) also has some relation with spectrum harmonisation and standardisation.

Each state, in compliance with its international commitments, allocates frequency bands either for government or administrative uses or for broadcasting and civil telecommunications (private industrial and commercial sectors, radio amateurs, CB, aeronautical, meteorological activities, etc.). The managing frequency authority draws up the national frequency allocation table and the national frequency register listing frequency assignments and keeps them up to date.

For a more in-depth description of the current frequency management system, see **Annex 2.**

As highlighted above, frequency management can be considered in terms of a number of levels: global, regional (CEPT and EU) and national. This Report is built around these levels and the following chapters describe for each level the experience obtained with the current system and the possibilities for improvement of frequency management in relation to enhancing harmonisation and introducing more flexibility.

Going from the international to the national level is equivalent to narrowing down the geographical area of interest and increasing the level of detail/complexity of the regulatory provisions which govern the use of spectrum in this geographical area. ITU Radio Regulations primarily ensure that the services within a frequency band can be operated by various countries through cross-border coordination. This leaves national administrations the flexibility to define which national allocation table will best fit their needs, for both government and commercial uses. At EU level, member states co-ordinate their national policies and take action to ensure the proper functioning of the single market for goods and services. It is at this level, for instance, that the requirements imposed on products, the procedures for products to reach the market and spectrum allocations can be harmonised within the EU. The CEPT level is an intermediate level which reflects both the need to minimise cross-border coordination and the political determination to achieve harmonisation, cross-border roaming and economies of scale. At national level, the spectrum management authority has the duty to draw up a National Frequency Allocation Table, which represents the conditions of use of spectrum, including restrictions agreed by the concerned administrations coordinated with their neighbouring administrations on an equal basis. Licensing is the ultimate level which defines the rights and obligations of the final users of the spectrum. The modalities of the licensing process are a national matter, but are in the EU constrained by various legal instruments (New Regulatory Package and the R&TTE Directive).

The current framework of frequency management has until now enabled timely responses to the changing technological and market requirements and in many areas improvements have been made, e.g. by accommodating new services and systems through innovative sharing approaches, or by identifying globally harmonised bands for emerging services (IMT-2000, PPDR, RLANs). However, in recent years views have emerged that, although many improvements have already been made, the changing spectrum management environment and increasing pace of innovation require a more flexible system able to respond quickly to new technological and commercial developments in order to make optimal use of the radio spectrum and promote European competitiveness. It is in accordance with the goal of the Lisbon summit to make Europe the most competitive and dynamic knowledge-based economy in the world by 2010. Making spectrum available for new services and technologies is crucial to this goal.

3.2 ITU level

3.2.1 Description

The worldwide allocation level is determined by the ITU Radio Regulations, which allocate the various parts of the spectrum to specific services (broadcasting, mobile, fixed etc.). Over time systems developed within those allocations have been tailored for specific use, and this has left its mark on current spectrum use. To respond to emerging requirements, more and more allocations have been made in all parts of the spectrum in a way that enables each country to select for each frequency band the specific services it wants to implement in the band, subject to coordination with its neighbours, and to certain constraints arising from sharing with space services.

Decisions to modify the Radio Regulations are taken by WRCs on the basis of consensus and are binding on all countries. The Radio Regulations reflect, at a given time, an allocation level which provides for flexibility for all countries: this is equivalent to a Pareto optimum, at least in theory, i.e. any significant change, whilst providing benefits for one country, would lead to costs for another country. However, it represents the outcome of complex negotiations and compromises.

3.2.2 Improvement of the international regulatory framework

There may be scope for seeking additional flexibility by amending the RR in general terms, for example by trying to widen the definition of services or to allocate more services in a given frequency band. The technical difficulties of such an approach have been studied in detail and are highlighted in ITU-R Recommendation SM 1265 (National alternative allocation methods). ITU-R Recommendations SM 1131 (Factors to consider for allocating spectrum on a worldwide basis) and SM 1132 (General principles and methods related to spectrum sharing) provide additional insight into the process which has lead to the current state of the RR.

These issues are currently being taken up again in the ITU by ITU-R Study Group I following the adoption of Resolution 951 at (WRC-03). This Resolution, entitled "Options to improve the international spectrum regulatory framework", was considered at the first Conference Preparatory Meeting (CPM06-1) in July 2003, and assigned to ITU-R SG 1.

In response to this Resolution, the outcome of the work aims at providing an assessment by the ITU-R of the effectiveness, appropriateness and impact of the Radio Regulations, with respect to the evolution of existing, emerging and future applications, systems and technologies, and identifying possible options for improving the Radio Regulations.

When asked for their opinion by ITU-R SG 1 the other ITU-R Study Groups were of the opinion that the service definitions in Article 1 of the RR appear to have generally been sufficiently flexible to adapt to technology evolution, but there may be a need for ITU-R to examine the certain existing definitions associated with the mobile and fixed services.

The ongoing work in ITU-R SG1 has identified three possible options for improving the effectiveness, appropriateness and impact of the Radio Regulations with respect to the evolution of existing, emerging and future applications, systems and technologies have been identified. A combination of these options may also be considered.

Option 1 – Current practice
Under this option, it is considered that there is sufficient flexibility within the present Radio Regulations and the WRC processes to meet any current or likely future requirements. Where new technologies are to be implemented, the Radio Regulations provide sufficient flexibility for their introduction. Where an improvement is required, the present WRC process can meet the needs of Member States within a reasonable timeframe. If new applications need to be introduced in a shorter timeframe, this can be done in specific bands (ISM), or under specific regulatory conditions (N° 4.4 of RR), although without protection against harmful interference.

Option 2 – Reviewing and possibly revising some of the Current Service Definitions
Under this option, the current service definitions in Article 1 of the Radio Regulations would be reviewed in order to ensure that they adequately and unambiguously cover actual use and emerging technologies. This review would encompass the fixed and mobile (except aeronautical and maritime mobile) services[5]. It may lead to:

- modifying the current definitions for these services, and/or
- adding a new service to the list of service definitions, which would encompass several of the existing ones. If such a new service definition was to be included in Article 1, it is understood that any allocation to this new service could only be made by a future WRC. This definition could be, for example:

1.xx New (additional) service: A radiocommunication service for use by or between stations in the fixed service or in the mobile(except aeronautical and maritime) service.
If this review led to changes in the definitions of the corresponding stations, there may also be a need for consequential changes in the definition of mobile earth stations.
Possible changes to the service definitions would also need to be addressed from the point of view of their regulatory implications in the assignment and use of frequencies, in particular in the ITU coordination, notification and recording process, and impact on assignments made under the current definitions.

[5] Although no response was received from the ITU-R SG-6 in relation to possible need to include the broadcasting service in this review, the corresponding definition might be affected by this review.

Option 3 – The introduction of a new provision in the Radio Regulations expanding the principle of substitutability

Under this option, a new provision would be introduced in the Radio Regulations in order to apply the principle of substitutability in the context of fixed and mobile (except maritime and aeronautical mobile) services, in the same way as it is applied by Nos. 5.485 or 5.492 in the context of the fixed-satellite and broadcasting-satellite services.

This would reflect the current convergence between fixed and mobile services, address the current ambiguities between the definitions of these services, facilitate timely implementation of new applications, provide adequate regulatory protection for such applications and protect the rights of other administrations against interference caused by them. An example of such a new provision could be the following:

XXXX *Assignments to stations of the fixed service which have been recorded in the MIFR with favorable finding may also be used for transmissions in the mobile (except aeronautical or maritime mobile) service, provided that such transmissions do not cause more interference, or require more protection from interference, than the corresponding assignments in the fixed service recorded in the MIFR. Assignments to stations of the mobile (except aeronautical or maritime mobile) service which have been recorded in the MIFR with favorable finding may also be used for transmissions in the fixed service, provided that such transmissions do not cause more interference, or require more protection from interference, than the corresponding assignments to the mobile (except aeronautical or maritime mobile) service recorded in the MIFR.*

It is recognised that implementation of this approach would require technical tools for the Radiocommunicatios Bureau to assess the compliance of a proposed use of this provision. In the absence of such tools, the provision could only be applied in cases where the interference situation is obviously unchanged (e.g. when the same parameters are used).

3.2.3 Conclusions

Although the ITU Radio Regulations already provide for a high level of flexibility, i.e. more and more allocations are made in all parts of the spectrum, in a way that enables each country to select, for each frequency band, the specific services it wants to implement in the band, subject to coordination with its neighbours, and to certain constraints arising from sharing with space services, studies in response to Resolution 951 are supported.

3.3 Regional level: CEPT and European Union

In recent years European harmonisation has become more dynamic. For example, the Spectrum Decision provides a mechanism less cumbersome than directives since harmonising measures introduced under the aegis of the RSC can be adapted faster than a directive. Nonetheless, further progress towards improving harmonisation can and must be made.

At the CEPT level, it was agreed in 2004 to review an ECC Decision every three years from its date of adoption to determine the extent of its implementation and the take-up of use in the frequency bands designated in the Decision. As a consequence of this review the ECC Plenary will decide whether to maintain, revise or abrogate existing Decisions.

The main areas of further potential improvement relate to:

- basing harmonisation on demonstrable benefits;
- giving appropriate focus to spectrum designation by removing restrictions that are not necessary or proportionate and making harmonising measures technology-neutral except where justified otherwise.

The following paragraphs analyse the additional flexibility recently brought into the CEPT and EU spectrum management process and discuss the two areas identified for further potential improvement.

3.3.1 CEPT level

Because each of the 46 countries in CEPT can define its own National Allocation Table with maximum flexibility within the framework of the CEPT and ITU allocations, it can optimise its own use of spectrum according to its evolving requirements (in terms of government and commercial services, as well as rural, suburban and urban development). ECC Decisions provide administrations with the possibility to benefit from harmonisation by signing them. In addition, European countries work together on long term planning, through voluntary endeavours such as ERC Report 25, the European Common Allocation table. This provides spectrum users with clarity over the long-term future of spectrum use**.**

Since the early nineties, following the success of the frequency harmonisation for GSM, which was achieved through a combination of EU policy, market consensus and CEPT frequency harmonisation activities, CEPT has made a major effort to propose harmonised frequency allocations in European countries via Detailed Spectrum Investigations (DSIs). The ultimate goal was a single European Common Allocation Table (ECA), with the aim of creating a European internal market in order to benefit from economies of scale (see above mentioned ERC Report 25). This common effort to limit the flexibility of national regulatory frameworks in order to benefit from the advantages of harmonisation has been one of the successes of CEPT.

Applications which have been subject to harmonisation measures by CEPT are not always successful. For example, TFTS was an aeronautical public correspondence system, for which harmonisation over Europe was a necessary, but not sufficient, pre-condition. The service did not succeed and, after most countries switched off their TFTS operation, CEPT started considering continued harmonisation of these frequency bands. The lower part of the TFTS band has been studied since 1999 as a potential extension of the MSS uplink allocation, and the upper part of the TFTS band is now subject to an EC mandate.

Further steps have been taken by CEPT through ECC Decisions and previously ERC Decisions, in many cases following a mandate from the European Commission, to harmonise the use of frequencies within Europe, within the legal framework defined by the ITU (RR and regional agreements).

These decisions are not of a mandatory nature, and administrations are at liberty to choose whether to adopt them or not. The issue of a new DSI has been addressed by ECC PT7 and, rather than starting a new DSI process, it was agreed that the bands in the ECA should be categorised according to the required level of harmonisation. Following this categorisation there should be a wide consultation as for DSI. Categorisation of frequency bands in the ECA table will improve information on spectrum use and guides CEPT to harmonise where harmonisation is likely to be beneficial.

The ECA should then be amended in accordance with the conclusions of this consultation. The resulting table should be more useful, more transparent and easier to implement.

New Decisions, or revisions to existing ones, are adopted by the ECC following requests by administrations and/or ETSI in response to user requirements and technological innovation. Adopting, revising and implementing Decisions takes time and this should be taken into account in order not to delay market development.

ECC Decisions should not include restrictions that are unnecessary or disproportionate, and should be technology-neutral and flexible except where justified otherwise.

As a starting point it was recently decided to begin a review of all ERC/ECC Decisions to investigate the impact of convergence of services and technology on the spectrum regulatory framework and consider whether any elements should be modified or, to be more precise, how the rules that apply to these elements might be modified or relaxed - while assessing what benefits such an action would bring. Each ECC Working Group was asked to begin this review of the ERC/ECC Decisions applicable within their area.

In addition, as mentioned above, it was agreed that each ECC Decision will be reviewed by the ECC every three years from its date of adoption.

Isolated actions taken by CEPT members regardless of the European Allocation Table would have a negative impact on achieving the objectives which have been sought through harmonisation efforts. Any step in this direction should therefore be carefully considered.

It is important that the European regulatory framework (CEPT and EU) be sufficiently effective, either by being sufficiently reactive to adjust to such situations, by suppressing or amending existing Decisions/directives as necessary or by introducing less prescriptive means of regulating spectrum use. In particular, there should be a balance between the degree of freedom given in the use of the band, and the need to give enough confidence to manufacturers and operators for a market to develop.

Furthermore, although technical innovation is perceived as happening faster than ever before, one should not underestimate the time span between the point in time when an idea emerges and the point in time when it becomes a successfully marketed application. It should also be acknowledged that all innovations, no matter how good they may be, do not necessarily turn into successful products. However, European manufacturers, through ETSI, are aware of the importance of spectrum studies to determine the minimum technical characteristics that should be met by their

future products to ensure that they can be operated without affecting other uses of the spectrum. In this instance, flexibility requires cooperation and common understanding between standardisation bodies, manufacturers, operators, users and frequency managers. This is the reason for the MoU between ETSI and CEPT.

There are two categories of innovations; the first for niche and customised market, the second for European or worldwide markets. In both cases it seems that CEPT has been able to help those innovations break through, leading to a number of well known success stories such as GSM[6] and PMR 446.

It must be stressed that direct implementation of a new product in a part of the spectrum requires careful consideration because it is the task of administrations, before such implementation takes place, to ensure efficient use of spectrum and to protect the systems operating in the bands concerned (private radiotelephones in aeronautical bands, emergency bands, broadcasting bands etc) from harmful interference. It should be noted that the level of protection from harmful interference may be subject to negotiation between stakeholders, which may in some cases include a commercial element. However, this obligation to protect existing services from harmful interference clearly puts a limit on the possibilities for a spectrum manager to accommodate proposed innovations.

3.3.2 EU level

In the past, the EU has produced technology-specific Directives[7] in three cases (GSM 900, ERMES and DECT). In addition there have been two Decisions, on 3G and S-PCS, respectively, which contain a sunset clause. Experience has shown that using Directives for designating specific technologies in certain frequency bands has led to inflexibilities, as the modification or abrogation of Directives requires a proposal from the EC for initiating a co-decision process (involving the Council and the European Parliament), which takes a long time. This is particularly a problem when a market (e.g. paging) does not develop as expected or when a band should be opened up to include other applications because of technological or market developments.

- ERMES

  In the case of ERMES it is taking considerable period to lift the restrictions on the harmonised spectrum. Meanwhile CEPT administrations have taken some measures to reuse these frequencies. For example, another paging technology (FLEX/REFLEX) was introduced in this frequency band and, after the paging market definitively failed in Europe because of the GSM success, administrations started to use these frequencies for other applications (e.g. PMR, temporary networks, radio microphones). However, the Directive has been interpreted as requiring each SMA to retain some ERMES capacity for Single Market purposes.

- GSM

  In the case of GSM 900 harmonisation measures have been a success. Nevertheless for the migration to 3G or other future mobile services the Directive has to be abrogated. Based on the ERMES example, the abrogation process should start as soon as possible.

- 3G

  Designation of a core band of spectrum for IMT-2000 technology was justified by the need to ensure roaming and availability of low-cost equipment. IMT-2000 covers a family of technologies, which provides flexibility for operators to select which variant to employ. 3G services are now being developed commercially. In the meantime the EC decision on 3G has expired and its purpose fulfilled.

In the light of experience with ERMES and GSM, the EU has introduced a sunset clause in some EC Decisions which has increased flexibility, since the situation can be reviewed after the expiry date.

With the approval of the Spectrum Decision in 2002, a new framework for spectrum harmonisation measures was established in the EU. On the basis of this Decision the European Commission can, where required, approve specific Commission Decisions on the basis of the comitology procedure.

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[6] Cellular phones penetration rates in May 2004 : 86.2% in EUR and 58.1% in the USA (Source EMC). In 1990, 2.0% in the UK and 2.1% in the USA. In 2001, 75.0 % in the UK and 46.4 in the USA (Source Eurostat - Information Society Statistics - *PCs, Internet and mobile phone usage in the EU. Statistics in focus 15/2003)*

[7] - Council Directive 87/372/EEC of 25 June 1987 on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community
- Directive 90/544/EEC on the frequency bands designated for the coordinated introduction of pan-European land-based public radio paging in the Community
- Council Directive 91/287/EEC of 3 June 1991 on the frequency band to be designated for the coordinated introduction of digital European cordless telecommunications (DECT) into the Community

Harmonisation of frequency usage conditions (preferably proposed by the CEPT) may be imposed on administrations that are Members of the European Union pursuant to Article 4 of the Radio Spectrum Decision in situations where harmonisation is considered necessary. These EC Decisions currently define the type of service and application to be used in a given frequency band, and the associated technical, operational and regulatory provisions under which spectrum is to be used in accordance with the Radio Spectrum Decision.

It should be clearly determined, though, that these EC decisions do not stand in the way of flexibility which may be introduced in the CEPT. They should be easy to adapt and should preferably contain an end date, after which they expire.

The R&TTE Directive is the legal basis for the creation of the single market for radio products in the EU. It determines the requirements that products must meet (most notably the obligation to avoid interference), and the procedures manufacturers must apply to place such products on the EU market. As a new approach Directive it delegates technical fine print to standardisation, albeit giving appropriate safeguards for public authorities to ensure that products do not cause harmful interference. Harmonised standards reflect an accepted means of meeting the requirements of the Directive and are thus the "rule" that is normally applied. Their adoption mechanisms ensure that all stakeholders, including spectrum managers are involved. The MoU between CEPT and ETSI provides a mechanism to ensure that the radio parameters are checked with CEPT in order to ensure compatibility with other services.

As regards radio matters, notably ETSI, and to a lesser extent CENELEC, play a role.

Although harmonised standards set the normal rule, the Directive offers the possibility for manufacturers to bring innovative products to the market that do not meet the standard, but nonetheless meet the requirements of the Directive. The Directive offers flexibility for the market at two levels: it offers the possibility for the market to influence harmonised standards in order to take account of new technological developments, and it allows products to be placed on the market in the absence of harmonised standards or where interference is avoided using technologies other than those contained in harmonised standards.

Thereby it inherently introduces elements of flexibility by allowing for innovation, albeit within an existing spectrum allocation framework.

3.3.3 Basing harmonisation on demonstrable benefits

It is becoming increasingly important to move towards a frequency management regime that does not sterilise spectrum unnecessarily and is both flexible and dynamic.

Spectrum harmonisation can bring benefits, but can also impose costs.

Harmonisation can, by making spectrum available on an assured basis, promote confidence for equipment manufacturers and service providers to invest in producing new equipment and roll out networks. It can generate economies of scale arising from the size of the pan-European market, although these benefits may vary with the category of equipment and have to be quantified on a case-by-case basis.

It also provides opportunities for consumers and users to use their equipment throughout the Community, especially where these are portable. Examples include mobile telephones, PMR-446, anti-collision radar for automobiles and wireless enabled laptop computers and PDAs.

At the European level, cross-border coordination is particularly critical. Harmonisation is a way to alleviate cross-border issues and constraints.

Harmonisation is clearly even more necessary where there is an operational necessity for the same frequencies to be made available on a multi-national basis (safety services, roaming terminals, Air Traffic Management, satellite services etc.).

A further important benefit of harmonisation is that it helps competition in both the provision of services and terminals (since the end user can switch terminals and service providers independently). New networks will also enhance competition, and should have the opportunity to gain access to spectrum.

However, spectrum management needs to ensure that the harmonisation process will not increase spectrum scarcity, which may prevent services and technologies that are different from the harmonised application to access spectrum. If the harmonised application does not succeed commercially, the increase in spectrum scarcity can impose considerable costs on European businesses, consumers and workers by holding back other applications and, more generally, innovation. As already mentioned in the introduction to section 3.2, the ECC has already taken steps to review the implementation of ECC Decisions and the use of bands designated in ECC Decisions.

European harmonisation of a frequency band may also lead to increased refarming/reallocation cost at a national level. Therefore, CEPT should endeavour to base harmonisation measures on justified need following a cost-benefit evaluation and, in some cases it may be appropriate for the ECC to assess whether a proposed Decision would be beneficial or not in economic terms. This could take different forms, quantitative estimates, qualitative assessments or risk analyses, taking into account the uncertainty related with market predictions. Such a cost benefit analysis should not take the form of an ECC deliverable and should not block the development of a new Decision. It should be taken into account along with other considerations when the ECC considers whether to proceed with the development of a harmonisation Decision. The assessment would be largely based on market elements provided by industry, mainly through "System Reference Documents (SRDocs) information (which contains a market section) and discussion at European and national level. It is recognised that administrations do not have all the elements (e.g. market information) to forecast market developments and to quantify precisely the benefit or cost of a harmonisation measure.

The ECC should not try to formalise the cost-benefit assessment of harmonisation measures by giving a permanent group this responsibility as it would increase the burden and bureaucracy of the harmonisation process.

Such an evaluation should include operational requirements, cross-border mobility, market demand, potential economies of scale, and where feasible the potential impact of increasing spectrum scarcity which may limit spectrum access for other existing or future applications. The cost-benefit analysis should not delay the introduction of desirable harmonisation, as it can be carried out in parallel with technical work.

3.3.4 Technology neutrality

According to the 'New Regulatory Framework for electronic communications infrastructure and associate services' of the EU, member states have to ensure that SMAs take the utmost care to make regulation technology neutral, i.e. it should neither impose the use of a particular type of technology nor discriminate against it. This does not preclude taking proportionate steps to promote specific services where justified.

At the same time harmonisation of the European market and of standards is another essential requirement of the European Community.

The Framework Directive requires member states to provide effective management of radio frequencies for services. Allocation and assignment of frequencies must be based on objective, transparent, proportionate and non-discriminatory criteria. Member states must also promote the harmonisation of use of radio frequencies to ensure effective and efficient spectrum use.

Another important point relates to the conditions that may be attached to rights of use for radio frequencies. One of the conditions mentioned in the Authorisation Directive is the "Designation of service or type of network or technology for which the rights of use for the frequency has been granted". The concept of technology neutrality is therefore not in contradiction with the identification of any type of technology.

Identifying particular technologies is therefore permitted by the Authorisation Directive as long as it is justified. There is also a need to impose certain technical and operational conditions to avoid harmful interference. Moreover, there is an obligation to promote harmonisation to ensure effective and efficient use of frequencies.

In any case, it is clearly not a task for SMAs to predict which technologies will best meet consumers' and business users' needs and so succeed commercially. This is better left to industry, standardisation bodies and market forces. For example, IMT-2000 technologies have not been specified by administrations, which have only ensured that standardisation would happen. However, administrations sometimes need to balance between conflicting requirements in order to ensure effective use of spectrum.

It is therefore necessary in each case to balance the principle of technology neutrality and the aim of effective and efficient spectrum use. Therefore, it may be necessary to impose conditions limiting the technology used or service provided. But these should be no more restrictive than necessary to achieve effective and efficient use of spectrum. It

is, in any case, virtually impossible to have a truly technology-neutral allocation or band plan that does not favour a particular technology over others. The subject of technology-neutral spectrum rights is discussed further elsewhere in this Report.

With regard to 'technology neutrality', the ECC has adopted an amendment to its Rules of Procedures:

> Art 12.3.3bis: "ECC Decisions shall not inhibit radiocommunication equipment meeting different standards from operating in an identified frequency band provided it offers the same spectrum use and application as specified in an ECC Decision for the band and is placed on the market in conformity with the essential requirements i.e. it makes effective use of the spectrum allocated to terrestrial/space radio communications so as to avoid harmful interference. ECC Decisions should neither impose nor discriminate in favour of the use of a particular type of technology, although this does not preclude the taking of proportionate steps to promote certain specific services where this is justified. The term "services" does not refer to services as defined by the ITU in the Radio Regulations, but it has a meaning close to that of "application" used in the EFIS data-base held by the ERO".

CEPT should therefore pay particular attention to the definition of application for which a frequency band is designated, and justify cases where harmonisation objectives may lead to the restriction to a particular type of technology. Suggestions for further work are recommended later in the Report.

3.3.5 Application definition

The ECC harmonisation process works through the designation of frequency bands for particular "applications". The list of applications currently used in ECC Decisions is described in the EFIS database.

Similarly to the discussions on technology neutrality, it is important for the ECC to define the application for which a frequency band is designated with the appropriate balance between flexibility and *de jure* harmonisation. Too wide an application definition may fail to achieve the harmonisation objective and too rigid a definition may prevent innovative applications from developing.

It should also be noted that the designation of a frequency band for an application or a type of technology does not mean that the band is reserved exclusively for that application or technology. The definition of the word "designation" (see **Annex 7** Glossary) gives details about the flexibility that administration have in implementing other applications or technologies. This definition relies on the interpretation at a national level of the "market demand" for the application or type of technology for which a frequency band is designated. This definition does not prohibit CEPT members committed to the Decision from conducting an auction or using other competitive procedures in which bids may be invited for the designated applications as well as for other applications or from using spectrum trading as a tool to assess market demand. [8]One should acknowledge that SMAs have to interpret and apply Decisions depending on their national context, and the extent to which they have chosen to introduce market mechanisms, which may be used to make spectrum available for initial assignments or afterwards.

CEPT may also consider it appropriate to adopt a Decision harmonising an application in a frequency band which has already been designated for another application. For example, the same spectrum has been designated in different Decisions for narrow band PMR/PAMR and for wideband PMR/PAMR and the frequency band that may be designated for UWB would overlap with several frequency bands already designated for various applications.

3.3.6 Ways of enhancing the regional spectrum harmonisation process

3.3.6.1 Existing process

The process of spectrum harmonisation relies mainly on the cooperation between CEPT and ETSI and is described in the Memorandum of Understanding (MoU) between ECC and ETSI.

The process is generally initiated by the development of a "System Reference Document" (which has the status of an ETSI Technical Report), describing the requirement for spectrum for a particular application and providing market and technical information and submitted by ETSI to ECC Working Group FM (WGFM).

[8] This last sentence is not necessarily applicable to all services, for example some satellite services and other services that can only operate when harmonised European wide.

WGFM will takes appropriate measures to be in a position to respond to ETSI, calling for compatibility studies from WGSE and, in some cases, for regulatory advice from WGRA. Taking into account all available elements, WGFM will then decide on the appropriateness of harmonisation and on the way to achieve it, for example by starting to develop an ECC Decision.

Apart from the harmonisation of frequency bands, the ECC in cooperation with ETSI also harmonises the RF parameters such as channelling arrangement, conditions to avoid harmful interference etc., which will be included in the licensing conditions or in the harmonised standard.

3.3.6.2 Requirement for improving the process

The CEPT process for designating frequency spectrum for new and innovative services and systems has sometimes been criticised for being too slow. As a matter of fact, some Decisions have required more than two or three years to be finalised, reflecting on the one hand the difficult debate between different interest groups and the politics of the frequency management process, and on the other hand, the actual difficulty in solving complex compatibility issues resulting from the initial choice of a frequency band for operation.

The most important issue for industry is to obtain a certain degree of ***certainty in the process***, i.e.:

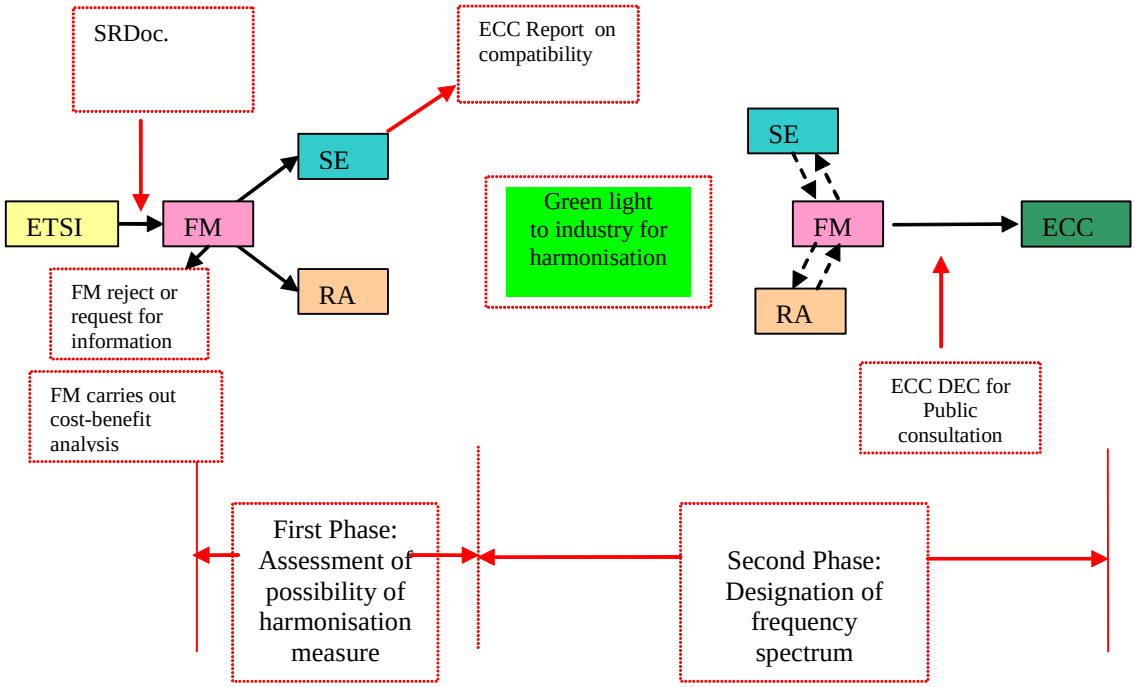
- an agreed and transparent process is followed
- industry and users have formal opportunities to contribute and be consulted
- industry at an early stage can achieve a ‘go or no go’ indication even before the process is finalised
- the final result is provided within agreed timeframes.

Currently no timescales and milestones have been specified in the process starting with the System Reference Document and ending with an ECC Decision allowing the system or service under particular conditions. Due to the diversity of requests from ETSI, it seems difficult to adopt a single timescale valid for all requests, but CEPT could, on a case-by-case basis, indicate whether the deliverable can be expected within “one year”, “two years” or “in an unpredictable timeframe”.

This would result in a more responsive frequency management system which could take account of industry needs concerns of other spectrum users and deliver harmonised frequency management solutions with regulatory certainty, all in a timely manner. The end result should be a responsive frequency management system which makes Europe an attractive environment for innovative radiocommunications technologies and applications.

3.3.6.3 Streamlining the process

It is suggested to consider the following idea to improve the existing process of developing harmonised spectrum decisions:



This process would rely on the following assumptions:

1. Industry provides a system reference document and the technical elements necessary to justify the requirement and to carry out compatibility studies with existing services.
2. WGFM considers the documentation from a frequency management perspective and may, based on frequency management criteria, reject or request further information.
3. WGFM carries out the cost-benefit analysis of the harmonisation measure.
4. WGFM invites WGSE to carry out the compatibility studies with industry support and to liaise with ETSI as appropriate; WGFM also invites WGRA to comment on regulatory issues regarding the implementation and use.
5. WGFM considers the output and draft report in response to ETSI with conclusions on 'go-no go' based in particular on the elements given by WGSE and WGRA and informs industry about the possibility of success (green light given to industry for standardisation)
6. WGFM considers the results of the draft report and the final SRDoc (if not done before)
7. A draft ECC Decision is developed by WGFM and following public consultation on the Decision it is adopted by the ECC.

3.4 National level

3.4.1 Spectrum management

This section is intended to be illustrative and does not correspond in all respects to the actual national institutional structure in every country. These have certain generic features in common but differ from country to country depending on constitutional, political, legal and historical factors.

At national level, the frequency authority has the duty to draw up a National Frequency Allocation Table, which represents the conditions of use of spectrum. For this reason, this Table is in many countries adopted at a rather high level e.g. the responsible minister, the cabinet of ministers or the prime minister (see **Annex 2** for further details on national structures). For each frequency band, it specifies the service(s) allocated in the band, the type of

systems/applications, the relative status of each use in the band (exclusive, priority, equal, secondary). The higher the level of approval of the Table, the more stability and force it has, which also means that it takes more time and effort to modify it, hence reducing reactivity and flexibility. A degree of stability is important, however, to provide the certainty necessary for industry to make substantial and long-term investments which are required for some systems and networks.

Each National Allocation Table is the result of an evolutionary process which has taken place over decades through a permanent negotiation between commercial and government users, with the objective of responding to their requirements, to technology and market evolution while preventing the occurrence of harmful interference (in the same and adjacent bands) and maximising efficient use of spectrum[9]. These negotiations result in regular revisions of each national Table. Such revisions are also needed to take into account on-going negotiations at international level such as:

- Changes to the Radio Regulations, as decided by World Radiocommunication Conferences,
- Agreements reached in NATO or other military and emergency organisations
- ICAO, IMO, WMO… agreements
- Regional Agreements in the ITU framework (e.g. ST-61 and GE-89 Agreements on terrestrial television broadcasting)
- ECC Decisions/Recommendations,
- EC decisions/directives
- Sub-regional agreements (e.g. Chester and Maastricht agreements, Vienna/Berlin Agreement)

It is important to note that there is a close link and interaction between negotiations at national and international level. As a result, the entity in charge of representing a given country in international negotiations is also the one in charge of the corresponding national negotiations.

The national Frequency Allocation Table also reflects the specific choices made in a country, in particular with regard to accommodating national defence, security, research, audiovisual policies or industry requirements. Such choices may differ from one country to the next, and may lead to different status between users within a given country (exclusive, priority, equal, secondary status).

Most frequency bands are shared between various terrestrial and space services, in a way which enables the users of both services to co-exist in the same bands and in the same geographic areas with limited constraints. As a result of increased spectrum congestion, it is expected that new sharing schemes will continue to appear to enable such co-existence between services. A recent example is the 5 GHz RLANs, which share a band with defence radars. In each case the sharing framework for each of the services involved, as well as the sharing conditions, must be specified by the national Frequency Allocation Table.

3.4.1.1 National institutional structure

As indicated above, each national Allocation Table is the result of an evolutionary process which has taken place over decades through permanent negotiation among commercial and government users. The national institutional structure establishes the framework for such negotiations. Hence this structure has the ability to facilitate or

[9] So far *harmful interference* (as defined in No. 1.169 of the Radio Regulations, i.e. *interference* which seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations) has been handled by frequency planning, regulation and control. Negotiating acceptable levels of interference may be left to market players when the levels are low enough so that they can be resolved without undue constraints. In contrast, *harmful interference* usually cannot be resolved without arbitration and severe constraints on one or both parties. Harmful interference also needs to be avoided between adjacent frequency bands allocated to different services. For example, if broadcasting and mobile have allocations in adjacent bands, mobile reception will not be possible in large areas around each broadcasting transmit station. Resolving the difficulty at equipment level ((in terms of receive filters or transmit combiners) may have unacceptable cost implications to one or both services. Resolving it by frequency planning (i.e. avoiding certain frequencies in certain areas) may lead to unacceptably low spectrum efficiency. For these reasons, the design of the national allocation Table is essential to prevent the occurrence of critical problems associated with harmful interference.

complicate the negotiations and therefore has a significant impact on the flexibility of the spectrum regulatory framework in a country[10].

There is a source of rigidity where separate entities (e.g. NTIA and FCC in the United States) independently manage the government spectrum and the commercial spectrum, with no permanent/legitimate body to arbitrate between them. This is particularly critical given the general trend during recent years of shifting spectrum from government to commercial sectors (which permitted GSM and IMT-2000). For example, this situation resulted in the opposition from the USA to include in the WRC-2000 agenda a point relating to the identification of additional spectrum for IMT-2000 and, once this point was included, in difficulties in agreeing on this identification, which resulted in national rigidity being "exported" to the international allocation process .

It is essential that the institutional framework provide for a structure to facilitate discussions between spectrum users, government departments/agencies, independent regulatory authorities so that they can negotiate any changes to the Allocation Table, taking into account their respective spectrum requirements. Industry, operators and end-users are consulted and provide input to this process. Such a structure should preferably be permanent (to provide for institutional stability and experience build-up), and as independent as possible. Decisions in this set-up should preferably be reached by consensus, for several reasons,

- Given the stakes, a decision taken against the will of one of the key parties is likely to be challenged at a higher level in the process (e.g. cabinet of ministers or parliament), to the potential detriment of all parties;
- A party whose interests have been negatively affected by a decision will be less inclined to provide relevant information in future discussions, hence reducing the flexibility of the process;
- Since the system goes from one state of consensus to another, any failure of the market to develop within the newly adopted framework can be solved by reverting to the previous state of consensus (i.e. this is a reversible process);
- As a result of the close interaction with similar negotiations at international level, decision by consensus leads to in-depth discussions and maximizes adherence to a national position, which is a key for success in preparing for international negotiations where consensus is also the rule.

This structure should preferably be manned with permanent staff. To be able to fulfil its role, the staff should be highly qualified in technical, legal and economic aspects of spectrum management. In particular a detailed understanding of compatibility aspects is necessary to understand the sources of rigidity in the positions of the various users and resolve them. Building up and maintaining such expertise is seen as one of the key obligations of the administrations[11], since there seems to be no credible alternative to it, whether by legal decisions, private consultants, or both.

As a result of the close linkage and interaction between negotiations at national and international levels, it may be preferable that the entity in charge of representing the country in international negotiations on spectrum be the same as the one in charge of the corresponding national negotiations. This structure would then be able to demonstrate its capacity to successfully represent the interests of all users at the international level, which is essential to establish the necessary confidence.

[10] CEPT administrations have been requested to provide a brief summary of their institutional structure, identifying the mechanisms in the decision process leading to changes in allocations, and areas in which flexibility has been or may be improved. See details in **Annex 3.**

[11] For recent consideration on this aspect, see "Spectrum Policy for the 21st century – The President's spectrum policy initiative: Report 1 (Recommendations of the Federal Government Spectrum Task Force), June 2004. Recommendation 4.

3.4.1.2 Role and current tools of the administrations

At the moment, the SMA has at its disposal various frequency management tools that could enhance flexibility and efficient use of spectrum. Those tools as well as the role of the administrations are reviewed in this section.

- **Spectrum monitoring and resolution of harmful interference**

In order to ensure that transmitters are operated in accordance with licence conditions (frequency, power, bandwidth etc.) and that harmful interference is promptly eliminated when it occurs, administrations have established monitoring facilities which require important resources in terms of investment and operations, but are essential to guarantee the rights or spectrum users, in particular in terms of protection from harmful interference.

Interference results in degradation in the reception of a radio signal. Since such type of degradation may also have other causes, such as malfunctioning of the system or specific propagation conditions, it is generally difficult to diagnose interference. If interference is diagnosed, the second step is to characterise and localise the source of the interference, which may be extremely difficult in the case of sporadic interference, or interference from multiple sources or moving sources[12], and is more difficult in case of digital signals. The final step is to alleviate the interference, which often requires difficult negotiations between the parties concerned at national and/or international level. Even in cases where the interferer is clearly responsible for removing interference, technical, regulatory or economical reasons may have to be taken into consideration. Furthermore, the interferer generally needs to continue to provide services, which requires a change in frequency, a modification of the system or a relocation of the station(s).

Resolving harmful interference after it happens is therefore a very costly and time consuming process, and it is generally unsatisfactory for all parties involved. This means that all possible efforts should be made *a priori* to define the conditions which avoid harmful interference[13] and once this has been done, to check regularly that spectrum is used in conformity with regulations and with the conditions included in the licences and when this is not the case, to take appropriate enforcement measures.

These checks need to rely on accurate, complete and up-to-date registers containing the details of the assignments for which a licence has been given. Establishing, validating and maintaining these registers are essential in providing a reliable reference against which spectrum monitoring can be performed.

In this respect, it should be noted that the introduction of secondary spectrum trading and liberalisation is not likely to reduce the need for spectrum monitoring, but may rather be expected to increase it**.**

Spectrum monitoring data may also provide valuable information on the actual use and quality of frequencies, the value of changing (inter) national frequency allocation plans and the need to do so.

Monitoring the radio spectrum therefore represents a substantial contribution to the development of a frequency allocation policy by:

- Contributing to the development and revision of national frequency allocation plans, in particular by monitoring the actual use and identifying unused spectrum;
- Enabling optimum allocation procedures for frequencies to be developed;
- Encouraging European and global harmonisation of frequencies;
- Improving the quality of radio communication links;
- Helping to enforce the rules and regulations;
- Helping to phase out old radio systems in an organised fashion.

[12] This is why the concept of real time management by the network of the "interference noise temperature", as suggested in the FCC task force report, is not applicable to mobile networks.

[13] As an example, the implementation of a national coverage of monitoring stations in France has helped decrease the number of harmful interference cases (from 1041 in 1997 to 528 in 2003), but the processing delay has increased due to the increase in complexity (average from less than 80 days in 1997 up to 140 days in 2003. This means that the monitoring system helps to suppress many interference cases quickly; however the complex ones are still difficult to solve). In the meantime, the number of radiocommunication stations in France has doubled (from 51,000 in 1997 to 100,500 in 2003).

- **Role of SMA as trusted third party**

The existence of a trusted third party is an essential element in the field of frequency management in order to bring about the necessary confidence for the emergence of new markets. Until now, administrations have successfully discharged this duty.

One of the main reasons for this is that changes to the spectrum regulatory framework often require access to confidential information relating to commercial as well as to government uses. Such information may be commercially sensitive or relate to defence (including NATO) or security systems, which means that none of it can be made publicly available. Access to this type of information is essential in order to determine the amount of spectrum to be used by both types of applications and the level of constraints to be applied to each of them in shared bands in order to ensure mutual compatibility. In particular, the fact that commercial bands are used or are likely to be used by government applications in exceptional cases imposes strong constraints in terms of frequency management.

The trusted third party also has a role to play in checking or certifying compatibility studies between systems, especially when they are subject to confidentiality.

In all such situations, an administration has the credibility to act as a trusted third party. In particular, it engenders confidence in both parties that a deal established under its auspices will be guaranteed under all circumstances. This credibility is further strengthened by the key role played by governments in negotiating and guaranteeing the global or regional agreements, which are the foundation of spectrum management and which are very often closely related to and condition such deals.

In the absence of the kind of confidence provided by administrations acting as trusted third parties, many deals between different government users and between government users and civil users, that are necessary to relocate spectrum or modify sharing constraints would not be possible; consequently, less flexibility to change the existing framework would be achievable.

- **Spectrum refarming**

Changing market or technical requirements may require the administration to change the Allocation Table in the public interest, for example to introduce commons, or to transfer bands from government to commercial services. The considerable experience gained with such situations in CEPT shows that such changes are facilitated by a national decisional structure which is matched to the situation (i.e. which offers the possibility and opportunity for discussions between the parties involved) and provides financial incentives for the incumbents to move out of the band or make the necessary adjustments to allow new entrants (e.g. accounting law, tax incentives or a spectrum refarming fund).

ITU-R Recommendation SM 1603 (Spectrum redeployment as a method of national spectrum management) considers this issue in detail.

- **Allocation fees**

Optimum allocation between users may be facilitated by the use of allocation fees, encouraging these users (for instance defence or other government users) to release spectrum to others when its retention is no longer justified. Depending on the level of the allocation fees, this approach may also make it easier to avoid spectrum hoarding and reduce inefficient use of spectrum.

3.4.2 Licensing

Article 18 of the Radio Regulations stipulates that “no transmitting station may be established or operated by a private person or by any enterprise without a licence issued in an appropriate form and in conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station in question is subject”.

This provision is a key element in ensuring traceability of interference across borders, by establishing the continuity of the legal link from the cause of the interference to the victim. In situations where there is no risk of causing harmful interference across borders, for example when low power transmitters are used, administrations may overlook this provision, designating the relevant band for “unlicensed use”, or “commons”.

3.4.2.1 Licensing methods

Licences may be granted to spectrum users through various approaches, which should be based on objective, transparent, non-discriminatory and proportionate criteria. These approaches may involve or combine the following:

- First-come-first-served
- Beauty contest
- Auction

Once granted, the rights and obligations associated with these licences may be transferred fully or partly from one spectrum user to another through secondary markets, where trading has been introduced.

It would be interesting to consider licensing selection procedures such as auctions or beauty contests and see how flexibility can be introduced in these assignment processes. ECC Report 65 provides further insight on the use of auctions and beauty contests in CEPT countries.

3.4.2.2 Licence conditions

Rights and obligations attached to licences for the right of use of frequencies as defined in the Authorisation directive are subject to certain limitations, i.e., conditions specifically relating to spectrum use may encompass “designation of service or technology, efficient/effective use of spectrum including coverage requirements, technical and operational conditions to prevent harmful interference, maximum duration, transfers, fees and commitments made via auction or beauty contest as well as compliance with international obligations”.

The rights relate to the use of a given part of the spectrum to provide a given radiocommunication service, under certain conditions/limitations which are part of the licences. These include the right to operate, transmit and receive radiocommunication stations, with a certain level of protection from harmful interference. It is for the SMA to decide on the level of protection to be given to radio services within its territory. In so doing it has to take into account all relevant international obligations.

In any case, spectrum is a part of the public domain and licences are granted on a revocable basis even if the licence is given to an operator for a number of years, i.e. the administration/regulator may decide to withdraw or vary a licence subject to appeal, on grounds of public interest or for any other reason foreseen in the licence. Such withdrawal or variation may be subject to appropriate compensation and these measures should be proportionate.

Individual spectrum rights have at least three dimensions:

(1) Spectrum bandwidth which can be used (radio frequency area from x MHz to y MHz, with duplex band when needed)
(2) Geographical area where rights to use can be exercised
(3) Time

The validity of spectrum rights is normally limited in time. Time limitations may differ according to the type of service provided.

The obligations attached to the rights follow from a legal basis and a regulatory framework which involve national and international constraints. Regulatory authorities may impose obligations to share spectrum with other services and networks, to use spectrum efficiently and to limit interference. Regulatory bodies/administrations may also impose obligations to promote competition, to contribute to the development of the internal market and to promote public interest.

More flexibility may be sought by reducing obligations, in particular in relation to the type of services that may be provided within the scope of the licence, and in relation to the associated technical parameters. This flexibility however, has to be exercised by the regulatory authority within the limits negotiated in the National Allocation Table. Any change in the terms of a licence to allow other services or relaxed technical parameters may therefore require a new negotiation at national level, and in many cases at regional or worldwide level.

Duration

Duration of use in frequency allocations may range from very short term such as for temporary use for experiments to long-term such as for GSM/UMTS, emergency networks, military use, broadcasting services and satellite networks, where rights of use have often been granted for 15 years or more, but without common starting or ending dates of use between different countries or even within a given country. The type of services concerned, the types of use or markets addressed and the level of investment needed to develop those services have determined the type of duration chosen by licensors when establishing licence conditions.

Operators who have to invest large amounts of money in order to develop 3G networks, for instance, need certainty and security of tenure. However, by granting long-term licences, spectrum managers reduce their flexibility to take back the spectrum awarded for different purposes should the market develop differently than expected or even to modify licence conditions if there should be a case for this. Shorter term durations therefore provide greater flexibility for spectrum management, enabling inter alia the refarming of frequencies or review of licence conditions in general.

In contrast, increasing the licence duration provides increased flexibility to operators, in particular in the framework of a secondary market. The longer the licence duration, the higher the resale value of the associated rights for the operator, hence the higher the opportunity to sell it on secondary markets in case of unsuccessful business.
'"Rolling-term' licences balance these two considerations. Such a licence remains in force with no fixed end date and so has some characteristics of a perpetual licence. However, the SMA may revoke it at a defined period of notice, which may need to be shortened for specified reasons, such as on grounds of national security, public safety or compliance with international obligations. The length of the notice period may be chosen to take into account factors such as the scale of investment in the radio system in question. A minimum of five years may be suitable for most applications. This feature provides the SMA with the flexibility to take back spectrum if necessary, e.g. for re-farming purposes.

There is therefore a delicate trade-off between the need to allow spectrum management to react to new market developments and being able to refarm spectrum rapidly on the one hand and the need to give incentives for the secondary market to rapidly react to new market developments on the other.

Transfers of licences

Transfers of licences have been limited in scope up to now and have mostly meant transfer in the sense of change of ownership of a company that had been granted rights of use, or modifications of existing licences.

In some cases, transfer of licences has taken place via barter or limited market mechanisms (e.g. in France, PMR installers are acting as brokers to identify underused frequencies for new entrants and convince incumbents to release them), with effective implementation upon the regulator's approval. This has provided increased flexibility in ensuring timely response to operator's/user's requirements, with allocation fees providing an economic incentive to release underused spectrum.

The additional benefits that may be achieved in terms of flexibility by implementing spectrum trading have been considered by RSPG who delivered an opinion to the EC[14].

- **Modifications of licences**

In the past, modifications of licences have always been possible after negotiations between the licensing authority and all affected interested parties. This will continue to apply with the introduction of spectrum trading, where prior agreement of the licensing authority will be requested before authorising change of use, as emphasised in the RSPG opinion on secondary trading.

Therefore, the regulator will have to respond on a case-by-case basis to individual requests to allow a change of use beyond the terms of the original licence or by making a licence more generically flexible so as to authorise a wider range of applications within the licence conditions.

[14] See "RSPG Opinion on the secondary trading of rights to use radio spectrum - document RSPG04-54" (http://rspg.groups.eu.int/doc/documents/meeting/rspg5/rspg04_54_opinion_second_trading.pdf)

If the SMA agrees to a request to modify a licence to allow a change of use, this may result in an increase in interference. This raises the question for the SMA how to maintain users' confidence that their services will not be adversely affected by interference if flexibility is increased.

Spectrum licences usually define the technical characteristics of the transmitters permitted to operate in the band, for example parameters such as output power, location and antenna height. However, an important criterion for judging the possibility of change of use is the quality of spectrum for reception. The issue for the SMA is how to provide assurance to users and transparency about the spectrum quality they can expect.

In general, the decision to modify licence conditions is taken after a compatibility analysis has been carried out, based on technical planning assumptions and criteria and coordination procedures applied by the SMA, i.e. modeling the coupling between transmitters and receivers in geographical and frequency space. However, it should be recognised that these compatibility studies are sometimes complex.

Another way forward is to publish spectrum quality indicators based on present planning criteria and to allow users to negotiate variations between themselves, as long as they do not unduly affect third parties. These indicators will vary from band to band and application to application and will be expressed in various ways. This is an approach which has sometimes been taken in the case of coexistence between FWA operators in neighbouring areas, in the form of technical parameters such as power flux density level at a specified geographical boundary.

The process by which the SMA considers requests for licence modifications for change of use will be the same as now. Publication of indicators is transparent and engenders user and market confidence. However, the choice and definition of such indicators remain a challenge in general cases, given the wide range of possibility of change of use requests and the difficulty to have reliable and precise indicator correctly reflecting the real impact on the receiver. Further work on developing and validating the concept of such indicators is necessary before they can be considered as a tool to allow greater flexibility in spectrum use.

It is not necessary to provide a formal guarantee, and indicators may differ from the pre-existing actual level of spectrum quality, especially if the band is not currently fully occupied.

- **Role of the administration in introducing spectrum trading**

The introduction of spectrum trading is likely to add to the SMA's tasks and responsibilities in some respects while relieving them of some responsibility for selecting the licensees to whom the spectrum is assigned. Additional tasks include the following:

a. Detailed rules with defined rights and obligations for all parties involved need to be established

b. Observance of competition rules needs to be ensured; in particular anti-competitive behaviour and market failure (in particular excessive concentration of market power) need to be detected and controlled

c. Information on licence conditions, rights and obligations should be available, as well as the information relating to rights and obligations associated with each trade, the corresponding assignments and any information affecting the price, in particular the content of all relevant coordination agreements. The extent of the information to be published should be discussed with interested parties.

In addition the SMA has to continue to play the following roles:

d. Protect spectrum rights, police obligations, investigate possible infractions and manage disputes between users by taking binding decisions on them. This role may be expected to increase as a result of the introduction of secondary trading.

e. Establish acceptable levels of interference and ensure that these levels are not exceeded.

f. Ensure efficient and effective use of spectrum. This may include the prevention of hoarding and avoidance of excessive spectrum fragmentation.

g. Evaluate and control change of use beyond the terms of licences.

Two ways of increasing flexibility with regard to the evolution of an application under a specific licence have been identified. The first involves requests from licensees to the SMA to vary spectrum licences individually in order to reduce or remove restrictions. The second involves changing licences generically to make them less usage and technology specific.

Of these two mechanisms, the first allows the SMA to control interference, consistency with European harmonisation and other policies on a case-by-case basis and to agree on a certain level of interference. However, licensees (and the industry more generally) will not have certainty about what will be permitted until the SMA has given its consent to a specific change. The SMA may also decide to promote the change of use in an harmonised manner (i.e. revision of an ECC Decision) in order to benefit from European-wide harmonisation and more generally ensure that such change of use is consistent with the evolution of harmonisation measures at the European level. This mechanism may be administratively burdensome.

The second mechanism provides more certainty and is less of a burden administratively and legally. However, implementation is more challenging as spectrum usage rights need to be defined generically in a way that is more technology and usage neutral while maintaining the necessary degree of control over interference. Generic definition of the application will also limit the possibility of harmonisation in the band. Due to the difficulties of redefining existing spectrum rights, the SMA may prefer a progressive approach in the definition of more flexible spectrum rights, starting with the first model described above**.**

Flexibility can also be increased by allowing licensees to negotiate changes to technical parameters between themselves. For example, a licensee wishing to increase transmitter power and increase the number of transmitter stations could negotiate with neighbours to accept the higher emissions that would result. The licensees would then apply to the SMA for a licence variation to reflect their agreement. This would apply only where the relaxed parameters would not unduly affect a third party.

Removing restrictions on spectrum use has the potential to lead to an increase in interference that could reduce the value of spectrum. The SMA needs to remain actively engaged in interference investigation, be vigilant against this risk and, in general terms, maintain sufficient control to prevent undue interference and meet other objectives and obligations while allowing as much flexibility as possible.

A possibility is to base initial spectrum rights on existing spectrum planning assumptions that are implicit or explicit in technical frequency assignment criteria or national coordination requirements. Licensees could then negotiate and trade in order to adjust their licence parameters. This will give licensees confidence that spectrum quality will not be reduced below the level allowed by the SMA although they may themselves choose to tolerate a lower quality in return for acceptable compensation from another licensee.

It is possible that a licence variation has a greater effect than foreseen on the spectrum quality of neighbouring assignments. In that case, the SMA needs to remain vigilant in investigating interference and taking appropriate enforcement action where necessary.

Fees

There is a distinction between charges intended to recover costs of spectrum management and fees imposed for the purpose of providing incentives for efficient use of spectrum. Fees can have an impact on the behaviour of spectrum users, in that they provide economic incentive to release spectrum which is not used efficiently. Fees are therefore an instrument that spectrum managers can use to enhance flexibility.

Whether or not to introduce spectrum pricing in excess of cost recovery is a matter for individual SMAs. If it is decided to introduce spectrum pricing, the SMA will need to decide the methodology for setting fees. It is beyond the scope of this report to discuss this in detail but there are two essential principles that should be observed:

- licence fees should be no higher than necessary for spectrum management purposes, for example reduction of spectrum congestion or making spectrum available for other users or uses; and
- spectrum pricing should not be considered or used as a tool for maximising revenues.

The level of fees must be sufficient to provide an effective incentive for the licence holder to release or trade underused spectrum. Optimally, fees should reflect the economic value of the spectrum. Economic theory predicts that overall welfare will be maximised if finite resources, such as radio spectrum, are priced at a level that reflects their marginal value. Marginal value is difficult to estimate correctly, given the uncertainty of the evolution of the market and spectrum use. Auctions are a special case of spectrum pricing in which the price paid for the spectrum is determined directly by market participants instead of being determined by the regulator and licences are placed in the hands of those valuing them most.

There is a complex relationship between the setting of fees and spectrum trading. On the one hand it may be argued that the incentives provided by spectrum trading make it unnecessary to charge fees in excess of the costs of spectrum management. The ability of users to trade means that they forego the market value of the spectrum if they continue to hold the licence, and that this opportunity cost is sufficient incentive without pricing. On the other hand, spectrum pricing may play a role in reinforcing the effects of trading, especially in the early stages of the development of secondary markets. In particular, spectrum pricing imposes a direct economic cost whereas the opportunity cost of not trading does not. If the value of spectrum is expected to increase, spectrum pricing can be expected to help discourage licensees from holding spectrum in expectation of future gain. Moreover, spectrum pricing can operate to promote spectrum efficiency where trading does not take place because of transaction costs or information asymmetry. Spectrum trading can therefore be seen to be complementary to spectrum pricing rather than a substitute.

- **Additional roles of the *SMA* after introduction of spectrum trading, flexibility and liberalisation**

As explained in **section 2.1 and 3.2,** conditions of use contained in licences correspond to the regulatory radio interface. Under the R&TTE Directive, parameters which could be included in such regulatory radio interface were limited to the set of parameters defined by TCAM RIG as follows,

- Frequency bands
- Radio Service (ITU)
- Application restriction
- Channel spacing and designation of emission
- Transmit power limit
- Channel occupation rules (duty cycle, channel access protocol, transmission capacity)
- Duplex direction and separation
- Licensing regime

In cases where spectrum trading is introduced in a given frequency band, the administration may prefer to define the application in a broader way and limit or exclude licence conditions other than those relating to the frequency bands.

It has to be noted that unwanted emission masks are not included in this list since these are assumed to be already addressed in the harmonised standard. Since harmonised standards are not mandatory, it could be questioned whether an administration could include such unwanted emission or block-edge masks in their licence conditions.

It is important to emphasise that making greater use of market mechanisms does not mean that spectrum management is left entirely to market forces. SMAs and other regulators will continue to have a central role as discussed elsewhere in this Report. This includes:

- ensuring compliance with international obligations;
- making spectrum available for essential services, furthering broader social objectives and acting as ‘trusted third party’ in dealings with governmental and other public sector spectrum users;
- investigating abuse of dominant positions and ensuring that competition is not distorted;
- assigning spectrum and setting licence fees where spectrum has not been auctioned;
- maintaining records of assignments and trades and publishing market information;
- enforcing licence conditions and determining applications to change use outside those conditions;
- investigating and resolving interference and acting against illegal transmissions.

- **Administrative Management of licences and recording of frequency assignments**

Article 11 of the Radio Regulations requires that frequency assignments made by administrations (i.e. the detailed characteristics of each station) that are capable of causing harmful interference to services of other administrations or require protection from such interference be notified to the ITU Radiocommunication Bureau (BR) and recorded in the Master International Frequency Register (MIFR).

For reasons of continuity, and to ensure traceability of interference, there is a need for each administration to maintain a national frequency register that contains all the assignments made on its territory and reflects the rights of the users of each of the stations in the country. In bands shared between several users/services the time of recording in this register determines the right for protection (this is the first-come-first-served principle also embedded in the Radio Regulations). This process is central to both licensing and spectrum management activities.

Licences may cover different types of networks, usually: public networks (GSM, IMT 2000) and public access networks (PAMR), PMR.

Depending on the type of network, several models of detailed recording of the rights exist,

1. The licence covers the right for exclusive use of a frequency band and assignments are communicated to the administration. This covers GSM, IMT-2000 networks, PAMR and fixed link networks having exclusive frequencies or frequency bands. Exclusive right to a frequency band does not mean that any assignment may be used in the band. Recording of the assignments is subject to successful coordination with neighbouring countries and/or space services sharing the same band.

2. The licence covers the right to use assignments in a given frequency band or at (a) specific frequenc(y)(ies), on a shared basis with other uses/users, and assignments are made by the administration and recorded beforehand on a first-come-first-served basis. This typically concerns special events, PMR and fixed link networks which do not use exclusive frequencies. In the case of PMR, a specific frequency may be shared between many PMR networks in the same geographical area. Before assigning this frequency to a new network, the regulator needs to assess feasibility on the basis of the expected traffic loads of the networks involved. Such shared use may be difficult to deal with when secondary markets have been introduced.

Assignments are usually described by a set of data defined by files specified by the ITU BR. Secondary markets requires more complete data sets, such as service areas defined by a given field strength measured at specific test points.

The format of these data files allows in theory on-line frequency management, offering opportunities for secondary markets, where the publication of data concerning assignments gives flexibility, by enabling users requiring frequencies to design their own network.

The principles of such a market for PMR were tried on an experimental basis by a number of CEPT administrations (publication of assignments opened to everyone, interventions of frequency compatibility experts under the supervision of the administration acting as trusted third party). However, the number of negotiations, which varied through the years, remained very low and may not justify the important investments for an e-frequency licence management.

The management of frequency assignment and the recording in bands exclusively allocated to commercial uses (i.e. not shared with government services) may be made by a private body acting under the authority of the administration (e.g. for special events), provided that the process guarantees objective, transparent, proportionate and non-discriminatory access to spectrum.

3.4.2.3 Unlicensed devices and existing limitations

The main difference between licence-exempt operation and licensed operation is the protection given to the licensed applications.

Demand for frequency bands in which licence exempt applications can be deployed has grown considerably in recent years. A number of ECC Decisions have facilitated this for a number of applications in defined frequency bands (e.g. SRD bands). This gives users great flexibility to access spectrum for the designated application, and they are guaranteed that the band will be available for a long time.

Licence-exempt frequency bands with technology and serviceneutral regulations reduce the costs of entry for market participants and foster innovation by allowing innovative technologies to enter the market without requiring further negotiations with existing rights-holders or regulators, as long as the new technology respects the regulatory conditions imposed on the frequency band under consideration. [15]

Although the trend towards unlicensed usage is expected to continue, it should be noted that this cannot apply to every frequency band or application for several reasons:

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[15] See also the work of WGFM 43

While offering distinct advantages, licence-free operation may not be suitable for all applications or services. For this reason, a reasonable regime for frequency management consists of a mixture of different frequency management models, and it is important to find the right balance between them based on an assessment of the costs and benefits of different approaches and their suitability for different applications and frequency bands.

Introducing licence-exempt operation may be difficult in occupied bands that are subject to a different regime, which is a problem that this spectrum management model shares with other modes of spectrum management. In this case, the introduction of a new mode of spectrum management requires vacating the band of incumbent users. Difficulties may increase if the band is already subject to secondary trading, especially if the type of use is defined in a flexible way.

Compared to other, more centralised forms of spectrum management, the use of bands designated for licence-exempt operation may be more difficult to change at a later stage due to the large number of potential users and the lack of registration: Introducing licence-exempt operation in a given band makes it very difficult for the spectrum manager to subsequently modify the allocation scheme, or establish a secondary market in the band. It is possible to clear bands of licence-exempt applications only after a considerable transition phase**.**

Under the current regulatory regime, there have also been successful examples of operation of "underlay" unlicensed devices in coexistence with primary users under detailed technical conditions (e.g. RLANs at 5 GHz with DFS to protect radars). However, it is in general at this moment not yet allowed for unlicensed devices to use licensed frequencies, even if the operation does not lead to harmful interference for licensed users.

As addressed in the next section on new sharing approaches, there are several solutions to enable underlay users to gain efficient and low-cost access to spectrum. Even if it does not negatively affect their operation, such a solution may reduce the perceived rights of licensed users and make the evolution of usage in this frequency band more complex. Finding the proper balance between the rights of licensees, the requirement of "sharing" users and the need to preserve the possibility of evolution constitutes a difficult task; it is necessary, however, to facilitate in some cases the development of such solutions.

The answer to such situations is sometimes seen in a system of secondary trading. Under such a system exclusive, but flexible rights to use a specific frequency are given to a single actor, who can then provide access to this frequency to a secondary user under well-defined conditions.

In a world without transaction costs, this will lead to an efficient outcome, as the owner of a frequency will sell or lease all or part of the spectrum to those who value it more highly. In practice, transaction costs, uncertainty about prices and anticompetitive motivations may well impede theoretically efficient changes from happening.

First, transaction costs are likely to be greater for the more complex transactions. Depending on the technology, the secondary user may need access to a frequency along a number of different dimensions, making it difficult to standardize transactions in order to reduce transaction costs. In addition, for technologies that need access to a large number of different frequencies, the costs of negotiating access with all the different owners of these frequencies are likely to be prohibitive.

Second, an efficient system of secondary trading requires that parties to the transaction are able to determine the value of using it in advance. This may be very difficult in markets that are still under development and subject to significant technological and market uncertainty.

Third, for competitive reasons a frequency owner may deny access to his or her frequency to others even in conditions which would guarantee the absence of interference.

Due to these potential problems, a system of secondary trading based on unrestricted exclusive rights to specific frequencies may not be sufficient to foster the development of underlay applications. In these cases, SMAs may need to use regulatory mechanisms to enable the use of underlay applications. Whether this is possible, depends on the range of rights that have been transferred to the licensee/owner of the frequency.

Thus, it may not be feasible in practice to rely solely on market mechanisms to allow the introduction of underlay rights and there may even be a tension between a complete privatisation and liberalisation of spectrum on the one hand and underlay technologies on the other. For SMAs to be able to allow underlay applications to be introduced in frequencies subject to secondary trading, it would be necessary for licensees' rights to be carefully defined so that they do not allow licensees to block the introduction of underlay services.

3.4.2.4 Licence for experiments and system trials

Administrations authorise frequencies for experiments and system trials where possible. Experimental licences can be granted by administrations for a limited duration at a limited geographical location. Usually, the frequencies selected are similar or close to those envisaged for future operation of the system. In many cases trials are also possible in the bands used by commercial operators. This gives a lot of flexibility to both administrations and industry.

3.4.3 Introduction of market mechanisms: a practical illustration

This section illustrates how market mechanisms can lead to harmonised outcomes although there may be circumstances in which this does not necessarily occur.

If market mechanisms are successful, imposing exclusive harmonisation would not be expected to generate greater benefit than a technology and application neutral approach and there would be plausible circumstances in which *de jure* exclusive access would significantly reduce the benefits or prevent innovation and technical progress. On the other hand, there are also circumstances where harmonisation is a prerequisite for market success and for increasing the value of the spectrum. Some elements and level of *de jure* harmonisation would remain necessary to foster the development of the market and to ensure innovation and technical progress. The challenge before any introduction of market mechanisms is to determine the necessary elements and necessary level of *de jure* harmonisation.

In cases where administrations rely on market mechanisms, the following example illustrates the process that could be used:

- **Standardisation:** Standardisation is industry-led and tends to be agreed by manufacturers rather than imposed by regulators. The absence of *de jure* harmonisation does not prevent standardisation.
- **CEPT making spectrum available:** CEPT carries out the necessary technical studies to decide whether spectrum can be made available for the application without causing interference problems. CEPT then promulgates a Decision to make spectrum available for the designated application or technology subject to a minimum of technical conditions that are needed in order to avoid harmful interference. The spectrum may also be subject to a band plan designed to accommodate the designated application or technology. The Decision may prescribe a time frame for making the spectrum available so as to facilitate coordinated roll-out of the service across Europe.
- **Award of spectrum by SMAs:** SMAs award spectrum in the harmonised band by auction. The band is planned in accordance with a spectrum scheme laid down in the harmonising measure and designed to accommodate the designated application. The award process may involve a pre-qualification stage, but the licences being offered contain only those technical restrictions which are in line with the ECC Decision.
    - As a result of the auction, the designated application gains the possibility to access the spectrum. In valuing the band, bidders can be expected to take account of the advantages of inter-operability, cross-border roaming and economies of scale, which will tend to favour the harmonised application.

- **Following the initial award by SMAs:** the availability of trading opens up possibilities for more spectrum to be assigned to the designated application following the initial award in accordance with market demand without the need for the SMA to re-farm spectrum. If circumstances change following the initial award (e.g. demand from the designated application grows and/or demand for other application decreases), spectrum can be transferred to the designated application through the secondary market and change of use. Because the spectrum scheme is compatible with the designated application, it will be feasible to fit it into the harmonised spectrum scheme without the need to vary licence conditions. In this case, whether or not a trade takes place will depend on the level of transaction and other costs associated with change of application; spectrum trading does not guarantee access to sufficient spectrum for the harmonized application if demand for both designated application and other applications is growing.
    - Trading can be expected to lead to a transfer of spectrum to the designated application where that application offers some market or commercial advantage that exceeds all costs such as transaction and refarming costs. The SMA may, in exceptional cases, decide to intervene, e.g. if there is a market failure of some sort. Tools available for the SMA include regulatory re-farming and payment of spectrum efficiency incentives to compensate for costs incurred in re-farming, subject, of course, to rules on state aid. The fact that market failures may occur in some cases is to be balanced against the potential benefits of market mechanisms more generally.

- **International negotiations:** According to the Radio Regulations, before the use of radio frequencies/radio stations commences, it is necessary to execute coordination and notification procedures and agree on the conditions of the use of frequencies with neighbouring countries via negotiation.

- This process provides a mechanism for the designated service to have the possibility to access spectrum through the market, therefore resulting in *de facto* harmonisation.
- **After CEPT review:** after 3 years, the harmonising measure will be reviewed in accordance with CEPT Rules of Procedure and may be maintained, revised or retired. If the designated service has not developed successfully, it is desirable to modify or retire the harmonising measure.

3.5 Scenarios for flexibility in spectrum management

3.5.1 Introduction

This Report shows that frequency regulation is a complex matter in which technical, social, regulatory and market aspects are closely interrelated. Changes in individual sub-areas can hence cause the entire structure to shake unless the effects on other sub-areas are investigated in detail. Furthermore, both the telecommunications markets and the frequency usage situations in the CEPT member states vary considerably so that a certain measure intended to render frequency regulation more flexible may have a totally different impact in different countries.

Nonetheless, in the following an attempt is made to present various scenarios on the subject of “Introducing flexibility in the spectrum regulatory framework”. At the same time it should be noted that these scenarios merely constitute examples for possible frequency regulation without recommending their implementation in any specific frequency bands.

As described in Chapter 2 of this report flexibility can be understood very differently by different stakeholder, and a number of scenarios have been developed in order to elaborate on the various elements of flexibility.

These scenarios shall only be seen as guidance for future discussions on the topic of flexibility and as a tool to structure these discussions. The two terms *market flexibility* and *technology flexibility* are used to describe the scenarios. Market and technology flexibility span from low to high. High market and technology flexibility make market entry easier and so tend to promote competition. However, competition is also affected by other factors, such as intellectual property rights."

3.5.2 Description of the scenarios

The two terms “market flexibility” and “technology flexibility” are used as axes in a chart to describe the scenarios.

The extremes of the market flexibility axis have the following characteristics:

- Low market flexibility is characterised by investment certainty, high entry barriers, strict market and service definitions, oligopolistic markets and restrictive service and market definitions.
- High market flexibility is characterised by free competition in services, low entry barriers, no service and market definitions.

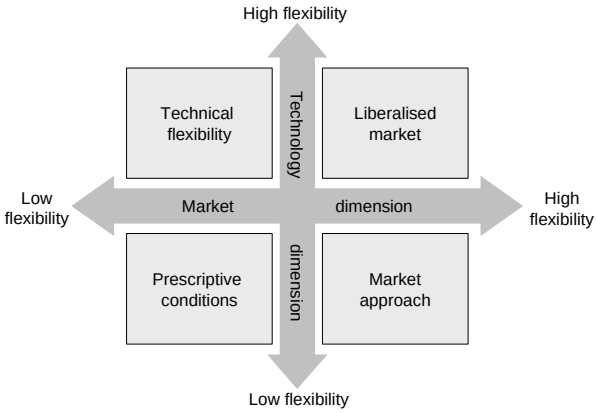
The secondary market is also part of market flexibility. However, secondary market can also be introduced with low market and/or low technology flexibility.

The extremes of the technology flexibility axis have the following characteristics:

- Low technology flexibility is characterised by investment certainty, spectrum scarcity, many restrictions, technology harmonisation, consensus-driven decision process, non-interference basis, longer and more complex process for change
- High technology flexibility is characterised by minimal restrictions, boundary conditions, change of technology, reconfiguration, lower harmonisation and higher probability of interference.

3.5.3 The scenarios

Four scenarios have been developed:
prescriptive conditions, *technical flexibility*, *market approach* and *liberalised markets*. The scenarios aim at illustrating the different elements of flexibility and represent tools that can be used to increase flexibility in spectrum management. Furthermore some of the foreseen effects of a greater or lesser flexibility are highlighted. The four scenarios represents different views on the way in which a frequency band can be managed. The different scenarios all have benefits and drawbacks, and will have a different impact on the market. One scenario should not be considered to be applicable to all frequency bands but would rather be applicable on a case by case basis.



3.5.3.1 Prescriptive Conditions

Prescriptive Conditions is based on low market and technology flexibility. Characteristics of this scenario are harmonisation of technology and services, regionally and internationally, national restrictions and obligations on technology and services, as well as a band-by-band, service-by-service approach. Examples within the *Prescriptive Conditions* scenario are GSM, Broadcasting and Air Traffic Management systems and more generally cases where interoperability and harmonisation are the main objectives.

The *prescriptive conditions* scenario can enable competition between services based on the same technology (e.g. GSM).

3.5.3.2 Technical Flexibility

Technical Flexibility is based on removal of unnecessary technical constraints. Examples of the freedom of choice of technology are the introduction of GPRS, EDGE, HSDPA, HSUPA and other enhancements to existing technologies (GSM, UMTS etc.), GSM and UMTS solutions in the same bands, freedom to use fixed or mobile technology in a specific band. To some extent, the development of underlay applications (UWB, cognitive radio) also brings technical flexibility.

Tools for achieving technical flexibility include removal of unnecessary constraints and innovative sharing.

The *Technical Flexibility* scenario can make new technologies possible and drive innovation. It also allows competition between different technologies within a defined market.

3.5.3.3 Market Approach

Market Approach is based on high market flexibility and low technical flexibility. This scenario is characterised by the creation of a market for the use of spectrum and will open the market for services. Examples include public mobile applications in PMR/PAMR bands (in cases where the technology to be used is specified in the licence) and fixed wireless applications in GSM bands. The "*market approach*" scenario is based on service neutrality potentially associated with primary markets and secondary markets.

The *market approach* scenario can enable competition between exiting technologies that are converging (e.g. mobile content over UMTS or DVB-H).

3.5.3.4 Liberalised Markets

Liberalised Markets is based on high market and technology flexibility. The scenario is characterised by technology neutral and service neutral licence conditions in order to let the market offer economically and technically effective solutions. This does not prevent *de facto* harmonisation of technologies and applications. It allows a multi-platform, multi-service offering (any network, any service) Examples are UMTS in GSM bands, BSS in MSS bands and mobile service in FWA bands.

One consequence of the *Liberalised Market* scenario, in the bands where it is introduced, is that spectrum management will have to focus on interference management. The scenario may enable innovation and in cases where *de jure* harmonisation is not necessary increase competition between technologies and applications.

3.5.4 Concluding remarks

The scenarios for future spectrum management presented above depict a situation where different bands, applications and spectrum management regimes can be presented and the potential for increased flexibility can be assessed. The scenarios aim at identifying the possibilities to increase the level of flexibility in spectrum management in cases and frequency bands where it would help drive innovation and foster competition for the benefit of the end user. All four scenarios presented here would benefit greatly from being introduced in a harmonised way.

3.6 Models for increasing the level of flexibility

Throughout this report a number of different scenarios and different proposals for increasing the level of flexibility in spectrum management are described.

There are already some well-known and developed models for increasing flexibility such as the “pure commons” model. One such example is the 2.45 GHz band. The need for more spectrum for the pure commons model is visible through the success of applications currently available in the 2.4 GHz band. However, since this model is well known and previously described it will not be explicitly discussed here.

It should be noted that the list of models presented below is not exhaustive. There might be many more models that could lead to increased flexibility on both national and European level.

The need for and actual effects of these models can vary tremendously in individual cases, depending on the frequencies used and the national market in which they are employed. This can only be determined on a case-by-case basis by means of a detailed analysis of the relevant pros and cons and is not within the scope of this Report.

Of course, for a number of bands the models presented are neither desirable nor possible to implement, but for other bands, that have to be identified, the models could be implemented. These models can be used as a basis for further discussion, and represent opportunities to increase flexibility.

3.6.1 Flexible bands

This model is based on individual licences with minimal technical constraints and no market constraints.

The basic idea is to lay down framework conditions in certain frequency bands for the protection of services operating in neighbouring bands and ensuring safety while omitting any further parameters for the use of the band as such. The licences are technology neutral, and can be used to offer any electronic communications service. This kind of license would allow flexible technologies, and since the usage has not been defined there is no need for administrative procedures in case of change of use of the frequency. There may still be a need for ‘site clearance’ procedures to coordinate transmitters of more than a certain power or antenna height.

A prerequisite to such an approach would be the definition of minimum requirements for compatibility ensuring a compatible and efficient coexistence of flexible bands and conventional bands.

Furthermore, in order to guarantee a maximum degree of flexibility for new technical developments, there should be no further specifications within these frequency ranges. If necessary, it would be possible to include conditions ensuring efficient frequency use.

These frequency bands should be harmonised at European level. In addition, minimal framework conditions would need to be defined. These conditions need to ensure compatible coexistence with conventional bands.

A few possible topics for discussion are listed below without further evaluation:

- number of licence holders
- conditions for efficient band usage
- radio interface descriptions
- coexistence conditions and dispute resolution framework

- conditions for duration of band usage
- spectrum mask (radiated power, maximum interference power at the band edges)

To ensure maximum freedom for the development of a new technology, usage conditions for the protection of neighbouring frequency bands should also be restricted to a necessary minimum.

Some of the above factors may not need to be harmonised. The concept will require further study to develop it further and it is recommended that CEPT should undertake work in this area, drawing as necessary on the results of studies into these topics.

The transition of a frequency band into a flex band may be facilitated by spectrum trading and interference trading where the different operators negotiate coexistence conditions including possible compensation payments on commercial terms. The complexity of such transition would depend on the difference between existing and planned usage in terms of technical characteristics.

In some geographical areas, bordering with neighbouring countries, which do not use particular bands as flexible bands, additional regulations shall be implied to ensure compatible coexistence of services used in those neighbouring countries. Such specific conditions will reduce benefits of flexible bands and therefore it is necessary to encourage and endeavour that, as far as possible, countries use a flexible band model.

3.6.2 Light Licensing Regime

A 'light licensing regime" is a combination of licence-exempt use and protection of users of spectrum. This model has a "first come first served" feature where the user notifies the regulator with the position and characteristics of the stations. The database of installed stations containing appropriate technical parameters (location, frequency, power, antenna etc.) is publicly available and should thus be consulted before installing new stations. If the transmitter can be installed without affecting stations already registered (i.e. not exceeding a pre-defined interference criteria), the new station can be recorded in the database. A mechanism remains necessary to enable a new entrant to challenge whether a station already recorded is really used or not. New entrants should be able to find an agreement with existing users in case interference criteria are exceeded.

The " light licensing regime" may lead to a very efficient use of spectrum where only active users are protected and where interference is less constraining (for example: ERC Recommendation 12-09 "Radio frequency channel arrangement for Fixed Service systems operating in the band 57.0 - 59.0 GHz.).

It can enable the SMA to protect a limited number of sensitive sites while giving greater flexibility elsewhere than could be allowed without the geographical limitation.

3.7 Conclusions

- Pace of change, development of competing technologies and uncertainty about the future of convergence make it necessary to review spectrum management policies to strengthen innovation and European competitiveness.
- For experience to be gathered of new approaches to spectrum management, greater flexibility in harmonising measures should be allowed in appropriate cases.
- It is for SMAs to decide in the light of national circumstances whether to rely on market mechanisms to comply with ECC Decisions. Rules of Procedure and Working Methods do not preclude use of market mechanisms by those SMAs that have introduced them.
- Administrations have a number of tools at their disposal to enhance flexibility, ranging from use of regulation to refarm spectrum to market mechanisms, including incentive pricing to encourage efficiency, auctions and spectrum trading to transfer rights of use.
- Flexibility may be increased by removing unnecessary restrictions from licences, either through case-by-case variation to permit change of use or by making licences generically more flexible. In so doing, care needs to be taken not to increase interference to an unacceptable degree and to the impact on harmonisation.
- Introduction of spectrum trading is likely to add to the tasks and responsibilities of SMAs, eg in terms of preventing interference and observance of competition rules, while relieving them of the responsibility to select which users will generate greatest value from the spectrum.

- The scenarios for future spectrum management in section 3.5 aim at identifying the possibilities to increase the level of flexibility in spectrum management in cases and frequency bands where it would help drive innovation and foster competition for the benefit of end users and consumers. All four scenarios presented here would benefit greatly from being introduced in a harmonised way.
- Two licensing models have been described in this report which may present interesting solutions for additional flexibility:
    - Flexible bands, where licensing conditions are laid down only for the protection of neighbouring bands whilst omitting any restrictions on services or technologies. These frequency bands should be harmonised at European level. Actions have been initiated at the CEPT level to find adequate frequency bands for such flexible bands and for defining the minimum requirements for compatibility. This work should be proactively pursued with high priority.
    - Light licensing regime, where the position and characteristics of the stations are recorded on a database on a first-come first-served basis, with responsibility for subsequent users to ensure the compatibility with previously notified stations.

3.8 Recommendations

- To improve spectrum management at the CEPT and European level, frequency allocation and harmonisation measures should be based on the designation of frequency bands for a particular application, as a result of the following process:
    - CEPT should base harmonisation measures on demonstrated need following an evaluation of operational need, cross-border mobility, market demand, economies of scale, effect on innovation and possible impact of limiting spectrum access for other applications.
    - CEPT should then pay particular attention to :
        - the definition of the application to which the harmonisation applies, taking into account the impact of convergence;
        - technology neutrality, which should be restricted only in specific cases where harmonisation justifies the restriction to a particular type of technology;
        - specification of the minimum necessary technical characteristics to achieve effective and efficient use of spectrum through prevention of harmful interference.
- When CEPT has adopted a harmonisation measure, all CEPT administrations are encouraged to implement it so that the harmonised application fully benefits from a European-wide market, without prejudice to their discretion to decide whether or not to commit to the Decision. Isolated actions taken by CEPT members regardless of the European Allocation Table would have a negative impact on achieving the objectives which have been sought through harmonisation efforts. Any step in this direction should therefore be carefully considered.

CEPT has decided to regularly review harmonisation measures and to decide whether they need to be maintained, modified or withdrawn. This is an element that increases flexibility. EC Decisions should be easy to adapt and should preferably contain an end date, after which they expire. If the EC agrees on including a sunset clause in its decisions, the sunset clause of the EC decision should coincide with the first review date of the ECC Decision on which it is based. EC decisions should be drafted so as not to stand in the way of flexibility which may be introduced in the CEPT..

4 TECHNICAL ASSUMPTIONS AND DEVELOPMENTS AFFECTING SPECTRUM MANAGEMENT

This Chapter gathers together some technical considerations relevant to the introduction of greater flexibility.

4.1 Basic technical assumptions in spectrum management

In order to illustrate various cases where underlying technical assumptions affect the flexibility of spectrum management, a list of examples is given in **Annex 5**. These examples show that it is always necessary to make certain assumptions as to the characteristics of the systems, when defining spectrum management solutions and identifying spectrum for introducing new applications.

Experience has also shown that additional sharing possibilities between different users/systems/services have been made feasible through the introduction of new technical concepts. In **Annex 5,** this is illustrated with RLAN and the DFS concept, NGSO system and the epfd limits, SRD and duty cycle or listen before talk limitations. In this respect, it is striking that the concept of promoting underlay services and systems, i.e. protecting primary spectrum users, needs to be coupled with rigid requirements such as extension of DFS, obligation to monitor interference temperature (for the primary user) and to connect to a database (for the interferer), or obligation to obey instructions from the monitoring control centre. Through these examples it can be seen that introducing more flexibility in the management of a particular frequency band generally results in imposing new constraints on the systems in that band (and in some cases in adjacent bands), i.e. limiting their flexibility in using spectrum.

With the goal to remove any unnecessary regulatory burden for radio applications, it is sometimes tempting to try to oversimplify the regulatory technical requirement. Below some examples of common misconceptions are given:

- Using a block edge emission mask to improve flexibility and technology neutrality. However, as illustrated in various examples of **Annex 5**, a mask is always based on assumptions about the system to which it applies and on the victim which is to be protected. It does not mean that it could not be applied to any system, but at the cost of more guard band and less protection for some systems. A certain mask will minimise the guard band for certain types of transmitting systems, need large guard bands for others and fully protect some systems and not others.
- Defining e.i.r.p. rather than output power and antenna gain in order to leave the flexibility to balance between power and directivity to the operator/manufacturer. This is true when the maximum interfering distance is the key protection criterion. However, when statistics of antenna discrimination can be introduced in the compatibility scenario, it often turns out that the output power is the relevant limiting parameter. Therefore, sharing studies need to take into account the benefit brought by the antenna discrimination and the technical constraints defined to enable the sharing between two applications in the same band should more often consist of a limitation of the output power rather than the e.i.r.p. For example, ERC Recommendation 12-09 on fixed service at 59 GHz has been revised in order to increase the maximum e.i.r.p. while introducing a constraint in terms of output power.

4.2 New sharing approaches

4.2.1 The FCC's concept of "Interference Noise Temperature"

Interference Noise Temperature is not in itself a new sharing approach, but could be seen as a means to facilitate the implementation of a new sharing approach. The concept has been discussed in the United States following a recommendation by the Spectrum Policy Task Force that FCC "shift its paradigm for assessing interference to an approach that uses real-time measurements of actual spectrum use and adapt the responses of transmitters and receivers to these measurements" and "adopt a new "interference temperature" metric to quantify and manage interference".

The basic idea behind this concept has been used for a while in ITU-R and CEPT compatibility studies: one of the most objective way to gauge the impact of interference on a system is to assess the increase of noise caused by the interferer or rather "by interference". As a corollary, any system should include in its design (e.g. in its budget link), some allowance for external interference.

While this corollary has been widely used in all compatibility studies, it is not always easy to make it accepted by the proponents of the potential victim system. It is therefore recommended that ECC should advocate the need to include some allowance for external interference in any radio system design.

The problem with interference analysis is that it is difficult to extrapolate local results to conclusions about system behavior within the whole coverage area, and vice versa. The substitution of the 'worst case approach' by global Monte Carlo simulations in the past can be seen as a significant step forward in interference analysis. As mentioned above, there are certain shortcomings with the latter approach. The next logical step would be to improve existing analysis methodologies with which it should be possible to take into account the dynamic behaviour of the complete system.

The Task Force also recommended that FCC should "obtain data on the condition of the RF environment in each frequency band that would be used in setting temperature limits" and "undertake a systematic study of the RF noise floor". This information would indeed be useful and some elements already exist in ITU-R literature. However, the cost of monitoring campaigns is always high, particularly considering the number of frequency bands concerned. Therefore, the benefit of carrying out more systematic reviews of the RF noise floor should first be considered in terms of cost and benefits.

As a further recommendation, the FCC Task Force also addressed the need to use receiver standards which would make it possible to implement the interference noise temperature concept and benefit to interference management. In this respect, CEPT and ETSI have always paid continued attention to the need to specify receiver parameters in order to be able to carry out compatibility studies and to avoid harmful interference.

FCC has recognised the difficulty in implementing this concept and is not expected to find applications anymore.

4.2.2 Cognitive Radio

The Cognitive Radio concept increases the 'intelligence' in a radio system to provide it with the functionality to adapt to its environment. Such behaviour could facilitate more efficient use of shared frequency bands and lead to new models of spectrum management.

The cognitive radio concept has been introduced in the FCC Report and Orders on Cognitive Radio (FCC 05-57). Cognitive radios are essentially related to the possibility of introducing underlay services, but cognitive radio could have a wider application in facilitating the sharing between users with equal status.

The FCC definition of cognitive radio is very broad since it encompasses technologies and capabilities which have existed for years such as Transmit Power Control (used in all digital cellular systems) or listen before talk feature (already used by e.g. CT2 or DECT). However, it illustrates the fact that some advances in technology will facilitate a more extensive and more flexible use of spectrum resources. Although the feasibility of Cognitive Radio is still under debate, the concept of Cognitive Radio deserves attention - and not least with regard to its possible impact on spectrum allocations and usage, rulemaking and harmonisation.

The development of cognitive radio is to be further investigated within CEPT in order to identify the potential benefits and disadvantages of its implementation in various bands. The specific case of cognitive radio for underlay service is discussed further below.

4.2.3 Underlay service

The main objective of the interference noise temperature concept was to enable the definition of "underlay rights" based on interference temperature in order to increase spectrum usage and efficiency.

4.2.3.1 Real-time adaptive radio

One possible way to allow operation of underlay systems is to rely on real-time adaptive radio such as Radio LAN in the 5 GHz band.

The use of the interference temperature concept as described in the NPRM FCC 03-289 would require, in order to function effectively on an adaptive or real-time basis, a system to measure the "interference temperature" in the band and communicate that information to devices subject to the limit. A response process would also be needed to restrict the operation of devices so as to maintain the interference temperature at or below the level of the limit. Propagation conditions have such a wide impact on interference received that it is almost impossible for a potential interferer to assess the interference it may cause on others.

Three different ways to implement such a concept are described:

- DFS-like mechanism: "In the simplest case, the entire process would take place within an individual device. That is, the device would measure the interference temperature at its location and make a transmit/not transmit decision based on this measurement plus the device's own contribution of RF energy. If the result of this analysis were below the interference temperature limit set for that location, the device would transmit."
- Victim-Interferer cooperation: "another approach would be for the receive sites of a licensed service to measure the temperature and communicate those measurements to a central site, where the interference temperature profile for the region would be computed. A message could then be broadcasted indicating the temperature values over that region and perhaps whether devices would or could not transmit on particular frequencies."
- Real-Time Ubiquitous Monitoring: "A third more general case, might be to establish a grid of monitoring stations that would continuously examine the RF energy levels in specified bands, process that data to derive interference temperatures, and then broadcast that data to subject transmitters on a dedicated frequency, again perhaps with instructions how to respond. The transmitted temperature data from this monitoring system could also include the frequency and geographic location of the interference temperature measurement(s) and the measurement bandwidth so that an individual device could compute the rise in temperature due to its own contribution and make a decision to transmit. A somewhat simpler version of the monitoring grid concept might be to equip all transceivers on a network operating with interference temperature "thermometers" and GPS receivers so that they could measure and transmit temperature data on a real-time basis."

The third implementation option seems to be unrealistic since it assumes costly solutions such as a very dense monitoring station network or an obligation for GPS receiver on all transceivers. Furthermore, making the link between interference noise temperature measured at some geographical points and the requested change of parameters of the underlay system would be very complex.

The second implementation option is somewhat less unrealistic but assumes a very rigid sharing scheme with consequences for both the design of the underlay system and the primary operating system. This would probably lead to significant costs and interoperability as well as transition problems.. To some extent it also contradicts the principle of an "underlay" system which can operate without affecting the primary service.

The difficulties with the implementation of the second and third approach would increase further in a real environment with moving victims and/or interferers and different sources of interference.

It could also be questioned whether such a centralised interference management would not result in more rigidity and a heavier regulatory burden.

Therefore, real-time adaptive radio is, in practice, equivalent to Dynamic Frequency Selection. This has been recognised by FCC which has not made any attempt to implement the "victim-interferer cooperation" or the "real-time ubiquitous monitoring" solutions. The question is therefore about the possible extension of such a concept to other bands and other sharing scenarios.

4.2.3.2 Dynamic Frequency Selection

As explained in more detail in **Annex 5**, the DFS concept (i.e. equipment stops transmitting or changes frequency when detecting a system that needs protection) was originally developed in the years 1997-2003 within CEPT, in cooperation with ETSI, to enable the use of the 5 GHz band by RLAN in sharing with radars. This concept was subsequently endorsed at the international level through WRC-03 decisions.

With regard to generalising the DFS functionality to other cases, one has to recognise that a lot of work was required to specify DFS characteristics for RLAN, and this specification was based on the following elements:

- The relevant characteristics of radars (power, scanning, antenna characteristics, bandwidth, signal structure) were consistent and stable amongst the wide range radar of use.
- The radars transmit and receive at the same frequency, i.e. the knowledge of the signal level received at the RLAN makes it possible to derive the maximum RLAN interfering level at the radar antenna.
- The radars transmit at very high power, i.e. they can be detected by the RLANs even at large distances, where the RLAN emissions would not interfere anymore with the radars.

In other frequency bands and sharing scenarios, this set of conditions, or perhaps others, could also make the introduction of a new service or a new application possible. However, it has to be studied and determined on a case-by-case basis and any attempt at an overall generalisation of the DFS concept would inevitably fail.

CEPT has already started to identify other cases where techniques similar to DFS would improve the sharing situation. For example, ECC report 37 recommends the application of this technique ("Listen Before Talk (LBT)") to facilitate sharing between different categories of Short Range Device applications in the band 863-870 MHz as an alternative to the "classical" duty cycle restriction. Practical standardisation work to achieve this has started in ETSI/TC-ERM/TG28. The work would probably cover a channel access protocol for a single channel and also a search mechanism for finding an unoccupied channel.

FCC has also made attempts (NPRM FCC 03-289) to use DFS-like concept within the fixed (FS) and fixed satellite service (FSS) uplink band at 6525-6700 MHz and 12.75-13.25 GHz. Later, FCC has also considered the possibility for such mechanism to introduce unlicensed operation (e.g. WiMax) in the band 3650-3700 MHz (NPRM FCC 04-100) while ensuring the protection of receiving earth stations.

These attempts were not really welcomed by industry and those interested in the development of unlicensed equipment, because of the complexity of implementation for the unlicensed device and the lack of protection to the incumbent service.

In fact, in all bands investigated by FCC, Frequency Division Duplex systems had to be protected. This would require knowing some of the characteristics of the networks to be detected (e.g. the duplex separation), preventing any modifications of these characteristics and defining an additional margin to take into account propagation differences between receiving and transmitting frequencies. In the 3.6 GHz band, this would also mean that unlicensed devices such as WiMax equipment would have to "listen" to the 6 GHz band to protect earth stations receiving in this band.

Furthermore, in the case of CEPT, the solution of "listen before talk" for the band 863-870 MHz was sufficient to ensure protection between various SRDs but was not completely satisfactory with regard to the protection of other co-frequency systems such as tactical radio relays, for which receiving and transmitting frequencies are different.

Therefore, DFS is an interesting sharing approach, but it cannot be extended without careful case-by-case studies.

4.2.3.3 Practical implementation example of a cognitive underlay radio

An approach, which may meet these goals, is to develop a radio that is able to sense the spectral environment over a wide available band and use the spectrum only if communication does not interfere with licensed users. Such unlicensed low priority **Secondary Users (SU)** would thus be using **Cognitive Radio (CR)** techniques, to ensure non-interfering co-existence with higher priority users. The sensing should not be based only on the determination of the power in a frequency band, since a wireless channel is actually built on multiple *signal dimensions* that include time, frequency, physical space, and user networks**.** The optimal CR operation may allow sensing of the environment and secondary transmission optimised across all of the dimensions, while causing minimum interference on licensed band owners. Thus, CR techniques may allow a truly revolutionary increase in the ability to support new wireless applications. The "cognitive" part of such a system will have to ensure that a secondary system is only allowed to transmit if it has predicted with an agreed high reliability that it would not intolerably degrade the reception of signals for a primary (licensed) owner. One challenge for CR implementation is how to tackle the "hidden terminal" problem, i.e. how CR could avoid interfering to the close-by primary receivers, if CR can not sense the corresponding primary transmitter e.g. due to a propagation obstacle (e.g. hill). In a sense the Cognitive Radio discovers unused capacity and creates out of this unused capacity a "virtual unlicensed spectrum" to be used in a way not constraining the licensed owner.

As presented in the **Annex 6**, the Corvus concept which is proposed by a research collaboration of the Telecommunication Networks group – TU-Berlin and the Berkeley Wireless Research Centre – UC Berkeley[16] corresponds to the generalisation to many radio systems and frequency bands of the RLAN-radar sharing principle

[16] Robert W. Broderson, Adam Wolisz, Danijela Cabric, Shidar Mubaraq Mishra, and Daniel Willkomm, "CORVUS: A Cognitive Radio Approach for Usage of Virtual Unlicensed Spectrum", White Paper, 2004. http://www.tkn.tu-berlin.de/publications/papers/CR_White_paper_final.pdf

recently introduced in the 5 GHz band. Similar sophisticated concepts are presently studied in European Commission IST projects (e.g. E2R[17], see Annex 7) but the feasibility in practice has not been demonstrated yet. Some highly technical issues such as the "hidden terminal problem" described in the paper as "to be further investigated" can only be solved once implemented successfully in a demonstrator

The introduction of such concept has a cost in terms of equipment (terminal and base stations or access points), due to the very complex "listen before talk" mechanisms that need to be implemented. It has also a cost in terms of services that can be offered by secondary users due to the uncertainty on the availability at a given time of spectrum resources: offering a guaranteed quality of service imposes to implement a high level of redundancy and lowers as a consequence the data rate that can be made available.

To work properly such system requires that a very detailed knowledge of each radio system sharing a given band is available somewhere (radio regulations, publicly available database, common control channel?), meaning that full and transparent technological neutrality is not possible in frequency bands where such systems would be implemented. While holding a lot of promise for better utilitisation of spectrum, cognitive radio technology is still in its early phases. Before the technology can be deployed, more research is necessary. Given the potential benefits for more efficient spectrum use, it is recommended to support research in this field to tackle the open issues that remain.

4.2.3.4 UWB

Another possibility to allow for underlay systems is to limit the power density of such systems to a level which would not increase significantly the interference noise temperature and therefore ensure the protection of other services and systems. However, in order to have sufficient capacity and range, such systems would have to operate over a very large bandwidth. This is the concept of Ultra-Wide Band (UWB) systems which are currently under study in regulatory and standardisation worlds.

Two EC mandates to CEPT have been issued to define the conditions of introduction of UWB in Europe and ECC has set up a specific project team to respond to these mandates. There have also been undertaken some ITU-R activities (TG1/8) to carry out the compatibility studies between UWB applications and all services to be protected. Subsequent activities, including the use of mitigation techniques, have been carried out to try to tailor UWB conditions of use of spectrum which would enable UWB operations while adequately protecting other services and systems.

The initial results show a contradiction between the power density limits which would be necessary to protect other radio services and those which would be necessary to enable the development of a mass-market for UWB, i.e. the introduction of attractive UWB applications. This area is under intensive study in Europe with a view to developing a harmonised pan-European framework for the introduction of UWB.

4.2.4 New geographical or time sharing opportunities

Geographical and, to a lesser extent, time separation have always been identified as ways to make sharing between different systems possible.

There have been many examples in the past of geographical sharing. For example, SAB/SAP equipment has operated in the broadcasting bands on frequencies which were not used locally for broadcast transmission. An example of dynamically coordinated spectrum sharing is the operation of NGSO satellites which cease transmission when aligned with GSO satellite in order to protect GSO operation. Mesh networks could also in the future provide similar sharing solutions.

The possibility to allow for interruptible systems in bands where a primary service would not need to operate in a given area except for a limited duration has been envisaged. This would require detailed arrangements regarding the obligation of the interruptible system. The merit of such a solution would then highly depend on the possibility to design and market such a system under such stringent obligations.

[17] E^2R website www.e2r.motlabs.com

4.2.5 Software Defined Radio / Reconfigurable Radio

The progressive miniaturisation of radios, growing computing power, and integration of communication and computing capabilities on the same chip provide the technological basis for reduced costs and increased interoperability. Radio equipment becomes increasingly re-configurable by software, and the encoding of information in signals will become more and more flexible.

Software Defined Radio is defined as a radio in which the RF operating parameters including *inter alia* frequency range, modulation type, and/or output power can be set or altered by software, or the technique by which this is achieved.

Radio functionality previously confined to fixed hardware implementations continues to migrate to software running on processors, e.g. by use of software defined radio (SDR).
In its most basic form, software defined radio may be viewed simply as an implementation technique in which signal processing hardware is replaced by programmable devices. In the broader perspective, software defined radio is a collection of hardware and software technologies that make reconfigurable wireless infrastructure and user terminals possible.

SDR technology may facilitate flexibility, through reconfigurability. However, it does not eliminate the need for radio standards or harmonised or 'quasi-harmonised' frequency arrangements, nor reduce the need for spectrum policy, but it may ease the frequency allocation process by allowing faster evolution and reconfiguration of radio interface, roaming facilities and easier implementation of sharing solutions.

Software defined radio would make it possible to reconfigure a terminal in a new wireless environment to which it has not previously connected. The change in environment could be related to the change of location of the user (e.g. roaming to another country, moving from an urban to a rural area) or to the change of the radio environment itself (e.g. dynamic resource management). For example, the capability for users to move and roam across different wireless networks using different radio interfaces, and choose the form of connectivity and access device which serve their needs at a particular location at a particular moment (and in most cases unaware that a transition between one service provider and another, possibly using different protocols, has even occurred).

Depending on the scenario, a complete change in the radio interface implies a common download procedure which would need to be carefully specified. This may require some frequency harmonisation (e.g. common frequency resources and protocol available worldwide) unless some other solutions are implemented (smart card, pre-download by internet, kiosk).

Nevertheless, the expectations on SDR should be realistic. SDR should not be considered as a means to enable roaming between an arbitrary number of different, possibly incompatible radio technologies. SDR is not an enabler of full technology neutrality but also requires standardised radio technologies.

But software defined radio will certainly provide new opportunity for sharing and improvement of spectrum efficiency. The knowledge of such opportunities, the timescale of introduction of such technology and the requirement to benefit from it will progress continuously.

The implementation of this technology in terminal radio equipment is a crucial issue. Indeed, SDR for networks equipment does not raise major problems insofar as it stays under the network operator's control. But when the end user is permitted to freely install different versions of signal processing software and/or protocol stacks in a terminal, the network integrity may be at risk either by incorrect use or by an illegal act. Security as well as privacy-related problems are a key concern for operators. These issues raise regulatory concerns that need to be considered further before SDR is introduced.

From the end user point of view SDR is expected as a means to alleviate problems (e.g. in case of software bugs or of roaming problems) but it must not cause additional complexity in the terminal handling and should therefore preferably be invisible to the user of the terminal.

4.3 Conclusions

- New sharing approaches that over time may become available on the market range from the concept of cognitive radio, to underlay services enabled through realtime adaptive radio, Dynamic Frequency Selection or UWB, to geographical and time sharing opportunities and finally Software Defined Radio.

- The implementation of SDR in terminal radio equipment is a crucial issue. Indeed, SDR for networks equipment does not raise major problems insofar as it stays under the network operator's control. But when the end user is permitted to freely install different versions of signal processing software and/or protocol stacks in a terminal, the network integrity may be at risk either by incorrect use or by an illegal act. Security as well as privacy-related problems are a key concern for operators. These issues should be considered before SDR is introduced. Moreover, to avoid confusing complexity of the terminal handling SDR should preferably not be perceivable by the terminal user. SDR can be seen as an appropriate means to correct software bugs in terminals or to enhance in a controlled way the terminal capabilities. The downloading of entire new terminal software packets might raise additional commercial and technical issues.
- The introduction of SDR will not happen as a regulatory act, but will be made by the manufacturers according to technological capabilities and market requirements. The interest of the regulator will probably be restricted to the conformity assessment procedures and in particular the definition of responsibilities of e.g. manufacturers in case of resulting malfunction.

5 CONCLUSIONS AND RECOMMENDATIONS

This Chapter gives an overview of all the conclusions and recommendations as presented earlier in the Report. Further some indications for further work for CEPT are highlighted.

5.1 Conclusions on harmonisation and flexibility

- The changing spectrum management environment and the increasing pace of change require improvement of the spectrum management system, including increased flexibility, in order to be able to respond quickly to new technological and commercial developments so as to make optimal use of the radio spectrum and promote European competitiveness.
- The aim of the SMA should be to secure technical and economic efficiency in use of the radio spectrum. Harmonisation of the appropriate type can contribute to this.
- Demand for spectrum is expected to grow, especially in the most sought-after part of the spectrum between 300 MHz and 6 GHz. Meeting this demand will become increasingly challenging.
  Regulators cannot be sure about which applications or technologies will succeed in the market place. This is better left to standardisation bodies, industry and market forces. The role of the regulatory authorities is to adapt dynamically to industry and market requirements while taking account of the desirability of promoting a sufficient level of confidence for the market.
- Introducing more flexibility in the spectrum regulatory framework can be understood as increasing the ability of the spectrum regulatory framework to facilitate and adapt, in a timely manner, to user requirements and technological innovation by reducing constraints on the use of spectrum and barriers to access spectrum.
- Flexibility and harmonisation are not incompatible.
- A high degree of uniformity in spectrum usage can in some cases for some applications be achieved *de facto* on an industry-led basis without the need for exclusive harmonisation.
- Harmonisation in the sense of making spectrum available for designated applications or technologies to a specified timescale is generally beneficial. However costs and benefits need to be assessed in each case.
- CEPT should continue to promote publicly available standards harmonised worldwide for the benefit of the market and customers in certain markets (e.g. in the core IMT-2000 bands for 3G) and also take a positive stance *vis-à-vis* the development of other solutions (e.g. WLAN, BWA).
- Standardisation should be encouraged and is not an activity that regulators need to lead or in which they should necessarily be heavily involved.
- Sharing is one of the main sources of flexibility in spectrum management for satisfying new requirements. New sharing techniques can be expected to enhance spectrum efficiency and provide added scope for different applications to co-exist.

5.2 Conclusion on the ITU level

Although the ITU Radio Regulations already provide for a high level of flexibility, i.e. more and more allocations are made in all parts of the spectrum, in a way that enables each country to select, for each frequency band, the specific services it wants to implement in the band, subject to coordination with its neighbours, and to certain constraints arising from sharing with space services, studies in response to Resolution 951 are supported.

5.3 Conclusions on the European level

- Pace of change, development of competing technologies and uncertainty about the future of convergence make it necessary to review spectrum management policies to strengthen innovation and European competitiveness.
- For experience to be gathered of new approaches to spectrum management, greater flexibility in harmonising measures should be allowed in appropriate cases.
- It is for SMAs to decide in the light of national circumstances whether to rely on market mechanisms to comply with ECC Decisions. Rules of Procedure and Working Methods do not preclude use of market mechanisms by those SMAs that have introduced them.

5.4 Recommendations on the European level

- To improve spectrum management at the CEPT and European level, frequency allocation and harmonisation measures should be based on the designation of frequency bands for a particular application, as a result of the following process:
    - CEPT should base harmonisation measures on demonstrated need following an evaluation of operational need, cross-border mobility, interoperability, competition (operators, networks, terminals etc.), market demand, economies of scale, effect on innovation and possible impact of limiting spectrum access for other applications.
    - CEPT should then pay particular attention to :
        - the definition of the application to which the harmonisation applies, taking into account the impact of convergence;
        - technology neutrality, which should be restricted only in specific cases where harmonisation justifies the restriction to a particular type of technology;
        - specification of the minimum necessary technical characteristics to achieve effective and efficient use of spectrum through prevention of harmful interference.In some instances limitations on technology may be justified for reasons of spectrum efficiency.
    - When CEPT has adopted a harmonisation measure, all CEPT administrations are encouraged to implement it so that the harmonised application fully benefits from a European-wide market, without prejudice to their discretion to decide whether or not to commit to the Decision. Isolated actions taken by CEPT members regardless of the European Allocation Table would have a negative impact on achieving the objectives which have been sought through harmonisation efforts. Any step in this direction should therefore be carefully considered.
- CEPT has decided to regularly review harmonisation measures and to decide whether they need to be maintained, modified or withdrawn. This is an element that increases flexibility. EC Decisions should be easy to adapt and should preferably contain an end date, after which they expire.. If the EC agrees on including a sunset clause in its decisions, the sunset clause of the EC decision should coincide with the first review date of the ECC Decision on which it is based. EC decisions should be drafted so as not to stand in the way of flexibility which may be introduced in the CEPT.

5.5 Conclusions on the national level

- Administrations have a number of tools at their disposal to enhance flexibility, ranging from use of regulation to refarm spectrum to market mechanisms, including incentive pricing to encourage efficiency, auctions and spectrum trading to transfer rights of use.

- Flexibility may be increased by removing unnecessary restrictions from licences, either through case-by-case variation to permit change of use or by making licences generically more flexible. In so doing, care needs to be taken not to increase interference to an unacceptable degree and to the impact on harmonisation.

- Introduction of spectrum trading is likely to add to the tasks and responsibilities of SMAs, e.g. in terms of preventing interference and observance of competition rules, while relieving them of the responsibility to select which users will generate greatest value from the spectrum.

- The scenarios for future spectrum management in section 3.5 aim at identifying the possibilities to increase the level of flexibility in spectrum management in cases and frequency bands where it would help drive innovation and foster competition for the benefit of end users and consumers. All four scenarios presented here would benefit greatly from being introduced in a harmonised way.

- Two licensing models have been described in this Report which may present interesting solutions for additional flexibility:
    - Flexible bands, where licensing conditions are laid down only for the protection of neighbouring bands whilst omitting any restrictions on services or technologies. These frequency bands should be harmonised at European level. Actions have been initiated at the CEPT level to find adequate frequency bands for such flexible bands and for defining the minimum requirements for compatibility. This work should be proactively pursued with high priority.

    - Light licensing regime, where the position and characteristics of the stations are recorded on a database on a first-come first-served basis, with responsibility for subsequent users to ensure the compatibility with previously notified stations.

5.6 Conclusions on new sharing approaches

- New sharing approaches that over time may become available on the market range from the concept of cognitive radio, to underlay services enabled through realtime adaptive radio, Dynamic Frequency Selection or UWB, to geographical and time sharing opportunities and finally Software Defined Radio.

The implementation of SDR in terminal radio equipment is a crucial issue. Indeed, SDR for networks equipment does not raise major problems insofar as it stays under the network operator's control. But when the end user is permitted to freely install different versions of signal processing software and/or protocol stacks in a terminal, the network integrity may be at risk either by incorrect use or by an illegal act. Security as well as privacy-related problems are a key concern for operators. These issues should be considered before SDR is introduced. Moreover, SDR should preferably not be perceivable by the terminal user to avoid confusing complexity of the terminal handling. SDR can be seen as an appropriate means to correct software bugs in terminals or to enhance in a controlled way the terminal capabilities. The download of entire new terminal software packets might raise additional commercial and technical issues as e.g. payment for transmission, network load or need of a Common Pilot Channel. In so far, SDR can presently not be considered as a substitute for harmonisation of technologies and as enabler for technology neutrality. All these issues impact the introduction and acceptance of SDR.

5.7 Areas for further study within the ECC

Areas of further study could include:

1. Study the technical and regulatory implications of the introduction of flexible bands **(Section 3.6.1)**
2. Investigate in which bands light licensing regimes could be introduced **(Section 3.6.2)**
3. Study the practical implications of the described scenarios **(Section 3.5)**
4. Study further the increased sharing opportunities mentioned in Section **4.2.**

ANNEX 1: NEW TECHNOLOGICAL DEVELOPMENTS

In the recent years, standardisation has been particularly active within the IMT-2000 family (within 3GPP/3GPP2 under ITU-R auspices) but also within IEEE. This annex describes the pace of these activities.

The IMT2000 family has evolved in a coordinated manner within each family member (W-CDMA, cdma2000 and TDD CDMA−TD-SDCMA). For example, W-CDMA now encompasses solutions to increase data rate in downlink and uplink with HSDPA (High Speed Downlink Packet Access – release 5 of W-CDMA) and HSUPA (High Speed Uplink Packet Access – release 6 of W-CDMA).

This coordinated evolution has been facilitated by the process set up in ITU-R with the support of European administration and industry which is both enabling evolution of technology and ensuring harmonisation and standardisation through the "consensus building" phase.

It has to be noted that work of 3GPP and IEEE802.x is difficult to compare, because of significant differences in the working procedures and in the objectives.

From a technical point of view, 3GPP standardises a complete mobile communication system (radio interface, network and service architecture) with the objectives of end-to-end service provision, a high level of testability, multi-vendor network operations and a high level of security. Worldwide roaming and service continuity is an essential asset this concept provides to the end user.

The relevant groups of IEEE802.11 to 802.20 standardise for different fields of application various technologies for wireless connectivity, described as Layer 1 and Layer 2 functions of the radio interface. These activities are restricted to the radio interface. Network components and end-to-end service-provisioning are not in the scope of these IEEE802-groups.

Concerning the results that will be approved as standards, 3GPP elaborates a consistent standard which is continuously evolved as shown in table A1-1. This standard includes test specifications and allows immediately the implementation of interoperable equipment by many different manufacturers. 3GPP compiles the best ideas of various contributors, by means of a consensus process. This process consumes some time, but ultimately produces a balanced system concept. In IEEE802.x, generation of standards is faster but the results might in some cases (e.g. 802.16, 802.11) constitute a collection of a number of options that are not interoperable. As a consequence an IEEE802.x standard does not lead automatically to the interoperable implementation of equipment by many manufacturers. For example, the IEEE802.16e standard allows different implementations of the physical layer (OFDM256, Scalable OFDMA). To obtain interoperable implementations of such IEEE802.x standards a second step of generation of a certified industry standard is necessary. For this purpose industry associations outside IEEE are founded (e.g. Wi-Fi Alliance or WiMAX-Forum) which

a) select one or a limited set of options out of a IEEE802.x standard,
b) describe this set in test and interoperability specifications, which form the basis of product certification (e.g. as a Wi-Fi compliant or a WiMAX-compliant product) and
c) promote in the market the trademark granted to certified products that are implemented according the test and interoperability specifications.

In some cases these fora specify further functionalities (e.g. network architectures and functionalities) which are not covered by the standard but are necessary for operation.

One important consequence of these differences is that standardisation and technology development times and finalisation dates of 3GPP and IEEE802.x standards cannot be directly compared: The development of interoperability and test specifications outside IEEE puts an extra delay to the product availability. In 3GPP interoperability and test specifications are an inherent part of the work. The two approaches should be seen as complementary.

3GPP release and main features	Commercial deployment
Release 99 – basic WCDMA/UMTS	2002
Release 4 – Minor upgrade, more efficient TDD, IP core	2003
Release 5 – HSDPA, IMS to allow VoIP, IPv6 support	End 2005/06
Release 6 – HSUPA, WCDMA/WLAN interworking, Multimedia Broadcast Service	2007/08
Release 7 – little detail available	?

Table A1-1: Continuing Evolution of 3GPP

The IEEE 802.x family has also considerably proliferated since Wi-Fi (802.11) was specified. It includes now Bluetooth (802.15.1) - although this was originally specified outside IEEE, WiMAX (802.16), UWB and ZigBee as illustrated in Table A1-3. These IEEE standards are not an evolution comparable to 3GPP. They specify technological solutions that are tailored for several fields of application and are not mutually interoperable. These IEEE standards are solutions which complement each other and are related to ETSI activities and standards as shown in table A1-2.

	IEEE	**ETSI**
WAN (Wide Are Network)	802.20	UMTS/3GPP, EDGE
MAN (Metropolitan Area Network)	802.16	HiperMAN & HiperAccess
LAN (Local Area Network)	802.11	HiperLAN
PAN (Personal Area Network	802.15	HiperPAN

Table A1-2: Relation between IEEE 802.x and ETSI standardisation activities concerning radio interface solutions

Standard - common name	Deployment	Name of Certified product and Industry Association	Spectrum	Commercial deployment
802.11	Wireless Ethernet/Wireless Local Area Network	Wi-Fi Wi-Fi Alliance	2.4/5 GHz unlicensed	2002 for 2.4 GHz
802.15.1 – Bluetooth	short range PAN technology, possible by-pass for cellular		2.4 GHz unlicensed	[1998?]
802.15.3 – UWB/WiMEDIA	short range, high capacity		Various	Expected 2006
802.15.4 – ZigBee	low power, short range monitoring and control		2.4 GHz unlicensed	Unknown
802.16	wireless backhaul and fixed wireless access (802.16a) now adding mobility (802.16e)	WiMAX WiMAX-Forum	2 to 6 GHz licensed and unlicensed	802.16a: 2004 802.16-2004: 2005 802.16e 2007/2008
Standard not Available	high capacity cellular, fully mobile IP-enabled		<3GHz licensed	Unknown

Table A1-3: Proliferation of IEEE 802.x technologies

CEPT has been able to identify frequency bands and conditions of use suitable for these kinds of systems:

- The 2.45 GHz band has been made available in Europe (Wi-Fi, Bluetooth, ZigBee).
- The 3.4 GHz band has been identified for Fixed Wireless Access and CEPT has initiated some work for harmonising this frequency band for applications such as WiMax. WiMax had also requested access to other bands such as 2.6 GHz which is designated for IMT-2000 in CEPT.
- The use of the 5 GHz band for Wi-Fi has been promoted by Europe.
- The anticipated introduction of UWB in Europe is under study, in response to EC mandates.

Some of the technologies mentioned above (802.16e) may address a similar market as IMT-2000 technologies (see Figure A1-1), i.e. full mobility radio interface. In the same time, 3GPP and 3GPP2 are studying the merit of an evolution of IMT-2000 which would include similar technologies (e.g. IP over mobile, new modulation scheme such as OFDM…). It is unclear what the situation will be in few years.

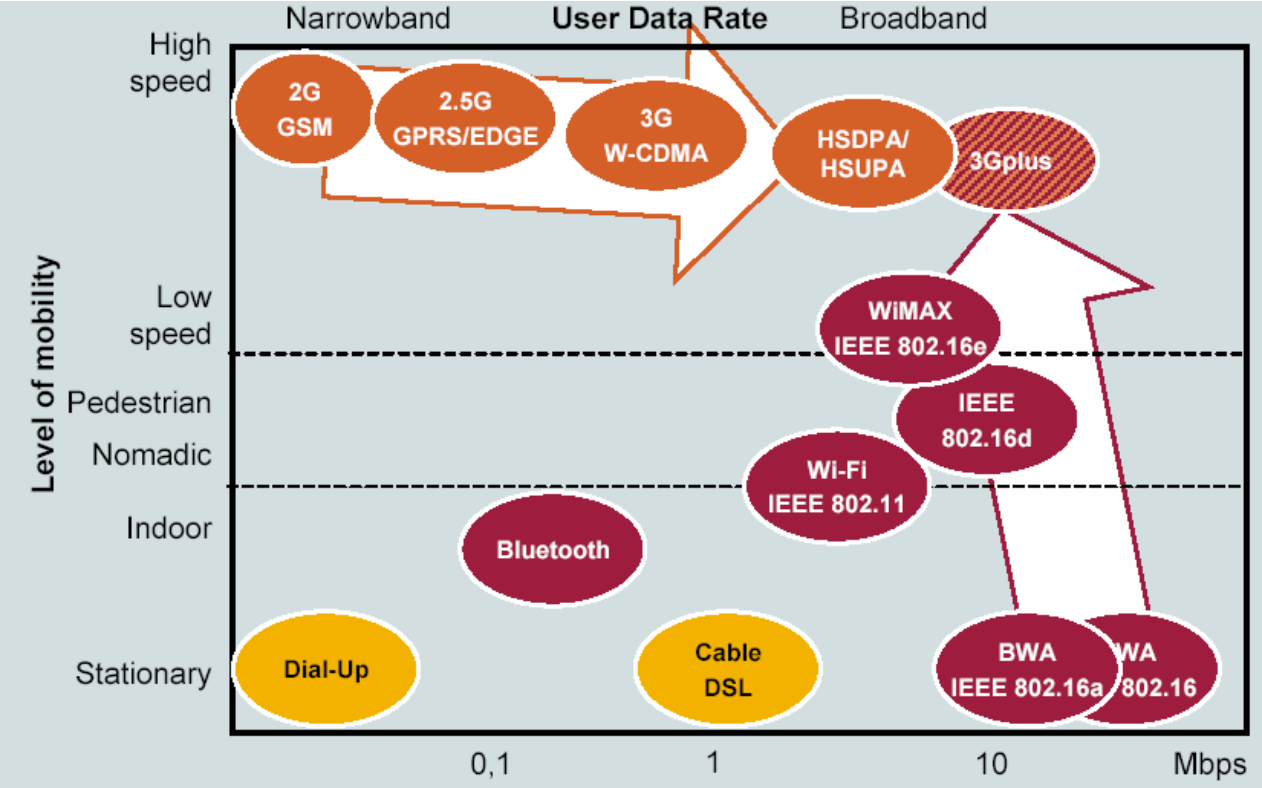


Figure A1-1: Relation between IEEE802.16 and IMT-2000 capabilities

The development of GSM and UMTS are good examples to show how regulatory activities (identification and allocation of spectrum) are a prerequisite for the successful, subsequent creation of an internationally standardised technology. Fig. A1-2 shows this for the example of UMTS and its evolution. It is obvious, how identification of suitable spectrum for a new to be developed technology/standard is an essential preparatory work in advance of the standardisation of the technology itself. This identification and allocation of spectrum requires major efforts by administrations and by industry as the creation of harmonized spectrum by reallocation and refarming of existing non-harmonized spectrum allocations in different countries is a difficult and time-consuming process.

As most of the wireless IEEE802.xx standards operate in unlicensed bands (e.g. RLAN, Bluetooth, some WiMAX profiles) the effort to identify spectrum for such technologies has been significantly smaller. This situation changes with the targeting by WiMAX of licensed bands.

With respect to the time lag between the initial efforts of spectrum identification and the later commercial deployment of the technology the fact that some new technologies are capable of using spectrum harmonized for IMT-2000 for other purposes does not necessarily justify a conclusion that technology cycles have become shorter. However, demand for harmonised spectrum from increasing numbers of technologies is growing and allowing them access to licensed spectrum would accelerate their introduction.

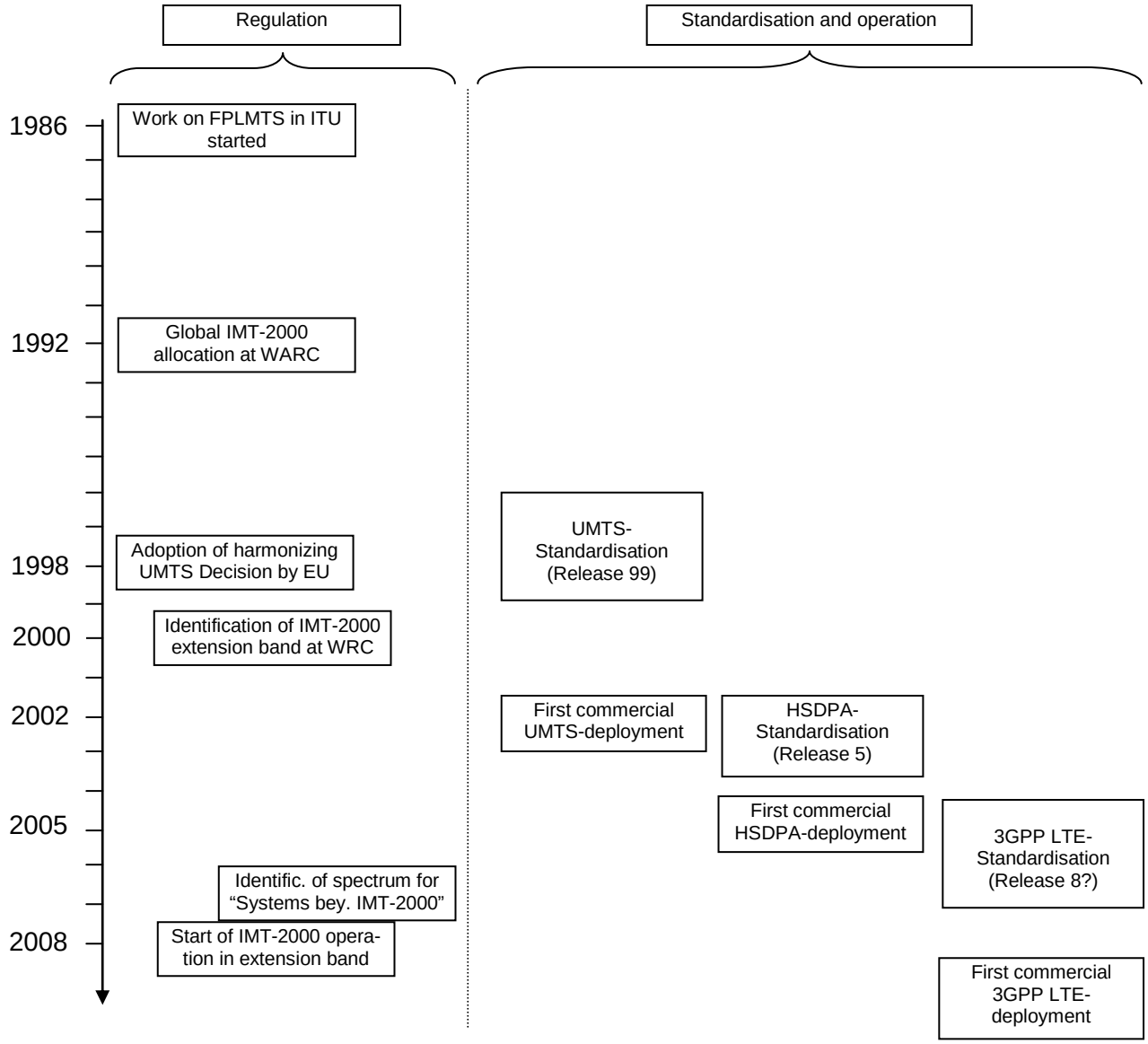


Figure A1-2: Dependency between Regulation and Standardisation in case of UMTS

ANNEX 2: CURRENT FREQUENCY MANAGEMENT ORGANISATION

1 Introduction

The radiocommunication sector is organised internationally within the framework of the International Telecommunication Union (ITU), which provides the basic technical and regulatory framework for the global coordination and management of the radio-frequency spectrum.

In between ITU and the national administrations, regional organisations establish common positions in preparation for ITU decisions, to harmonize national frequency allocations within the relatively flexible framework set by the ITU so as to allow for the coordinated introduction of new services in existing frequency allocations and to harmonise the standards and procedures with a view to the free circulation and use of radiocommunication terminals in the countries concerned.

It must be emphasised that only a few frequency bands are allocated exclusively to a single radiocommunication service. In most cases, frequency bands are shared by many radiocommunication services; the sharing conditions are regulated by technical compatibility rules decided after extensive studies and discussions between administrations and adopted by World Radiocommunications Conferences (WRC) as part of amendments to the ITU Radio Regulations (RR). Administrations are bound by the RR, which has the status of an international treaty.

In the field of radiocommunications, the European Conference of Postal and Telecommunications Administrations (CEPT) deals mainly with spectrum management, spectrum engineering and regulatory questions within working groups of the Electronic Communications Committee (ECC) which have the objective to harmonise frequency use in Europe in conformity with the RR, based on the principle of equitable access to the frequencies for all administrations and the efficient use of frequencies. The recommendations and decisions are usually adopted by consensus.

The European Union (EU) has general competence for spectrum policy and has established a regulatory framework for strategic planning and harmonisation of spectrum use within the Union with the objectives of establishing a framework of procedures. In particular, the EU Radio Spectrum Decision on a regulatory framework for radio spectrum policy in the European Community, establishes a cooperation mechanism which allows the EC to issue mandates to CEPT on the harmonisation of frequency use and to make the corresponding ECC decisions mandatory for all EU countries. The EU Framework Directive 2002/21/CE on electronic communications and the Authorisation Directive 2002/20/CE establish a set of rules applicable on secondary spectrum trading and frequency assignment procedures. The Radio and Telecommunications Terminal Equipment Directive (R&TTE) on equipment has also some consequences on spectrum harmonisation in particular on SRDs and on the standards dealing with radio-equipment.

Each State, in compliance with its international commitments, allocates frequency bands, either for government or administrative uses or for broadcasting and civil telecommunications (private industrial and commercial sectors, radioamateurs, CB, aeronautical, meteorological activities, etc.). The managing frequency authority draws up the national frequency allocation Table and the national frequency register listing frequency assignments and keeps them up to date.

2 Agreements between countries : principle of equitable access to the spectrum

The radio-frequency spectrum is a non-depletable natural resource available in all countries and in outer space. Since any transmitting radio station may cause harmful interference to spectrum uses on Earth or in space, the spectrum is a common resource of mankind that requires rational management by agreement between all countries.

Within this spirit, the ITU has been drawing up legal instruments for over a century, and the RR constitutes the principal regulatory framework within which States undertake to operate radio services and the basic tool for international spectrum use. The RR have international treaty status and are periodically reviewed (about every three years) by World Radiocommunication Conferences, which are attended by most ITU Member States.

The RR aims at allowing each country the greatest possible flexibility with regard to spectrum use. It specifies the frequency bands allocated to radio services, the regulatory conditions and the procedures that administrations must follow for implementing radio stations providing those services (Table of Frequency Allocations). The two guiding principles underlying all RR provisions are to ensure equitable access to spectrum resources by all countries and to avoid harmful interference to the services provided by stations using frequencies assigned to them in accordance with the RR and recorded in the Master International Frequency Register.

Within the CEPT organisation, decisions are not binding, and CEPT activities are based on a voluntary approach. However, the experience of the past ten years has shown that most CEPT decisions are implemented by a large majority of the members, even though they are not binding, and even if some administrations have not signed the

decisions in question. This is true for most important matters (UMTS, S-PCS, digital PMR, frequency band for Digital Emergency networks, short range devices) and has also been observed at WRCs, where European Common Proposals enjoy the broad support of the European countries.
CEPT Decisions designate frequency bands, conditions of use, and, if necessary, the conditions for sharing and the schedule of band availability for the services, applications and systems concerned. Each Decision also lists the national administrations that have implemented it. CEPT Decisions are generally adopted by consensus among the European administrations and as they are not binding, their implementation is the responsibility of the national authorities only.
Furthermore, a European Common Allocation Table resulting from three major spectrum investigations carried out since 1993, tends to forecast trends in spectrum organisation. These detailed spectrum investigations were based on public consultations opened to administrations, operators, industries, consultants and professional organisations.
The EU Radio Spectrum Decision replaces the case by case approach previously applied and several mandates pursuant to this decision have been issued on applications such as UMTS, RLAN, UWB, SRDs, ERMES bands. It also imposes transparency on national frequency allocation tables and associated information. CEPT establishes a database on national frequency tables which is managed by the ERO, the permanent office of CEPT.
In addition to the regulations on communication services, the EU has adopted the R&TTE Directive, which defines essential requirement for equipment placed on the EU market and removes obstacles to the free circulation of such equipment. The Directive also imposes the publication of information on regulated radio interfaces. R&TTE Directive has a definite impact on spectrum management by making a high degree of harmonisation among EU single market a necessity.
At national level, specific laws are applied to the radio-frequency spectrum which has to be managed so as to be of the greatest benefit to the entire population. The State is responsible for enforcement of international and regional commitments. In particular, allocations are to be listed in a national frequency allocation table, which has to indicate, for each frequency band, the authorised services with the corresponding authorised radiocommunication system categories and user categories.

3 Introduction of new services

Over the years the current framework of frequency management has enabled timely responses to the changing technological and market requirements and in many areas improvements have been introduced, such as accommodating new services and systems through innovative sharing approaches, or identifying globally harmonised bands for emerging services (IMT-2000, PPDR).

3.1 ITU level

ITU offers a broad forum in which problems can be discussed at global level with most of the parties concerned. There are obviously close relationships between ITU and national/regional standardisation bodies. All national or regional bodies stand to gain from ITU's role in defining global standards that offer numerous benefits in terms of cost reduction and market harmonisation.

The relatively flexible framework of the RR has the advantage of respecting the wide range of countries' spectrum needs and their sovereign right to meet those needs as long as it does not place undue constraints on other countries. It has the disadvantage of limiting economies of scale and the capacity for interoperability required to develop radiocommunications, in particular within the framework of worldwide services or those intended for the general public (e.g., mobile telephony, satellite broadcasting). For this reason, a major effort has been made in the past few years to harmonise spectrum use at regional, or even global, level, in particular with regard to mobile communication. The activity towards harmonisation has been to identify specific frequency bands for applications, corresponding to specific standards. The purpose of this harmonisation is to facilitate roaming and free circulation, to enable economies of scale and regulatory certainty for the large investments required in equipment manufacturing and network deployment and to decrease the risk of interference and incompatibilities between systems using the same or adjacent frequency bands.

International example : IMT-2000

One ITU project, IMT-2000, is an outstanding example of such a relationship. In that case, ITU had established a procedure for submitting the IMT-2000 radio interfaces proposed by the national/regional standardisation bodies. Those interfaces were then evaluated, and a final "consensus-building" phase resulted in a substantial reduction in the number of interfaces in the terrestrial component of IMT-2000 and in the greatest possible number of common features between them. This was a key factor in ensuring the success of IMT-2000 as a global mobile system with a global roaming capacity.

The IMT-2000 example demonstrates the growing importance of external bodies such as the Partnership Projects (PPs) established to develop the specifications for a given technology (3GPP for IMT-2000 CDMA-DS and CDMA-TD, and 3GPP2 for IMT-2000 CDMA-MC). In terms of IMT-2000, the purpose of the documents prepared by the Partnership Projects was to obtain recognition by ITU as elements of IMT-2000 specifications and endorsement by the various national/regional standardisation bodies as standards in their own right.

Example of satellites in the IMT-2000 at 2 GHz or 2.5 GHz

Parts of the bands identified by the ITU for IMT-2000 at 2 GHz and 2.5 GHz are also allocated, on a shared basis, to the mobile-satellite service for the satellite component of IMT-2000. This provides maximum flexibility for administrations to use these parts for the terrestrial component of IMT-2000 or for the satellite component. The power levels required for the satellite component are however, not compatible with the terrestrial component on the same service area. Since the rights associated to this use are based on the first-come-first served principle, the flexibility offered by the RR and the specific time limits included in the procedures of the RR entail that the rights for using the terrestrial component of IMT-2000 in the bands shared with the mobile-satellite service can only be secured three years before the terrestrial component is deployed, i.e. these rights may not be entirely defined at the time they are given.

At European level, CEPT decided to allocate 2x30 MHz in the 2GHz band only for MSS and to allocate the whole 2.5 GHz bands for Terrestrial IMT-2000.

Example of non-geostationnary satellite systems in the fixed-satellite service

At WRC-95, the USA proposed to open part of the 20/30 GHz allocation to the Fixed-satellite service (FSS) to non-geostationary satellite systems. The regulatory approach proposed by the USA was based on coordination between geostationary-satellite systems and non-geostationary satellite systems, which was presented as equitable and flexible. However, these conditions would have lead to a de–facto worldwide exclusive allocation in 1 GHz of spectrum and consequent monopoly for one US company (Teledesic) in the provision of wideband non-geostationary satellite services.

Europe unsuccessfully opposed to the proposed decision, but obtained that it would be reviewed at WRC-97. After extensive studies within CEPT in the 1996-1997 timeframe, and blockage of discussions by the USA in the ITU-R preparatory process, Europe was able to balance the WRC-95 decision by opening the remaining part of the 20/30 GHz FSS allocations and all the 11-12/14 GHz FSS allocations to non-geostationnary satellite systems, using an innovative sharing approach based on power limitations, without coordination, thus enabling full reuse of 7 GHz of spectrum by non-geostationnary and geostationary satellites (a practical doubling of the bands), and making competition possible. After three years of additional studies in the ITU-R, the approach adopted at WRC-97 was validated by WRC-2000.

Although the telecommunication crisis in 2002 stopped the development of these new systems, this result shows the flexibility and responsiveness of the CEPT and ITU framework in addressing new requirements through innovative sharing approaches in a context where a large number of services were affected.

3.2 Regional level : CEPT and European Union

Within the CEPT, a memorandum of understanding has been signed with ETSI (European Telecommunications Standards Institute) in order to ensure effective cooperation between the two organisations and to avoid any inconsistency between European standards and regulations. Thus, if standardisation and regulation are more distinctly separated at European level than within ITU, whenever possible ETSI promotes the worldwide standardisation process.

The EU policy defines essential requirements, and conformity with relevant standards can be undertaken either by the company responsible for the product or the service, or by a certification body. Under that approach, ETSI is given mandates by the European Commission to produce European Standards (EN). Once these standards are approved by ETSI, the list of their references is published in the European official gazette and they become Harmonized Standards (HS).

However, equivalent standards to ETSI standards can also be used in accordance with WTO obligations and EU regulation.

Implementation of an innovative spectrum management technique: the Dynamic Frequency Selection (DFS) and the RLANs at 5 GHz

This example is interesting to look at with regard to the introduction of new technologies and the impact it had on the frequency management environment.

Studies on developing RLAN systems in the 5 GHz band began in early 1991 within CEPT following a request from ETSI which had started its standardisation for HIPERLAN system. It was a recognition that the 2.45 GHz band already identified for RLAN, with its limited capacity (83 MHz) and the severe sharing environment (ISM, Short Range Devices), would create a risk of impairing the development of RLAN, although it was at that time mainly a concept.

CEPT designated, in ERC Recommendation T/R 22-06 approved in 1992, the band 5150-5250 MHz for HIPERLAN, taking into account the sharing constraints with other services, i.e. MSS feeder links. An "optional" 50 MHz in the band 5250-5300 MHz, in sharing with radar systems, was also proposed in this Recommendation on a national basis.

Later, a concept similar to HIPERLAN was developed in the United States under the name "U-NII". This led to the identification by FCC in 1996 of the band 5150-5350 MHz and 5725-5825 MHz for such applications. It corresponds to 300 MHz of spectrum, significantly more than what was designated by CEPT. Also, 200 MHz of this spectrum was allowed in outdoor environment.
Therefore, ETSI came back to CEPT asking for a similar amount of spectrum, justified by the need for a sufficient number of channels enabling quasi-cellular deployment, and for some spectrum authorised in outdoor environment.

CEPT initiated additional studies but faced two difficulties. Firstly, the band 5725-5825 MHz was allocated in Region 1 to the fixed satellite service, making this band unsuitable for outdoor applications. Secondly, the whole band 5250-5825 MHz was used for various kinds of radars and it was demonstrated that a large population of RLANs would have a high potential of interfering with such radars.

In this context, the idea of applying Dynamic Frequency Selection (DFS) to ensure the compatibility with radars was successfully developed in the years 1998 and 1999 within CEPT.
The DFS concept was not really new : it was often used to enable coexistence between digital equipment in the same system (e.g., in the DECT system). However, it was the first time that it was used as a mechanism for enabling sharing between systems as different as RLAN and military radars.

In practice, the definition of exact DFS characteristics required much more work in close cooperation between CEPT and ETSI, in order to define the level at which a radar signal will be detected and how the RLAN should behave when detecting such a signal. One initial difficulty was to persuade industry that the application of a simple "intra-system" DFS would not be sufficient to ensure the "inter-system" compatibility with radars.

In parallel, CEPT proposed at WRC-2000 that RLANs in the 5 GHz band should be included in the WRC-03 agenda in order to get an additional allocation for the mobile service to enable the "recognition" of the RLAN use in this band which was also partly allocated to space services. After long discussions with the United States in particular, the band 5470-5725 MHz was finally allocated to mobile service on a primary basis, subject to an obligation for mobile stations to use DFS.

This illustrates the fact that CEPT, in the framework of the CEPT-ETSI MoU, was able to identify and implement successfully a new sharing technique enabling the designation of a very large part of spectrum (455 MHz) for RLANs in the 5 GHz band. This technique was subsequently generalised to other parts of the world through WRC-2003 decisions.

Extensive studies were required to specify the DFS characteristics for RLAN, and this specification was based on the following elements:

- The relevant characteristics of radars (power, scanning, antenna characteristics, bandwidth, signal structure) were consistent and stable amongst the wide range of radar uses.
- The radars are emitting and receiving at the same frequency, i.e. the knowledge of the signal level received at the RLAN enables to derive the maximum RLAN interfering level at the radar antenna.
- The radars are transmitting at very high power, i.e. they can be detected at a point where the RLAN interfering signal is still negligible.

This example shows how compatibility studies organised by administrations to arbitrate between incumbents and new entrants (operators or manufacturers) have enabled a modification to the allocation framework in a timely and successful manner, within the current spectrum management framework.

3.3 National level

According to Recommendation ITU-R SM.1603 (Spectrum redeployment as a method of national spectrum management) and Report ECC Report 16 (Refarming and secondary trading in a changing radiocommunications world), refarming is a spectrum management tool that can be used to respond to changes in international frequency allocations or to satisfy new market demands relating to specific frequency bands.
Spectrum refarming is required when frequency bands have to be made available. At the national level, refarming makes it possible to introduce new radio applications and enables new applicants access to spectrum.
In that way, some administrations used or are using spectrum refarming to free frequency bands in order to implement faster 2G and 3G mobile services, Digital TV etc.
In order to increase the efficiency of refarming, a few countries have introduced a refarming fund to compensate spectrum users for having to hand back spectrum. Actually, such a fund can provide a convenient means to speed up the spectrum refarming process and makes it possible to meet the time table laid down for the availability of frequencies to newcomers.

It can be noted that institutional organisation at the national level and the distribution of responsibilities, between the different bodies that are in charge of the management of the radio spectrum or a part thereof, can hinder or facilitate the refarming process.
In countries where spectrum organisation makes no provision for discussions about spectrum uses and arbitration between governmental and non governmental uses, it seems very difficult to employ refarming.
On the contrary, in countries where institutional organisation enables main spectrum stakeholders to discuss about spectrum apportionment and provides for a body (e.g. the Prime Minister) in charge of arbitration between governmental and non governmental spectrum uses, refarming is much easier to do.

At a time of rapid technological evolution and globalisation, refarming organised by an organisation delegated with the appropriate authority by the State, is a spectrum management method that can take into account, on the one hand, the growing demand for frequencies for non governmental purposes and, on the other, the spectrum resources needed to carrying out of activities of general interest, notably those that help to ensure the safety of people and goods.
So, refarming introduces flexibility in the spectrum regulatory framework, although it can be time-consuming.

ANNEX 3 : DEVELOPMENTS IN CEPT ADMINISTRATIONS[18]

FINLAND

Organisation of frequency management in Finland

Historical development of frequency management in Finland

Radio administrative functions existed as a part of the Radio Department of the Posts and Telecoms already at least in the fifties. Since 1984 this unit then called the Radio Inspection Division became formally legally independent in its decision-making from the P&T, in particular Director of Radio Department. A separate independent telecommunications administration (Telecommunications Administration Centre) was founded 1st October 1988. Its name was changed to Finnish Communications Regulatory Authority (FICORA) in 2001. During all this time Radio Administration has existed as an internal unit.

Property of radio frequency spectrum

In Finland, radio spectrum is considered as public State property. The regulative powers to allocate the spectrum and assign frequencies to the users are divided between the Ministry of Transport and Communications and FICORA. The legal basis is defined in the Radio Act (1015/2000) and for authorisations for public networks in the Communications Market Act (393/2003) and for broadcasting in the Broadcasting Act (774/1998). Broadcasting authorizations are decided by the State Council. More details are given further below. Formally there are no other authority organisations but major user organisations like broadcast network operator Digita, cellular network operators, maritime authority and aviation authority make detailed plans for their networks under constraints given in block allocations, coordination agreements etc. The Military can plan the use of their dedicated frequency bands quite independently but for shared bands needs authorizations with a (confidential) legal instrument, which is in practice equivalent to licences for civil users.

Current organisation

Entities involved in national spectrum organization

- The Ministry of Transport and Communications (www.mintc.fi)
- The Finnish Communications Regulatory Authority (www.ficora.fi)

Their tasks and prerogatives

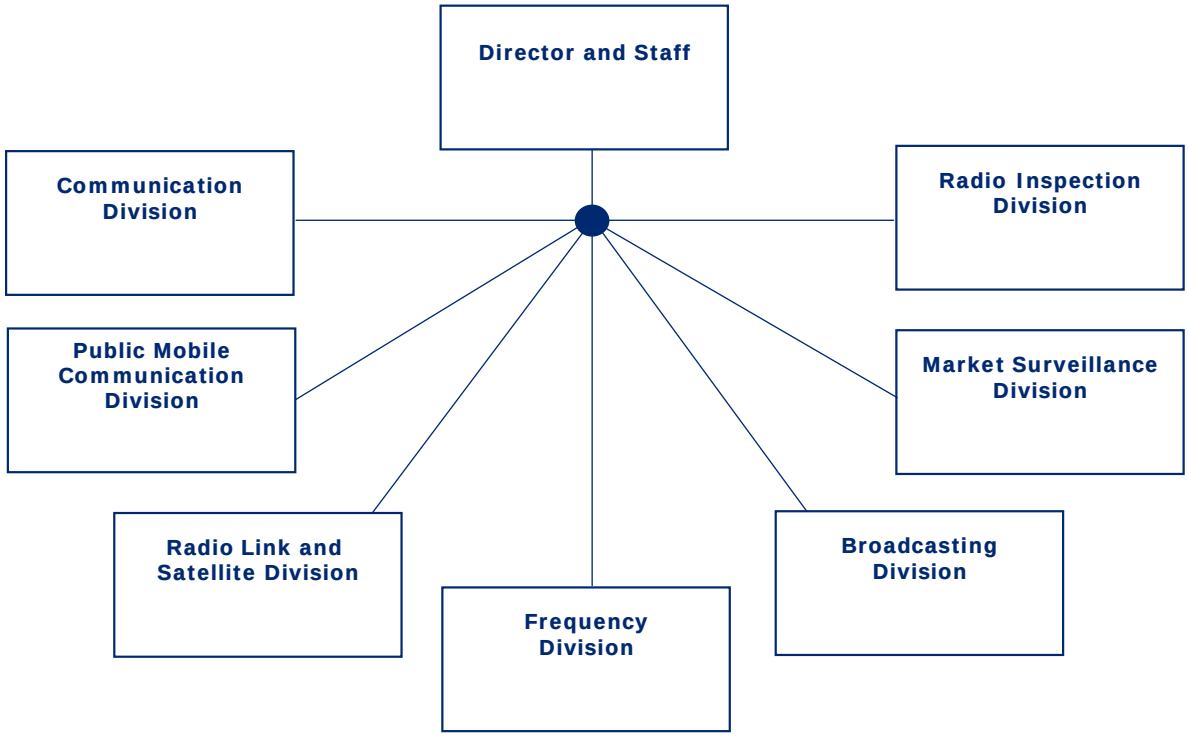
- The public cellular network assignments and broadcast assignments are defined in a Decree given by the Ministry. These are all networks for which an authorisation is needed under the Communications Market Act or Broadcasting Act.
- The Ministry is also active in defining the policy related to the selection process of authorised operators and general policy for development in these sectors of telecommunications.
- The overall national frequency plan is however a regulation issued by FICORA, which means that FICORA aims to fulfil in a balanced way the needs of all the radio services. This plan has to comply with the political goals of the Ministry but its revision is quite flexible and can be done within a few weeks if necessary.
- FICORA plans, manages and monitors the utilisation of frequencies. It defines the Finnish position and coordinates the action of Finland's representatives in international negotiations on frequencies. It also coordinates the establishment of radio stations on the national territory so as to ensure the best use of the available sites. This includes detailed interference analysis of all new radio networks or changes in existing networks and results in a radio network plan for the licensee. Radio monitoring and investigation of occurred cases of interference provides feedback for this work.
- FICORA consults the users and user groups when preparing changes in the frequency plans and in preparations for international meetings and in particular for WRC preparations.
- FICORA acts as the regulator for the telecommunication sector. It applies all the legal, economic and technical provisions making telecommunication activities possible.

[18] Situation end 2005/ beginning of 2006**.**

- FICORA's role as the manager of broadcast frequencies is constrained by the Ministerial Decree mentioned above to short-time events type of use and surveillance task under the Broadcast Act (programme content, cable distribution)

Internal organisation of the Radio Administration (unit name Radio Frequencies) within FICORA

Organisation chart of the Radio Administration



The figure above illustrates the internal units of the Radio Administration, which now has a new name Radio Frequencies. Apart from the Radio Inspection Unit, the organisation is based on certain split of Radio Services. This is however not obvious in all the names. Communication Division is dealing with Radio Amateur, Aeronautical and Maritime Services and also all other below 30 MHz, except broadcasting. Frequency Division is mainly dealing with Mobile Services (including all SRD applications) but also Fixed Service below 1 GHz, and it is responsible for overall development of the national frequency usage plans. In particular the Public Mobile Communication Division and Broadcasting Division are in close cooperation with FICORA internals units dealing with competition and multimedia issues, and also with the Ministry. FICORA defines the technical basis (frequency constraints) for Ministry's Decisions on authorizations.
There is no separate licensing unit but economical and customer billing issues are concentrated in the Radio Link and Satellite Division. In many cases dealing with a new radio network application requires cooperation of several Divisions. In such preparation meetings there are no Division borders.

International cooperation
A new unit for international affairs has been recently set up directly under the Director General of FICORA. Its task will probably form to represent Finland at a high level in the ITU, the CEPT and other international organisations. However participation in international groups dealing with the sectoral matters of substance is the task for expertise in the sectoral units. This means that the same people who perform the daily frequency management work also participate in international groups of their own area.

Consultation

The Radio Administration has organised open national consultation groups in order to use the expertise of its customers in future planning of our activities and for preparation of international work. The main group is dealing with budgetary issues and preparation of medium range future plans. It is normally meeting only twice a year but its membership forms also an email consultation list on more urgent issues. There are also permanent subgroups for

WRC preparations and for TCAM preparations. Electronic consultation is used regularly for national consultation of ECC deliverables and consultation on national draft regulations.

Flexibility and harmonisation

At present Finland does not see that there would be much possibilities to widen the licence-exempt area. For some frequency bands, which are in collective use for specific user groups, Finland has a simple licensing system only registering the users because there is no need to assign frequency channels. However these bands are national and unless their continued use for this purpose can be guaranteed by European harmonization (like PMR446) we do not think it is possible to open them for license-exempt use.

Finland is constantly following the developments on the market through art. 6(4) notifications in order to see if existing national deviations from ERC REC 70-03 seem to cause undue difficulties for taking innovative products in use.

FRANCE

Institutional organisation for frequency management in France

Property of radio frequency spectrum

In France, Radio spectrum is clearly defined as State public property. The government allocates frequency bands to various radiocommunication services, to be managed by government departments of agencies and independent authorities. In conformity with No. 18.2 of the Radio Regulations, the government (either directly or through independent authorities) delivers authorizations for the use of spectrum by private entities.
Under French law, State public property cannot be sold or alienated. The State has the obligation to maintain its domain (and through the Radio Regulations, to use it efficiently). Rules on occupation of State public property are defined by laws, there are the bases for authorization of use by operators.
The property rights of the use of spectrum derive from the status of State public property.

Current organisation
Entities involved in national spectrum organization[19]

- The Prime Minister.
- The Direction Générale des Entreprises (DGE) which answers to the Ministry for Economic, Financial and Industrial Affairs.
- The Agence Nationale des Fréquences (ANFR), a public administrative body.
- The administrations and authorities to which frequencies have been allocated, i.e. the governmental authorities utilizing frequencies (the Defence Department, the Department of the Interior, the Centre National d'Etudes Spatiales (CNES), the meteorological administration, the civil aviation administration, the ports authority, radio astronomy in the Education Department) and two independent authorities, the telecommunications regulatory authority - Autorité de Régulation des Communications Electroniques et des Postes (ARCEP) and the broadcasting authority - Conseil Supérieur de l'Audiovisuel (CSA).

Their tasks and prerogatives

- The Prime Minister approves the national frequency allocation table submitted by ANFR.
- DGE prepares the government's policy positions on postal and telecommunication matters. The minister in charge of telecommunications grants operating licences for public networks and public telephone services.
- ANFR plans, manages and monitors the utilization, including for private purposes, of frequencies in the public domain. It draws up the national frequency allocation table, and defines the French position and coordinates the action of France's representatives in international negotiations on frequencies. It also coordinates the establishment on the national territory of radio stations so as to ensure the best use of the available sites.
- The administrations and authorities to which frequencies have been allocated manage the frequencies allocated to them, in part or in whole, under the national frequency allocation table. They are full members of the ANFR Board of Directors.

[19] http://www.arcep.fr
http://www.anfr.fr
http://www.minefi.gouv.fr/minefi/pratique/telecommunications/index.htm

- ARCEP (the Regulatory Authority for Electronic Communications and Post) is the regulator for the electronic communications sector. It applies all the legal, economic and technical provisions making electronic communications activities possible.

  As far as the regulation of the electronic communications sector spectrum is concerned, ARCEP allocates to operators and users, in an objective, transparent and non-discriminatory manner, the frequency resources needed for their activity, and ensure that they are used efficiently.

  Where there is a proven scarcity of frequencies, ARCEP may propose conditions for their allocation to the Minister responsible for Electronic Communications (DGE), after public consultation. In this case, the period of investigation may not exceed eight months.
- CSA manages broadcasting frequencies. It issues broadcasting licences to FM radios and private television companies. It is also the regulatory authority for terrestrial and satellite broadcasting and for cable. It is also the regulatory authority for programme content.

Legislative and regulatory framework

For electronic communications: the Post and Electronic Communications Code codifies the sector's legislative and regulatory texts, including:

- The telecommunications regulation law of 26 July 1996, which establishes the legal framework for telecommunications and lays the legal foundation for the creation of ARCEP and ANFR.
- The implementing legislation on the organization and functioning of ANFR and ARCEP.

For broadcasting:

- The law on freedom of communication of 30 September 1986 as modified and completed by further laws.

Both legislations have been modified by the Law of 21 June 2004, relating to confidence in digital economy, and the Law of 9 July 2004, relating to electronic communications and audiovisual communication services, which implements, in particular, the elements of the Framework Directive.

Rationale for institutional changes

Before 1 January 1997, the national frequency management framework was the following:

- The Prime Minister approved the national frequency allocation table submitted by the CCT (Telecommunications Coordination Committee, created in 1945)
- DGPT prepared the government's policy positions on postal and telecommunication matters. The minister in charge of telecommunications granted operating licences for public networks and public telephone services, as now. DGPT also regulated the telecommunication sector (as now ARCEP).
- The administrations and authorities to which frequencies have been allocated managed the frequencies allocated to them, in part or in whole, under the national frequency allocation table. They were full members of the CCT, which offered a framework for discussions between them to plan, manage and monitor the utilization, including for private purposes, of frequencies in the public domain.
- CSA managed broadcasting frequencies as now.

As currently done by ANFR, the CCT drew up the national frequency allocation table, and defined the French position and coordinated the action of France's representatives in international negotiations on frequencies. It also coordinated the establishment on the national territory of radio stations so as to ensure the best use of the available sites. CCT’s role was essentially the same as ANFR now, except that it had very limited financial and staff resources (14 staff members), hence increasingly inadequate resources to fulfil its role. This led to a situation where most of the work in spectrum planning was done directly between the administrations and authorities to which spectrum was allocated, leading to:

- the absence of a trusted third party qualified in all areas of spectrum, and
- build-up of mistrust between the telecommunication sector, represented by DPGT, and other ministries/authority.

This situation was especially detrimental during international negotiations, at CEPT or ITU levels.

The situation was also detrimental in the field of spectrum relocation, due to the absence of financial resources. By creating the ANFR, the new regulatory framework enabled a fully staffed (350 staff members) and financed

government agency to carry out national spectrum allocation, coordination, recording planning and monitoring, and national leadership in international negotiations, as well as financing spectrum relocation.

On 1 January 1997, a telecommunications regulator, ART (which became ARCEP in May 2005), was created, independent from the government. The board of ARCEP is named by the President of the French Republic, the Chairman of Assemblée nationale and the chairman of Sénat. ARCEP has its own budget financed by public funds voted by the Parliament. Fees and taxes are paid to the general budget.

Frequency management tools – Example of Relocation Fund in France

Introduction

The introduction of new applications requires access to spectrum. New applications are developed taking into account available spectrum and need to be optimised within the constraints inherent to the frequency band selected. Depending on its degree of utilisation by other entities, the frequency band selected may offer varying degrees of difficulty of access for new applications. Some incumbent users have the flexibility to move their equipment from one frequency band to another and may accept to vacate spectrum, provided adequate encouragement or compensation. Others could not accept it. The apparent degree of flexibility that administrations may have to accommodate new applications/users is closely related to the type of encouragement/compensation that is available to give access to these applications in a given frequency band.

The whole Spectrum is allocated and used by different Radiocommunication Services operated by private companies or directly by administrations/government agencies. In recent years, making spectrum available to satisfy European and/or Global Harmonization and benefit from it has required the relocation of many users. This has allowed or will allow the introduction of GSM, IMT-2000/UMTS, PPDR, satellite applications, digital television broadcasting. Also, the introduction of innovative technologies requires access to spectrum to demonstrate their viability and to succeed.

This problem is not new. In the past, the cost of spectrum relocations was supported by monopolistic operators. However, the question of access to spectrum and the means of relocating incumbents appeared with the liberalisation of telecommunications, and has been addressed in various ways.

One simple way is “to let the market do it”, for example through secondary trading. This however, is not suitable for the introduction of unlicensed uses such as RLANs, or in frequency bands which are unlikely to be opened to spectrum trading for a long time (e.g. those bands currently used by government or safety services, for scientific applications, or for broadcasting or satellites), or even at any time, because the corresponding applications/services have no alternative frequency bands available. It is significant that in recent years, most of new technologies/applications (e.g. GSM, UMTS, RLANs) have been introduced through spectrum relocations in situations which would be unsuitable for spectrum trading for these reasons. In such instances where secondary trading may not be a suitable option, additional flexibility may be sought by efficiently managing spectrum relocations, through specific tools such as relocation funds.

In this framework, it should be reminded that administrations have the responsibility, through the ITU Constitution, Convention and Radio Regulations, to manage spectrum efficiently, hence to manage the relocation of incumbents when required.

Need for spectrum relocation

The ultimate goal of spectrum management is to give access to spectrum to interested parties in due time, while ensuring the overall efficiency of spectrum use and avoiding harmful interference between spectrum users.

The fulfilment of this complex task might be possible only by applying a specific blend of tools of different origins: primarily engineering, but then (and increasingly so) general regulatory, competitive market, financial and political measures.

In their daily practices SMAs operate within a number of specific aims and objectives for management of the radio spectrum. These will reflect national policy and may e.g. favour public use or private enterprise. Stability in national policy is important to spectrum users for investment decisions. These policies and objectives will, inter alia, determine the shape of the spectrum management authority within the available resources and legislative requirements.

Part of efficient and effective spectrum management is to ensure the availability of spectrum for new or innovative applications in a timely manner, which means in anticipation of their implementation. Typically, this activity requires 2 to 10 years advance planning, which is commensurate with most technology developments, from the laboratory to mass market production.

To improve existing services or introduce new services it may be necessary to move existing spectrum users to more modern technologies or new frequency bands. This movement of existing spectrum users, or as it is otherwise known, spectrum refarming, or redeployment, or relocation, needs to be planned, although in some instances, it may be left to secondary trading. Spectrum relocation should be included in the administration’s national spectrum

strategy together with the mechanism identified to assist implementation of such relocation. It should be considered equally with all other options, i.e. sharing, removing restrictions, and not as a last resort.

Studies on relocation mechanisms and advantages

Report ECC Report 16 (Refarming and secondary trading in a changing radiocommunications world) and Recommendation ITU-R SM.1603 (Spectrum redeployment as a method of national spectrum management) can be used as guidelines for national consideration of relocation issues. These documents describe the refarming process, associated economic aspects and refarming instruments which can be used by the SMAs.

According to their analysis and conclusion, spectrum refarming is a spectrum management tool, which can be used to cater for new market demand, increase spectrum efficiency, work towards international harmonisation of spectrum usage or respond to changes in international frequency allocations.

In addition, spectrum refarming makes it possible to observe the timetable laid down for the availability of frequencies to newcomers.

Principles about relocations

The main principles to be applied in deciding on spectrum relocations are the following:

- Transparency
- Introduction of new entrants while taking into account economical aspects of existing networks
- facilitation of competition
- Avoidance of negative external effects by introducing direct interventions of state
- Avoidance of access barriers for entry in spectrum
    - No excessive entry costs (transaction costs for example…)
    - No creation of situations which may allow to retain frequencies or to introduce speculation
    - No cartelisation
    - No need of setting up hoarding by a new entrant
    - Fight against inertia of capital due to uncertainties, for example, created by asymmetrical information (unknown occupancy of frequencies or in part of concerned spectrum)
    - To avoid coordination problems which could lead to viscosity for investors or possible destabilizing activities, etc. A centralized authority facilitates this coordination and avoid chaotic management (for example it shows its interest when introducing wide band systems in a frequency and allocated to a narrow band systems operated by a multitude of users)
- To facilitate European and Global harmonisation and innovation
- To keep flexibility in the management of the use of spectrum and again to avoid chaotic situations
- For the State to carry out its duties as owner of State public property, in particular to keep control of spectrum and ensure its efficient and timely use.

Application in the French frequency management

Historical experience with relocations

In the past, the only telecommunication operator concerned was the historical, monopolistic operator, which was also part of the administration, as the other users of spectrum, e.g. Defence, Research, Space... Direct financial decisions could be taken between government entities to facilitate relocation, if required through arbitration at prime minister level.

The separation of the operator from the administration, the increase in the number of operators and the development of new applications have led to much greater demand on spectrum, hence more relocations have been necessary, in a situation where the solution previously used was no longer possible.

Between 1987 and 1996, the French Administration met with a new challenge in the frequency management when it was decided to introduce new networks within already occupied bands, for example:

a. National Paging in 464 MHz band in a heavily used PMR band
b. Analogue radio cellular telephone in 450 MHz band in a heavily used PMR band
c. Ermes
d. Radio trunked systems over Paris in a heavily used PMR band (refarming)
e. Large PMR networks for public utilities in PMR band, especially in Paris
f. Introduction of innovative networks in dense areas, by modifications of assignments
g. Trans-border networks
h. Public mobile data network (restructuring the duplex and to move military)
i. Replanning frequency bands according to CEPT Recommendations T/R 25-08

By law, the French Administration had no possibility to compensate existing users and following the rules for the management of the State public properties there were no compensation to give.

Different problems were assessed in details, such as:

i. Competition problems when introducing new systems which were competitor to the incumbent ones s introduced the « Relocation Fund » as a management frequency tool.
ii. Inertia of all parties
iii. Defence problems
iv. Problems between incompatible systems and interference
v. social aspects for small companies and emergency services (emergency networks and secure networks)
vi. multitude of users
vii. cost problems for users (how to justify exceptional costs and to modify depreciation in the state of the accounts of business)
viii. Coordination of relocations, including technical problems which arose for some specific networks.

All these relocations (and refarming) were successful as a result of a close cooperation with operators and end-users and French Administration came to formulate the concept of a Relocation Fund.
So, when ANFR was created, in 1997, it was given the task to manage this Relocation Fund. It should be noted that this Relocation Fund is not to compensate the existing users of frequencies that have to move but to facilitate the movement and to avoid delays.

French spectrum management framework
In France, as well as in most countries, spectrum is State public property. In compliance with regulations, spectrum must be managed with the aim to maximise national welfare. That means spectrum management has to take into account simultaneously government uses, private enterprise interests and consumers benefits, i.e. all the spectrum stakeholders interests.
Spectrum is shared among seven government departments/agencies, which assign frequencies for government usages, and two independent authorities, which assign frequencies for non government usages, i.e. broadcasting and telecommunication). These nine bodies are known as “affectataires”.
The nine “affectataires” are represented in the Board of ANFR (Agence nationale des fréquences) which is responsible for managing the whole spectrum. ANFR sets up the national frequency allocation table which must be approved by the Board and the Prime Minister. ANFR is also in charge of the spectrum relocation process and manage the fund used to finance relocations.
To carry out these tasks, ANFR relies on a number of committees within which consensus is sought and found. These commissions are made up of governmental and non governmental spectrum stakeholders.
This organization makes possible dialogues between all spectrum stakeholders and makes easier spectrum refarming in order to meet increasing civil demands about spectrum.

French experience with Spectrum Relocation Fund
Begun in 1997, the French experience with the ANFR Spectrum Relocation Fund continues to give very good results in spectrum management. Since then, all frequency bands have been released in due time for interested parties.
The relocation fund is used as an incentive for incumbent users to move out of frequency bands. Since 1997, 75 millions euros have been spent to release frequency bands (altogether a 260 MHz bandwidth) in order to satisfy in particular new market demands such as IMT-2000 (150 MHz), GSM-1800 (25 MHz) and WiFi (83 MHz).
Since 2003, the Relocation Fund is also used for the deployment of digital terrestrial television.
Annex 1 provides more detailed elements on this experience.

Conclusion: Assessment and advantages
After 7 year of experience, especially in its implication for UMTS frequency bands, 2.45 GHz band for R-LAN, PMR 446, re-channelling of gap-filler to introduce DTT, the assessment is that the Relocation Fund:

- Makes the discussions easier between incumbents and new entrants (especially by suppressing transaction costs)
- Avoids speculation or opposition to a relocation project
- Shows that there is no interest to retain frequencies
- Puts the value on the creation of networks and intensive use of frequencies
- Gives predictable results.

In order to keep advantage of this concept, the body responsible of the management a Relocation Funds has to be considered as a trusted third party. It proceeds in a transparent manner associating all concerned parties in Radiocommunication sector.

French experience with secondary market
The law on electronic communications, transposing the new European regulatory framework, including the Framework Directive, has opened for the possibility of transfer of spectrum rights in bands and for applications to be decided by the Minister in charge of Electronic Communications. The law excludes broadcasting and governmental spectrum. A decree at the state Council is currently in preparation to define the process of the transfer rights including the provisions for transfer objections, the split between rights and obligations amongst primary and secondary users of a spectrum.

Discussions have also started concerning the bands and applications which will be open to such spectrum trading. These discussions are based on the principles described in the RSPG opinion in favour of a phased introduction of secondary trading.

Several bands and applications are under investigation. However, ARCEP has already announced its intention to propose the introduction of spectrum trading and leasing in portions of the band 3.4-3.8 GHz for fixed wireless access including nomadic applications. Transfer of spectrum authorization will also be made progressively possible in cases where authorizations are made through an assignment process, like PMR and microwave fixed links, and in the other band designated for fixed wireless access (24.5-26.5 GHz). The attribution process in the portion of the band 3.4-3.6 GHz which will take place very soon is yet to be confirmed and ARCEP is envisaging beauty contest including a criteria on price.

GERMANY

Market development, convergence and technological innovation require more flexibility in the spectrum regulatory framework; therefore administrations are forced to react faster to fulfill all the desires of the market.

The number of important technical innovations within the range of the radio engineering has increased rapidly over the past years. Terms such as UWB, SDR, DFS, CDMA, APC and Conversion A/D are thereby only an excerpt of keywords related to new wireless technologies. New technologies offer new possibilities of using the frequency spectrum more efficiently while at the same time presenting new challenges for the SMA's. In this context, the prime task of administrations will be to adapt the frequency management and the criteria of radio compatibility accordingly. This has to be done timely and very carefully, in order not to impede innovations resulting from new technical possibilities on the one hand; and to give the best possible protection to existing assignments and radio equipment on the other hand. In the end, market acceptance and competitive opportunities will depend on the quality of such adaptations.

Accordingly, there is an ongoing evaluation process in Germany to find out where more flexibility in the frequency regulatory Framework could be introduced.

I. National tendencies

There are different areas on the international or the German level, where more flexibility might be introduced:
- Radio regulations
- Frequency allocation plan
- Frequency usage plan
- Administrative Regulations
- Assignments (administrative procedures, content, form)
- Criteria of radio compatibility.

One of the questions to be answered may be, whether it is still necessary in the future to plan the frequency spectrum as detailed as we did in the past or is the introduction of common bands preferable. This leads to the next question: Can this process be initiated at the national level or does it have to start at the international (ITU) level ?

If the decision is taken to introduce changes to frequency management and criteria of radio compatibility the utmost account of the existing and planned radio applications has to be taken in order to avoid unreasonable disadvantages. This should not be implemented in an abrupt manner but has to be a "soft transition".

The principle of the allocation of fixed frequency ranges to certain radio services is presently discussed within the RegTP. It can be assumed that new technologies will make it possible to apply the principles of allocations more

flexibly and to use the frequency resource more efficiently. In this context the project "Adjustment of the radio compatibility criteria in view of the technological progress in the radio engineering" was started witin the Reg TP. The results achieved with regard to this project will also be made available to PTRA 12.

There will always be very sensitive radio services such as fixed services and satellite services, as well as safety services which require a special radio protection in relation to technical and administrative changes.

II. Possible introduction of a "noise temperature limit"

In connection with UWB and the possible introduction of "noise temperature limits" as a criterion for the possible allocation volume new ways of thinking are necessary in relation to the assessment of radio compatibilities.

The topic "noise temperature limit" needs to be considered very thoroughly because the following problems may arise:

- changes concerning the system of allocation and usage plans and criteria of radio compatibility will be necessary,
- the introduction of a "noise temperature limit" seems to be doubtful in many sensitive frequency bands.

Long-term advantages for frequency users, for the economy and for the frequency spectrum are particularly welcome. But unreasonable disadvantages concerning the existing and future frequency utilizations and also the radio compatibility have to be avoided by all means. Therefore every statement on this topic should be based on a critical comparison and evaluation of all pros and cons.

THE NETHERLANDS

New Memorandum on Frequency Policy
In November 2005 a new Memorandum on Frequency Policy has been issued. A combination of technological developments, market developments and a changing outlook on spectrum utilisation prompted the Government to evaluate its radio spectrum policy.

In the Memorandum on Frequency Policy the following main issues are addressed:

- The future radio spectrum policy should provide for the further liberalisation of spectrum use and adapt more rapidly to changing market conditions and technological developments; this can be achieved by more flexibility, which means by:
  - Tradability of licences or parts thereof after the assignment as a general rule
  - Allocating frequencies according to a procedure that is technology and service-neutral as far as possible
  - Permitting third-party use of frequency bands
  - Simplification of procedures and regulations
  - Application of the maxim 'licence-exempt wherever this is possible'.
- Public interest tasks are so beneficial to society that undisturbed access to sufficient spectrum is guaranteed. For this reason these tasks have been given a statutory preferential position, such as a direct assignment of frequencies and preferential licence treatment. However the frequencies used for these tasks should not be more than needed for the exercise of these tasks. Accordingly, the assignment is based on a needs justification plan.

Former proposals to make the opportunity cost manifest for vital spectrum users, or other non-commercial (e.g. passive) spectrum users, have not been incorporated in the new Memorandum on Frequency Policy.

The full text of the Memorandum is available on website: http://appz.ez.nl/publicaties/pdfs/06ET02.pdf

NORWAY

INTRODUCTION

Allocation of spectrum (including military spectrum) and assignment of frequencies are divided between the Ministry of Transport and Communications (broadcasting, GSM/3G spectrum) and the Norwegian Post- and telecommunications Authority (NPT).

In general terms, the main spectrum management objective is to encourage efficient use of the spectrum and the main policy objectives regarding allocation procedures is to promote competition and to have selection criteria which are objective, transparent, non-discriminatory and proportionate.

Auctions are objective, transparent, non-discriminatory and proportionate. (Well designed) auctions ensure efficient allocations because the undertakings which values spectrum the most wins the competition. By our experience auctions is much easier and less troublesome to handle than “beauty contests”. NPT has carried out several auctions the last years.

Technology neutrality and flexible use of spectrum have been introduced the last two years. Spectrum trading has been permitted for some time.

SPECTRUM RIGHTS

NPT aims at designing technology neutral and flexible spectrum licences with a precise definition of the rights of use. A spectrum licence is defined by a specification of bandwidth, spectral position, geographic scope and duration. In addition, a spectrum mask or equivalent technical description of boundaries between adjacent spectrum users and a technical description of the co-channel (geographical) boundary is provided. The technical description of the licence is complemented by legal rules governing interference

Anyone may at any point in time apply for spectrum licences. Licences which are currently assigned, but which will expire within the next three years, may be applied for both by the current licensee and by any other interested parties.

Specifications of bandwidth, spectral position, geographical coverage and duration are not sufficient to completely define the boundaries between the rights of the various users. The technical specification defines the frequency licences further by specifying the limits for what the individual user may do. Generally, NPT has a preference towards defining rights by means of a spectrum mask on the boundary between adjacent spectrum licences combined with a further specification of the co-channel (geographical) boundary.

The technical specification is based on the NPT’s assumption about the most likely use of the spectrum today. If there should be a need for some other use that affects (interferes with) other licence holders to a greater extent than use within the initial technical boundaries of the spectrum licence, such use must be coordinated with and permission obtained from the affected party. Any party that would like to use the frequencies in a manner that requires a higher level of protection against interference from other frequency users than provided through the boundaries between the licences must ensure this protection through coordination of / agreements on user restrictions. NPT refers to such coordination as “private coordination”. The parties to private coordination agreements are not required to notify such agreements to NPT. When supervision of use of radio frequencies and enforcement of conditions attached to spectrum licences is carried out, NPT will hold the licensee responsible. Consequently, it is likely that it is in the interest of the party which rights to use of radio frequencies follows wholly or partly from private coordination agreements to be able to substantiate its rights by a written document.

MAPPING/PUBLIC DEMAND

NPT has developed a solution to “mapping” / examine demand; we publish information when we receive an application, giving all interested parties an opportunity to apply for a licence before a deadline (usually 6 – 12 weeks from publication). If no more than one application is received, the licence is assigned to the only applicant shortly after the deadline. If mutually exclusive applications are received, the allocation is done by auction.

Policy objective of the concept of “mapping” / examine demand via publishing vacant frequencies is to get information on demand for the spectrum in order to find out whether it may be allocated by “first come first served” at this specific moment in time or to auction the spectrum if more than one undertaking is interested.

SWITZERLAND

Introduction

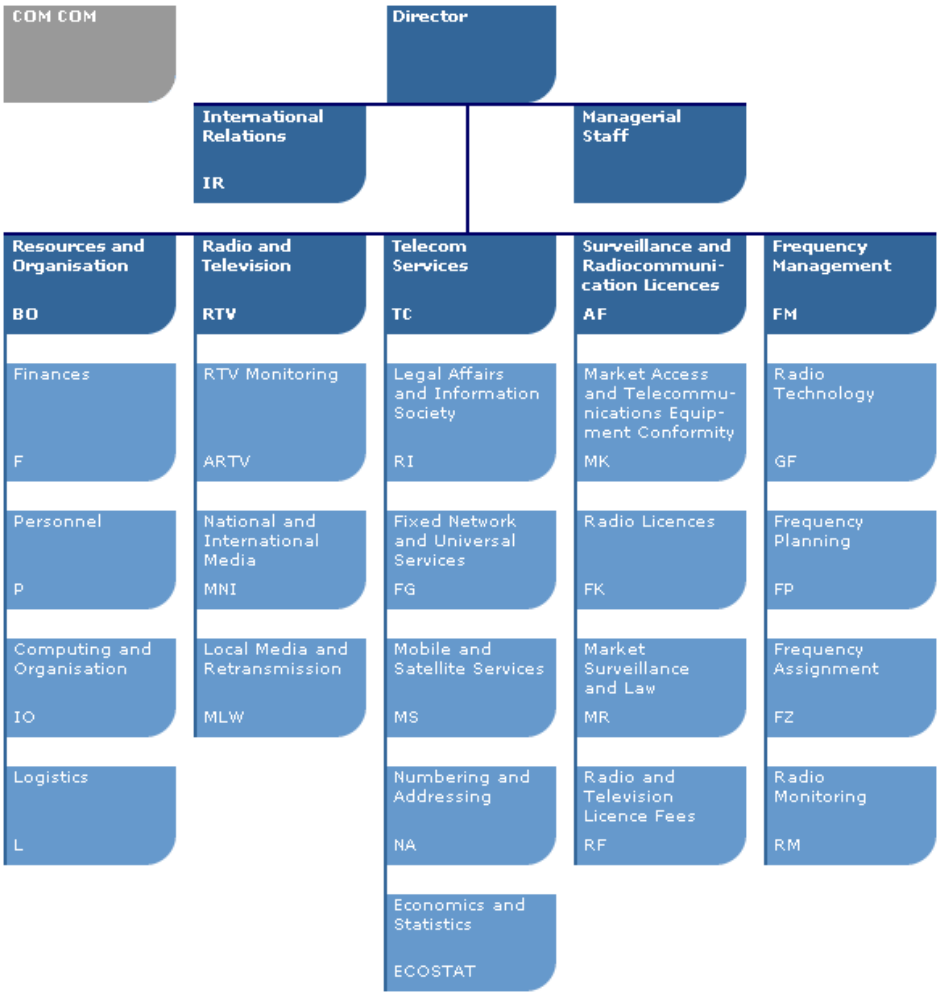
At its creation in 1992, OFCOM was assigned two major tasks:

- to regulate the broadcasting sector, and
- to establish and to apply the regulatory framework for the liberalization of the telecommunications market.

Today OFCOM oversees radio and television, radio communications, and telecommunications services and telecommunications installations. It enables efficient competition to take place and guarantees that market forces will have full play. OFCOM is also responsible for the management of the radio spectrum, including international activities (ITU, CEPT), establishing of the national Frequency Allocation table, assignment of frequency and radio monitoring.

Situated within the Federal Department of Environment, Transport, Energy and Communications, OFCOM attends to these matters for the Federal Council (Broadcasting) and the Federal Communications Commission (Telecom services) while fulfilling an advisory and coordinating function for the general public. It also guarantees that basic services will be provided in all parts of the country and for all sections of the population.

Organisation chart of OFCOM



Frequency Management at OFCOM

Within the organisation the Frequency Management Division (FM) fulfills a support function. This means:

The daily tasks of the FM-division are regulated via a service level agreement (SLA) with the following divisions:

- Telecom services,
- Radio and television (broadcasting) and
- Surveillance and Radio communication licences (non commercial)

The SLA's are reviewed every year and new priorities can be fixed.

National development
The Swiss FM-division is actually reviewing it's strategy for the coming 15 years. The project is planned to be terminated by the end of 2006.

The goals of this project consist of the following:

- **Identification of the evolution with regard to**
  - the legal and political framework, the international environment and the socio-economic impacts
  - The possible development in technology
- **Evaluation of the possible scenarios**
  - The project must, based on the possible evolution, develop and present corresponding scenarios and estimate the probability of their implementation.
- **Definition of the strategic options**
  - Based on the most probable scenarios the strategic options are defined for the spectrum management for the period until 2020.

In parallel a project on spectrum trading was initiated but put on hold until the first results of the above mentioned project are available. If the conclusion will be, that spectrum trading is an appropriate instrument to meet spectrum user's needs, we will study the cases and go into drafting the specific modifications and provisions to define where and in what form spectrum trading will be made possible in the future. The actual legal framework does allow license transfers, but every single transfer is subject to approval by the Communication Commission. A future scenario may be to implement secondary trading and spectrum liberalization (change of license conditions on demand).
In order to implement an internationally compatible solution, OFCOM is closely monitoring the (policy) developments on the European level while developing its own strategy.

UNITED KINGDOM

Since December 2003, most non-military spectrum in the UK has been managed by the Office of Communications (Ofcom), an independent regulator that is also responsible for regulating telecommunications and broadcasting. Ofcom also represents the UK internationally on spectrum matters.

Ofcom has a series of statutory duties. One of its principal duties is to promote the interests of citizens and consumers, where appropriate through competition. It also has a duty to secure the optimal use of the radio spectrum in the interests of all users. Ofcom believes that these objectives are, in general, best achieved through market mechanisms.

Overall control of spectrum, including allocation for military use, remains with the government and is exercised through the UK Spectrum Strategy Committee, of which Ofcom is a member. The government has powers to give directions to Ofcom on specified matters, including national security, public safety and international relations. The government may also give directions on any other aspect of spectrum management but such directions must be discussed and approved by Parliament.

The UK has, since 1998, used administrative incentive pricing and auctions to promote optimal use of the radio spectrum. Ofcom has since introduced spectrum trading (December 2004) and liberalisation (January 2005) in the Business Radio, Fixed Wireless Access and Fixed Links sectors and aims to roll these out progressively over the next few years.

Ofcom has published its Spectrum Framework Review[20], which sets out its high level approach to spectrum management. This aims to shift progressively from 'command and control' to market mechanisms from 96% command and control in 1990 to 72% market mechanisms by 2010. Over the same period, licence exempt use is predicted to increase slightly from about 4% to 7%.

[20] Ofcom Website | Spectrum Framework Review

The Ofcom Spectrum Vision

1. Spectrum should be free of technology and usage constraints as far as possible. Policy constraints should only be used where they can be justified.

2. It should be simple and transparent for licence holders to change the ownership and use of spectrum.

3. Rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

However, Ofcom recognises that there are areas that will continue to require a greater degree of regulation for the foreseeable future:

- where signals cross international boundaries, in particular satellite transmissions and low frequency signals;
- where international mobility is critical, for example maritime and aeronautical applications including communications and radar;
- where there are legally binding European harmonisation measures in force,
- defining the extent of spectrum that may be used without individual authorisation.

The Review also contains concrete proposals for technology and usage neutral licences based on a two-tier approach. These are being further developed., including a study into how to define technology and application neutral spectrum usage rights. This is expected to be published in 2006.

Ofcom is also engaged in a programme of releasing newly available spectrum into the market over the next 2-3 years in a range of frequencies from 174 MHz to 40 GHz. Ofcom published its proposals in its Spectrum Framework Review: Implementation Plan[21] and has now begun to consult on details of individual awards. Ofcom's general view is that an auction mechanism is likely to be its preferred tool for assigning licences to unused spectrum, in particular where demand for the licences is likely to exceed supply.

Professor Martin Cave was commissioned in late 2004 to carry out an audit of major spectrum holdings, including but not limited to spectrum used by public services and the military. The audit is considering a range of issues relating to public sector access to spectrum. The Audit reported at the end of 2005 and the UK government is currently considering its response, which is expected to be published shortly.

[21] Ofcom Website | Spectrum Framework Review: Implementation plan

ANNEX 4: CEPT MEASURES IN THE SPECTRUM MANAGEMENT AREA

One of the main CEPT functions is to promote further European harmonisation inter alia of the radio spectrum. In this context a number of Decisions and Recommendations has been adopted over the years, which have contributed to the development of the communications markets in Europe.

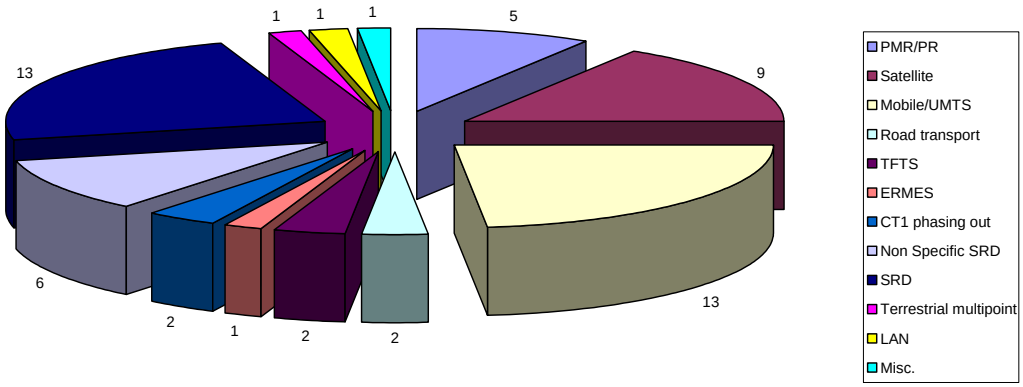
As Decisions are the most binding of the two instruments used by the CEPT to reach harmonisation objectives, this document focuses on spectrum related Decisions that have been adopted since 1992, namely a total of 99 Decisions, highlighting what areas of the radio spectrum they address. An additional 28 Decisions were adopted between 1996 and 1999 on approval regulation but have become obsolete. Other Decisions deal for instance with the provision of information such as for EFIS and are not addressed in this document.

Decisions on harmonisation of frequency bands

Over the years 1992-2004 the CEPT ERC / ECC have adopted 56 Decisions dealing with the harmonisation of frequency bands. The aim of these Decisions has been to facilitate the harmonised introduction of specific systems in particular frequency ranges across CEPT countries, thus fostering competition, encouraging innovation and enabling economies of scales e.g. for manufacturers.

The distribution of these Decisions is as follows:

Distribution of Decisions - Harmonisation of frequency bands

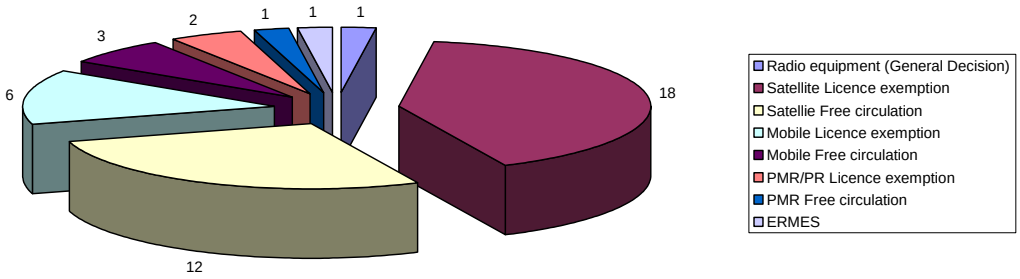


Among the type of services/equipment that have been facilitated, SRDs (both specific and non-specific) undoubtedly come first, followed by mobile systems and satellite systems.

Decisions on free circulation and licence exemption

Another area where the CEPT has been active in its harmonisation efforts has been that of licence exemption and free circulation. Such Decisions have been widely used for satellite systems (30 out of 44 Decisions). Other systems concerned have been mobile/UMTS, PMR/PR and ERMES. The first of these Decisions was adopted in 1995 and referred to radio equipment free circulation in general. Out of a total of 44 Decisions, 17 have dealt with free circulation and 27 with licence exemption.

Distribution of Decisions - Licence exemption and free circulation



The benefit of licence exemption and free circulation Decisions is illustrated by the fact that before a new system comes onto the market proposals are made for new Decisions in order to make sure that these new systems can operate without any unnecessary regulatory hindrance. The latest examples have been Aircraft Earth Stations (AES) for which a draft Decision is underway and Earth Stations on Vessels which are currently being studied.

Conclusion

Over the years the CEPT has taken a number of Decisions either on harmonisation of specific frequency bands, which has enabled the development of certain services or technologies, or on licence exemption and free circulation, which reduces the regulatory burden and promotes market development. Both types of measures are means of facilitating market access which show that the spectrum regulatory framework in CEPT countries has been capable of adapting to new developments

ANNEX 5: EXAMPLES OF UNDERLYING TECHNICAL ASSUMPTIONS IN SPECTRUM MANAGEMENT

SHARING BETWEEN RLANS AND OTHER SERVICES IN THE 5 GHZ

Several kind of technologies for RLAN at 5 GHz are expected to be developed and regulation in this band is technology neutral, i.e. administrations are not promoting the harmonisation of standards.

However, all compatibility studies which have been carried out in Europe and United States have been based on the existing standardisation development (IEEE 802.11a and ETSI Hiperlan 2).

The consequence of such assumption is not minor. For example, the specification of power and power density is consistent with a transmission bandwidth of around 20 MHz (i.e. power density = power/20 MHz). Other systems which would transmit with significantly larger or narrower bandwidth would then be much more constrained by the limit on power or on power density respectively.

Such constrain is fully justified by the protection of other services. In this example, specifying only the power would have created the risk of having a device concentrating the energy in a lower bandwidth which would in turn increase the interference potential into radars. A solution could have been imagined in this case, with DFS specification (the RLAN feature which enables protection of the radar) function of the power characteristics of the equipment. This would have resulted into a complex, parametric, regulation and a simpler and visible solution has been chosen.

For RLAN at 5 GHz, flexibility could also be considered interesting to enable power increase or outdoor operation for devices different from those assumed in the compatibility studies, e.g. with much lower density of use. But this kind of flexibility would in turn oblige to split the regulation into sub-categories of devices/market and to make it very … inflexible, in order to ensure that high density transmitters would not operate under the regulation applicable to low density and high power devices. Here, the flexibility would be at a price of threatening plain field level competition.

SHARING ISSUES IN THE UNLICENSED BANDS

One could think that conditions for operation in unlicensed bands could be very flexible. However, the reality is very different. In particular, Short Range Devices (SRD) are often creating interference between themselves. At first sight, this should not be seen as an issue for the regulator, since operations are on a non-protection basis. However, cases of interference, such as SRD on cranes invalidating door openers (car, parking…) in wide areas or high power RFID used as anti-theft systems threatening to freeze the use of other SRDs in neighbouring areas or “safety-related” SRD such as social alarms have obliged CEPT to divide the unlicensed bands into a list of around 12 different SRDs, with different sets of characteristics (power, bandwidth, duty cycle…) and operational conditions ensuring the absence of severe harmful interference.

It has to be noted, that the same kind of splitting can be seen in United States regulation (FCC part 15) or in Japan.

DEVELOPMENTS OF IMT 2000 FREQUENCY ARRANGEMENTS

The frequency band 2.6 GHz has been identified for IMT-2000 at WRC-2000 and the work on channelling arrangement has started immediately.

Between WRC-2000 and the year 2003, the key word used in the discussion within CEPT on channelling arrangement was “flexibility”. In particular, operators were wishing to have the capability to adapt the frequency arrangement with traffic and market development (TDD/FDD, traffic asymmetry, cell structure…). The arguments were based on the expected outcome of technologies like variable duplex spacing, software defined radio…

However, based on:

1. the studies done on traffic asymmetry (Ref:UMTS Forum report #33), which indicated UL/DL asymmetry-ratio of 1/2.3 and.
2. measurements on data traffic asymmetry in live mobile networks (Ref: data from operators GPRS-networks) and;

3. the fact that the FDD technology has been more developed than TDD, the frequency arrangement was finally based on a "classic", symmetrical frequency arrangement.

More generally, both in the core (2 GHz) and extension (2.6 GHz) bands, the channelling arrangement as defined in the ECC Decisions, will contain requirements such as minimum frequency carrier separation, guard bands to protect adjacent services, channel raster… For 2 GHz, all calculations were done on the basis of the UMTS specifications and the same will apply to the 2.6 GHz band. To alleviate this difficulty, it was stated that similar results could be obtained by taking into account other IMT-2000 technologies. This would not dramatically change the situation. Actually, this was done for the issue of narrow-chip UMTS TDD mode, which was not originally taken into account and corresponding results were included in a subsequent ECC Recommendation. On the other hand, the generalisation of such processes to any mobile technology which may come up in the future would be quite burdensome since the number of compatibility studies to be carried out would increase exponentially with the number of radio interfaces to be considered.

CEPT has also developed Recommendations relating to cross border coordination between IMT-2000 networks. Even more than in the case of channelling arrangements, the recommended solutions for coordination procedures, preferential codes and frequencies, and determination of field strength at the border were based on UMTS and would require considerable work in case of extension to other technologies.

It should be noted that for channelling arrangements as well as for cross border coordination, simplistic solutions such as “block edge mask” or “power flux density in dBm/MHz at the border” do not work. For example, it is largely sub-optimal to define the same block edge mask for TDMA and CDMA systems. Also, it is not possible to determine preferential codes and frequencies without knowledge of frequency raster and codes structures.

COMPATIBILITY BETWEEN VARIOUS PMR/PAMR TECHNOLOGIES

In the past, analogue PMR was using only FM modulation with 12.5 or 25 kHz channel spacing with strong adjacent channel protection. Frequency planning and cross border coordinations were based on this simple situation.

However, since 10 years, the development of digital PMR/PAMR technologies (TETRA, TETRAPOL, TAPS, CDMA…) has made it necessary to develop a set of reports and technical constraints applying to these new digital technologies in order to protect analogue PMR/PAMR and other digital technologies and the introduction of guard bands which had never been introduced previously for PMR. Also, guard bands were sometimes defined to protect other systems/services (GSM at 915 MHz, SRD…). Guard bands are not unused spectrum, but constrain frequency planning managers.

Such an approach does not prevent technology neutrality and flexibility but requires that CEPT administrations know in advance the development of a new technology in order to determine the conditions of operation which will prevent harmful interference. In this case, flexibility requires visibility and is time-consuming.

In a similar way, FCC had defined in the past very precise conditions to enable operation of CDMA systems in frequency arrangement used for analogue mobile systems (AMPS), based on the very specific characteristics of CDMA IS 95 and AMPS.

COEXISTENCE BETWEEN FIXED WIRELESS ACCESS SYSTEMS

The deployment of fixed wireless access systems by operators in bands such as 26 GHz, 3.6 GHz or 42 GHz is based on technology neutral regulations and the greatest flexibility is given to operators in their deployment.

However, manufacturers and operators have always expressed concerns about the issue of interference at block edges and at the border of the coverage. They supported the definition of EIRP limitation, guard-bands, co-ordination distance in the framework of a frequency reuse technology neutral assignment methodology. CEPT undertook such task and adopted various ECC Reports and Recommendations.

All these deliverables were emphasising that the amount of protection depends on equipment technology and characteristics that, in FWA bands, are consistently varying from system to system due to the large number of different market needs addressed. They stressed the need for a trade-off between providing flexibility and a “standard” approach that minimises options and equipment variants. Consequently, the definition of EIRP limitation, block edge mask etc… were based on assumptions on size blocks, EIRP requirements, number of states of the modulation and were not addressing specific deployment such as MESH networks, adaptive antennas.

CONSEQUENCE OF THE DEVELOPMENT OF NON GEOSTATIONARY SATELLITES

Many frequency bands are shared between fixed and fixed satellite services based on a very simple sharing scheme profiting of the fact that both services are using directional antennas: satellites are complying with pfd limits and fixed stations are avoiding to be directed towards the GSO arc.

Also, sharing between FSS GSO networks is based on coordination procedures well established and working satisfactorily.

Such a situation was in theory creating a lot of flexibility for fixed service and fixed satellite service operators. However, the development of non geostationary satellite systems made this completely obsolete and obliged administrations in ITU to develop a complete set of new regulations within ITU.

In the case of sharing with fixed service, the difficulty was related to the impossibility to avoid interference where the FSS satellite is directly seen in the main beam of the fixed station. Considerable work has been done and is still being done to define conditions of operations of satellites which would enable FS protection.

Similarly, the difficulty of sharing between geostationary and non geostationary satellites in the same band was related to the dynamic of the interference, where a non geostationary satellite would align with the GSO satellite – earth station direction. Innovative regulatory solutions, using the epfd concept, were defined to enable such sharing.

In both cases, the sharing remains based on the use of directional antennas.

This illustrates the fact that regulations which worked satisfactorily and in a flexible way in the past may suddenly not be appropriate for the development of a new technology and very inflexible. Therefore, “innovative” regulations always need to respond to “innovative” technology.

DIGITAL BROADCASTING: DVB-T AND T-DAB

The process of DVB-T and T-DAB planning has already started within CEPT and is within ITU the subject of a Regional Radiocommunication Conference in May 2004 and mid 2006 . The first session has mainly decided on the planning principles, including technical assumptions to be used for planning.

All technical elements in the first session report are based on the DVB-T and T-DAB standards. Although there is nothing preventing an administration to have individual requirement for another digital standard, this is not at all expected given the additional complexity that it would bring to the whole planning process. In the planning process, Administrations have also to take the protection of sensitive services such as Radiolocation, radio astronomy, terrestrial and aeronautical mobile services into account.

More generally, in the case of planning, flexibility is indirectly ensured by procedures which are enabling to do something else than what was planned. This is valid for terrestrial broadcasting as for satellite broadcasting or fixed satellite. Then, each administration can balance between its need for something different and the necessary burden of applying procedures.

It must be noted that for DVB-T, many configurations and reception modes can be planned. Digital Fixed antenna reception, comparable to analogue fixed antenna reception with the same percentage of country coverage, needs less frequency than analogue. However, DVB-T offers many opportunities: portable indoor, outdoor, mobile, etc which need more spectrum than digital fixed antenna reception.

Within this planning, administrations have the possibility to introduce other services compatible with the reception. One example is the sharing between broadcasting service and audio broadcasting ancillary (microphones, audio eng/ob) and military systems.

The flexibility for administrations is in terms of evolution of the broadcasting services from conventional fixed roof level antenna reception to mobile and handheld reception and in terms of a balance with potential other usage of the spectrum. All these being constrained by planning assumptions and results.

ANNEX 6: CORVUS (COGNITIVE RADIO APPROACH FOR USAGE OF VIRTUAL UNLICENCED SPECTRUM): A CONCEPT FOR FLEXIBLE RF SPECTRUM USAGE

In the following an example architecture for a CR system, called CORVUS: A Cognitive Radio Approach for Usage of Virtual Unlicensed Spectrum, is discussed. The basic premises of the CORVUS system are as follows:

1. Abundance of spectra, which is available and used for spectrum sharing by Secondary Users (SU).
2. SUs use Cognitive Radio techniques to avoid interfering with Primary Users (PU) when they are present.

A PU is defined as an entity that legally owns some frequency band (e.g. cell phone provider, TV station, emergency services, etc). PUs are not cognitive radio aware, i.e. there are no means to exchange information between primary and secondary users provided by a primary system. Specifically, PUs do not provide special signalling in order to access their frequency band. On the other hand, a Secondary User (SU) is an entity that wants to acquire unused spectrum of license owners (Primary Users) for its own communication. It is assumed all SUs having cognitive radio capability, i.e. the system only consists of Primary Users and Cognitive Radio capable SUs.

In this heterogeneous network, SUs have constrained access to a Primary User frequency band. SUs can use a frequency band (or parts of it) as long as the corresponding Primary User is not using it. Any frequency band currently used by a PU within a certain area cannot be used by a Secondary User. A Primary User PU_x can tolerate a maximal interference of Δt_x time units. Note that this interference time is dependent on the primary system and may be different for different PUs. After this interference time the PU must have a free frequency band in order to communicate which means that all SUs have to clear the frequencies belonging to the frequency band within this time period. Even if a Secondary User is currently using parts of a frequency band, the PU assumes that his/her frequency band is empty and starts the transmission without informing the SU. For PU systems using carrier sensing protocols a SU operating in that frequency band hence has to operate below the carrier sense sensitivity of the PU.

From the above, it is clear that a fundamental requirement for the SU is to reliably monitor the presence of Primary Users (at least every Δt_x). Detection of Primary Users is based on Primary User Footprints (PUF) assumed to be available in the SU System a priori. Firstly, before start of any activity the SU has to sense for PUs to ensure that it does not disturb PU communication. Furthermore, a SU has to periodically sense for PUs on the frequencies that it is currently using and back off as soon as a PU tries to access that frequency band. SUs should, however be able to organise (or re-organise) the usage of the spectrum so, as to compensate the possible re-claim of frequencies by Primary Users with minimum loss of service quality and service reliability for the Secondary User. Thus, as it is mandatory for the SU system to detect reliably any new or ongoing transmission by a PU , certain frequency bands (and therefore PU systems) are more suitable for the secondary usage concept than others. A simple CORVUS device might only be able to detect other systems by power detection along frequencies (using the FFT). In this case, certain transmission systems can not be reliably detected and the usage of the frequencies bands where such systems can be present has to be excluded. A second issue arises from the Hidden Terminal problem, especially if a primary system can not be detected by the secondary terminals due to an unfavorable channel gain constellation. This issue remains to be further investigated.

Independent SUs form Secondary User Groups (SUG) to coordinate their communication. Members of a SUG might communicate with each other in an ad-hoc modus or, alternatively access a fixed infrastructure via a dedicated access point, being part of an existing networking infrastructure, most frequently the Internet. In both cases organization of the communication might be either distributed, or centralized, with a specific station acting as leader.
Potentially, the CORVUS system operates in a large Spectrum Pool covering a broad frequency range from tens of MHz to several GHz creating a “virtual unlicensed band” with usage capabilities comparable to the ISM/UNII frequency bands.. A Spectrum Pool is defined as a (not necessarily contiguous) frequency range used by a Secondary User Group (SUG). Spectrum Pools of different SUGs may overlap and different SUGs will compete for the available resources.

Each Spectrum Pool will be divided into n Sub-Channels (where n computes to: “size of the spectrum pool” divided by “size of a sub-channel”). The size of a Sub-Channel should be selected such, that a single Sub-Channel is a (rather small) part of any frequency band defined in the Spectrum Pool.

As basic principle of the CORVUS system the Sub-Channels selected to create a Secondary User Link (SUL) should be scattered over multiple frequency bands s, ideally only one Sub-Channel should be taken out of any frequency band. This principle has a double significance. On one hand it limits the impact of the secondary user on the re-

appearing primary user (for example the carrier sensing function of the Primary User might ignore the existence of the Secondary User). On the other hand if a Primary User appears during the lifetime of a SUL it would impact very few (preferable one) of the Sub-Channels used by the SUL. The communication peers using that link would have to immediately clear the affected Sub-Channel and would start to find a new free Sub-Channel instead. In fact in order to keep a continuous QoS Secondary Users should always have a redundant amount of Sub-Channels for their SUL.
Within the CORVUS system, Secondary Users use dedicated logical channels for the exchange of control and sensing information. We envision two different kinds of logical control channels, a Universal Control Channel (UCC) and Group Control Channels (GCCs). The UCC is globally unique and has to be known to every SU a priori. Without the knowledge of that control channel a SU has no communication possibilities. The main purpose of the UCC is to announce existing groups and enable newly arriving users to join a group. Additionally SUs which want to create a new group can request the local PUF on that channel. Although globally unique the communication range should be locally limited as SUGs are as well limited to a local area. In addition to the UCC each group has one logical GCC for the exchange of group control and sensing information. Control channels will carry a limited load of low-bit rate signalling. These control channels might be:

1. located in some spectrum licensed specifically for this purpose
2. located in one of the ISM bands
3. UWB (Ultra Wide Band) at a certain level below the noise floor to avoid constant interference to other existing systems [FOER_01]

Note that the Universal Control Channel and the Group Control Channels are logical concepts, which might even be mapped to a single physical channel!

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ANNEX 7: FLEXIBLE SPECTRUM MANAGEMENT (FSM) IN THE END-TO-END RECONFIGURABILITY (E^2R) RESEARCH SCOPE

One of the main objectives of the work undertaken in the E^2R Project [1] is to facilitate the most efficient radio resource utilisation possible, while providing a "seamless experience" to the mobile users. Targeting this, it is essential to bridge the gap between different radio access schemes and their individual radio and spectrum resource allocation mechanisms. With this working assumption, and the aim to facilitate a more dynamic allocation of spectrum, different resource optimisation techniques have been defined and initially evaluated. These techniques range from the short term allocation of radio resources between different administrative domains, to the more mid-term dynamic allocation of spectrum between the different Radio Access Technologies (RATs) of one operator to the more complex allocation and management of radio resources between the access networks of different operators, to the fully dynamic radio planning that reacts to conditions and requirements and enables a 'longer term' allocation within a geographical area. Early investigations in E^2R [2-4] have shown that each of the individual problems of resource utilisation requires a different approach to achieve the optimal resource allocation. These initial investigations were followed by the definition of the basic functional architecture modules capable to provide and support the required functions [5].

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ANNEX 8 : GLOSSARY

Allocation (of a frequency band)*:* Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radio astronomy service under specified conditions. This term shall also be applied to the frequency band concerned. *(ITU RR Art 1.16)*

Within the Radio Regulation, there are two categories of allocation : primary and secondary. Stations of a secondary service shall not cause harmful interference to nor claim protection from stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date

Allotment (of a radio frequency or radio frequency channel)*:* Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space radiocommunication service in one or more identified countries or geographical areas and under specified conditions. *(ITU RR Art 1.17)*

Assignment (of a radio frequency or radio frequency channel)*:* Authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions. *(ITU RR Art 1.18)*

Convergence in the broader sense means the fusion of different telecommunications and information technologies in order to provide the end customer with the broadest possible range of services and applications, often accessible from one terminal. An example is the combination of public calling capabilities (telecommunications) with the reception of video and audio programmes (broadcasting) and remote computing (information technology), all manageable from a single (so-called multimedia) terminal.
(ECC Report 016)

Designation:
"ECC Decisions that "designate" a frequency band for a harmonised application are intended to foster the deployment of an application to meet a market demand in a harmonised manner throughout CEPT. Members signing the Decision commit themselves to make spectrum available for this harmonised application when and where demanded, however, such Decisions do not necessarily preclude authorising other uses and applications in the same band, or part(s) thereof on the following conditions:

- an underlay application (i.e., able to share co-frequency, co-coverage with the application for which the band was designated) may be implemented, preferably subject to prior harmonisation at CEPT level, without affecting the application for which the band is designated, i.e. this underlay system is designed in such a way that they are not causing interference to the application for which the band is designated nor request protection against interference.
- the deployment of the application for which a band is designated may be constrained geographically to reasonable extent in order to protect stations of another service/application using the same band.
- there may be a lack of market demand for the application for which the band is designated in some cases :
    1. absence of demand for deployment in certain geographical area, thus enabling geographical sharing with other applications
    2. transition period until equipment is available for the deployment of the harmonised application, so that other applications may be introduced or retained for this temporary period
    3. in spite of the measures taken to introduce the harmonised application in the band, market demand does not fully materialize in all or parts of the band, leaving blocks of spectrum available for alternative applications, having due regard to spectrum use consideration (channelling, guard bands, protection of the harmonised application).

In all these cases, Members retain the commitment to make the frequency band available for the application for which the band is designated in due time where the market demand materialises." (ECC PT7 Report)

Harmful interference:
means interference which endangers the functioning of a radionavigation service or of other safety services or which otherwise seriously degrades, obstructs or repeatedly interrupts a radiocommunications service operating in accordance with the applicable international, European or national regulations.

Refarming:
Spectrum refarming (redeployment) is a combination of present and future administrative, financial and technical measures within the limits of frequency regulation in order to make a specified frequency band available for a different kind of usage or technology. The measures may be implemented in the short, medium or long term. *(ECC Report 016)*

Rolling-term licences:
These licences have no fixed end date but are not perpetual. They may be revoked at a prior defined period of notice, which may need to be shortened for specific reasons.

SMA:
Spectrum Management Authority. The organisation within an administration which is responsible for the management of the spectrum. This can be a separate and/or independent organisation or can be part of a National Regulatory Authority (NRA).

Technology neutrality

- Technology neutral: A right (or licence) to use certain spectrum is technology neutral if the rights holder can use any technology or standard it wishes in order to provide services within its band (subject to interference restrictions)

ANNEX 9: DEVELOPMENTS IN AUSTRALIA

ERO produced a report on the *Australian spectrum licensing and trading regime* in April 2005[22], based on discussions held with the Australian regulator (ACA), the Australian Government Department of Defence and industry representatives on market-oriented approaches to spectrum management and the development of secondary markets. The conclusions are presented below.

- **On the Australian spectrum licensing regime**

The Australian spectrum licensing regime distinguishes between three types of licences: class licences and apparatus licences on the one hand as traditional types of licence, and spectrum licences that reflect a market-oriented approach, on the other. It is worth noting that spectrum licences, which are a prerequisite for the establishment of secondary trading, only represent a fraction of the total number of licences granted in Australia. The aim of the ACA is, however, to convert more apparatus licences into spectrum licences in the future.

Part of the Defence spectrum is envisaged to be converted from apparatus licences to spectrum licences in the near future, a development not necessarily welcomed by the Department of Defence.

Operators have expressed satisfaction with the current regulatory environment, and with spectrum licences in particular. These give certainty to market players and also provide a great deal of flexibility. For Australian market players spectrum licences –which are tradeable - have also removed a barrier to market entry.

The accreditation system by which external entities carry out frequency assignments for apparatus licences in place of the ACA has worked fine and seems to be welcomed by the market.

- **On spectrum pricing**

The ACA market-oriented approach to spectrum management is reflected in the use of incentive pricing methods and market-based pricing, i.e. auctions, in case of spectrum scarcity. Both methods aim at ensuring efficient use of spectrum. Fees are reviewed in cooperation with market players, and the fee schedule is generally accepted by the market. However, some operators mentioned the lack of certainty with apparatus licence fees which may increase suddenly from one year to the other, while spectrum licences, for which a fee is paid at an auction once for 15 years, offer greater certainty.

- **On auctions**

Auctions are the prime instrument used for assigning spectrum licences. Auction design together with technology neutrality has been crucial for successful market developments including the opening up to new entrants and the fostering of innovation. The absence of roll-out conditions is a key aspect on which the Australian and European views differ. In Australia such conditions are not deemed necessary, since licences can be traded if services or networks are not deployed and greater freedom is given to market players.

The market is very supportive of the auction process and design in Australia (in particular the definition of small units of spectrum and of reserve price levels), which allows the market to decide and gives greater flexibility than designs that have been used in Europe, in particular for 3G. There also seems to be a good balance between government goals to ensure spectrum efficiency and expected economic returns, as reflected in auction reserve price levels.

An important issue in the eyes of operators is the expiry of auctioned licences. The current regime foresees a decision on reallocation of the auctioned spectrum only within the last two years of the licence duration, which the market deems far too short. More certainty is needed to enable operators to pursue with investments.

[22] For full report, see www.ero.dk

- **On spectrum trading**

Levels of trade

Trading spectrum licences or parts thereof is possible by geography, bandwidth or both. Secondary markets have not developed as the ACA might have wished. Reasons for lack of trade may be taxes (capital tax, stamp duty) and possibly the lack of information on trades. The operators consulted mostly had bought or leased spectrum, but not sold on secondary markets.

The ACA is investigating possible means to encourage trading, with the publication of more detailed information on trades than is currently the case. Another possible development the ACA may pursue is the issuing of private band management rights in occupied bands. However the concept did not seem to appeal to the operators consulted by ERO at this stage.

It is worth noting that market players all share the view that low trade figures do not reflect a failure of the markets, but simply the type of market where high investments are made pursuing long-term goals. The mere flexibility given by the right to trade is of the utmost value and is a success in itself. Furthermore there are views that it would not be desirable to see spectrum trading develop with inherent risks of speculation.

Defence spectrum

For the Department of Defence, the development of trading poses a risk and Defence spectrum does not lend itself to a market environment. If spectrum licences develop, Defence foresees increased difficulties for their own spectrum management. The ACA on the other hand intends to introduce spectrum licences in Defence bands already in 2005.

Hoarding

While fears have been expressed in Europe about the risk of hoarding, this phenomenon has not materialised in Australia. There is evidence of unused spectrum, but the lack of buyers is the most likely explanation for this situation. Competition law is deemed to provide sufficient safeguards.

Interference management

Some of the concerns raised in Europe in the context of spectrum trading relate to potential interference management difficulties. The ACA on the contrary expects to be involved less and less in interference cases, as market players manage interference among themselves. The guidelines provided by the ACA and the interference boundaries defined in the spectrum licences are two key aspects of successful interference management.

Pooling

The spectrum licensing and trading regime, together with principles of technology neutrality enables spectrum pooling, which is a possibility welcomed by the market.

Sub-licensing and private band management

Operators are not highly interested in sub-licensing parts of their spectrum as the work associated with it outweighs the benefits. Market intermediaries such as brokers would be desirable. Attempts to establish brokerage failed in the early stage of spectrum trading in Australia, as at that point such business was not viable. With more mature markets, brokerage activities may have a chance to develop.

- **On spectrum refarming**

The Australian regime does not contain any provisions for compensation when a band is being cleared of its incumbents. Market players in Australia accept that such a policy minimises barriers to entry and encourages competitive innovation.

- **On the relationship between regulator and market players**

Spectrum management is seen as a partnership between regulators and market players. Market players feel they know best how to manage spectrum, while the government has engaged in market-oriented reforms supporting that view. Open processes, consultations and constant dialogues between industry and the regulator are the cornerstone of a well functioning market-oriented spectrum management.

ANNEX 10 : ETNO CONTRIBUTION

ETNO Expert Contribution on Harmonisation and Flexibility in the context of radio spectrum management

Executive Summary:

ETNO considers the standardisation of radiocommunication equipment and the harmonisation of radio spectrum as the basis for a successful development and placing on the market. Nevertheless, a more flexible use of radio spectrum could facilitate a more efficient radio spectrum use.

ETNO takes the view that sufficient experience has to be gained before appropriate regulation modifications can take place and favours a careful and progressive approach. The EC and the CEPT should be involved in order to adopt a common approach in the end.

1 INTRODUCTION

ETNO represents the voice of 41 of Europe's largest, well established telecoms groups in 35 countries. ETNO members operate numerous radio services over a wide range of the radio spectrum. Therefore, ETNO has a strong interest in radio spectrum management procedures and all related measures and follows with interest the discussions with regard to improving the international spectrum regulatory framework currently taking place in ITU-R, CEPT and also on national level within a number of European countries.

This Expert Contribution evaluates the current approach based on harmonisation and possible introduction of flexibility from a network operator's viewpoint.

2 HARMONISATION AND FLEXIBILITY

2.1 HARMONISATION

The deployment of radiocommunication networks mainly relies on standardisation of equipment associated with the harmonised use of frequency bands.

Benefits are well known, as harmonisation

- allows economies of scale and leads to a reduction of equipment costs.
- facilitates the provision of seamless service provision over wide areas (country, continent, world) in a way that customers can communicate with one single terminal wherever they are.
- gives confidence to operators to invest in a technology.
- reduces the amount of studies needed to establish the sharing conditions with other services and sets easier conditions for interference free operation.

The more a radiocommunication network extends over wide areas, the more these benefits apply. For example, the world-wide harmonisation of mobile networks brings invaluable benefits to customers as well as to manufacturers and operators. On the other hand, the need for harmonisation should be less stringent for fixed local applications.

However, even in such a case, one could observe that standardisation and harmonisation is often a prerequisite for successful equipment development and placing on the market.

2.2 FLEXIBILITY

Flexibility in radio spectrum management is understood by telecommunication operators as a higher number of possibilities to align spectrum resources with their needs in a timely and self-sufficient manner within the appropriate regulatory framework.

Flexibility could apply to technologies (standards, technical limits) or services/applications. The possibility to trade spectrum between users on a temporary or permanent basis is another means to implement flexibility.

In the paragraphs listed below some examples are given where higher flexibility for the right-holders has the potential to increase the overall efficiency in spectrum use.

- Additional spectrum could be needed e.g. in high densely populated areas, during a particular period of the day in order to allow the provision of services in line with customer expectations. Radio network operators could then trade underused spectrum to meet these peaks of demand. While an administrative process could reveal to be inconvenient, direct trading between spectrum users could prove to be an efficient means to manage such a transfer, provided sufficient radio spectrum is available.
- In some cases, radiocommunication operators should take advantage of the possibility to change the technology to be used within a frequency band according to market demand and their business strategies. Obviously, such a transition has to be carefully considered, and appropriate measures should be taken to ensure that no constraints would be created for users in adjacent frequency bands. This means that guard bands or exclusion zones may need to be defined. For example, the transition from 2G to 3G cellular mobile should be better addressed by leaving operators the freedom to decide on the time of the transition based on their market experience - which can differ from operator to operator - rather than by an administrative decision.
- The amount of frequencies assigned to an operator for the provision of a service is generally country-wide, but determined for the needs in the high populated areas. An operator could take advantage of unused spectrum in sparsely populated areas by offering wireless applications more in line with the particular local needs.
- Significant parts of spectrum assigned to governmental services are not permanently/countrywide used and could be made available for commercial services or equipment experimentation on a time or geographical based sharing. This generally supposes a change of use and should be managed accordingly, i.e. either using administrative procedures or bilateral negotiations between spectrum users.

3 ETNO POSITION

ETNO considers the standardisation of radiocommunications equipment and the harmonisation of radio spectrum as the basis for a successful development and placing on the market. The balance between mandated and market driven harmonisation needs to be carefully considered.

As a conclusion, while harmonisation is the basis for the development of radiocommunication operators' activities, a more flexible use of radio spectrum should also lead to more efficient use of this resource without damaging the efficient working of the services markets. Some regulatory modifications at the various levels (ITU-R, CEPT/EC, and National) will be needed in order to offer such new possibilities. One can observe that regulation becomes more constraining when moving down from the ITU-R level towards the national level.

- Significant improvement could be achieved by removing undue constraints in licences and other regulations at the national level. Spectrum efficiency could also be enhanced by providing more detailed information on spectrum utilisations, implementing refarming fund procedures, etc. Moreover, ETNO believes that the improvement of the speed of administrative processes and the possibility of negotiations between radio spectrum users could enhance the efficiency of spectrum use.
- The recent evolution of the way harmonisation is understood by CEPT is considered by ETNO to be a move in the right direction. The designation of a frequency band to a technology based on a particular standard gives a clear priority for this technology in the band, but does not necessarily preclude the use of other technologies more

appropriate to particular needs provided they can be implemented without causing interference.

- The current ITU-R regulatory framework has been proven effective and flexible enough to introduce innovative radio services and applications according to market needs, while avoiding harmful interference to the extent possible. ETNO considers that limited modification of the Radio Regulations in this respect might be needed in near future.

However, ETNO would like to recall a minimum of conditions to be considered in connection to the flexibility by establishing a regulatory framework to avoid

- Distortion of the competitive dynamics of the markets
- Lack of uniformity regarding access to market conditions
- Potential harmful interference and difficulties in the coexistence of services within the same and adjacent bands
- Intra-national coordination problems in adjacent geographical areas
- Harm to economies of scale and limitations to interoperability, roaming and free movement of equipment, etc.

Comprehensive experience has to be gained before appropriate regulation modifications could be reached. ETNO favours a careful and progressive approach, similar to the approach suggested by the RSPG concerning spectrum trading. Support by administrations would be essential in such a process and exchange of views on national experience should be encouraged and organised within relevant EC and CEPT groups with the aim to adopt a common approach in the end.