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RSPG OPINION ON COGNITIVE TECHNOLOGIES

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1 Introduction

In February 2010 the RSPG published a first report on cognitive technologies[1]. The report had the objective of informing policy makers in Europe as early as possible of the discussions and challenges raised by these technologies. The report gave a high-level look at each cognitive radio technology studied, it provided an overview of various components of cognitive radio (CR), it gave an insight in the way in which cognitive radio technologies could operate in some models for spectrum management and identified challenging issues which require further attention. The use of cognitive radio technologies is seen as an enabler providing more efficient spectrum sharing and providing more dynamic access to spectrum. The report also highlighted that the use of so-called 'white spaces' in the UHF band might be one of the first applications of CR.

This Opinion is a follow-up of the report and should be considered as a generic initiative to approach the issue of the implementation of CR technologies on a Community level. The aim of this opinion is to create enough confidence in current spectrum users and industry players to develop CR technologies and not as an attempt to impose any particular solution on individual Member States for the sake of uniformity. This opinion addresses the prospects of the implementation of CR technologies and to identify any need for coordination at EU level. In particular, the scope of this opinion encompasses:

- high-level approach at each cognitive feature studied within a common European framework;
- considerations on the possible merits of taking further regulatory steps;
- near-term regulatory action that needs to be taken to enable any cognitive technology;
- necessity of establishing a harmonised basis and if so the actions necessary.

In this Opinion it is assumed that the manufacturer is responsible for the CR devices to be compliant with the R&TTE Directive. This differs from Software Defined Radio (SDR) equipment where the responsibility for compliance may be divided between different hardware and software providers. However, with recognition of the role of ETSI to provide a suitable Harmonised Standards (HS) under EC mandate, suitable guidance will have to be provided with respect to how compliance with the R&TTE Directive for Cognitive functionalities can be met.

This opinion only considers the regulatory framework for the introduction of CR, including SDR functionalities. Any other SDR related issues, in particular the responsibility for compliance, are outside the scope of this opinion and expected to be addressed as part of the review of the R&TTE Directive.

[1] RSPG10-306 Final, Radio Spectrum Policy Group report on "cognitive technologies", February 2010.

2 Background

A device supported by CR technology is described as capable of cognitive behaviour in a cognition cycle of six phases “Observe, Orient, Plan, Learn, Decide, Act”.

A cognitive radio matches its internal models to external observations (in terms of available radio resources, prevailing spectrum rules, user needs and preferences, operational costs of a service etc.) and uses this knowledge to adapt itself to provide wireless services most appropriate to the user needs and preferences. The radio is capable of learning from its past actions and experience and incorporating this knowledge in the Decision and Act phases of the process/cycle.

Cognitive radio has been proposed and promoted as a technology to alleviate today’s spectrum scarcity problems. Actual usage of the spectrum varies considerably, dependent on various parameters like for example: the number of applications which are sharing the same frequency band, the number of users in a specific area and in a specific period of time, and the environment (urban versus rural with their difference in demand).

Cognitive radio technologies are seen as an enabler providing more efficient use of spectrum and providing more dynamic access to spectrum.

The following definition has been set by the ITU-R Study Group 1 in Recommendation ITU-R SM.2152:

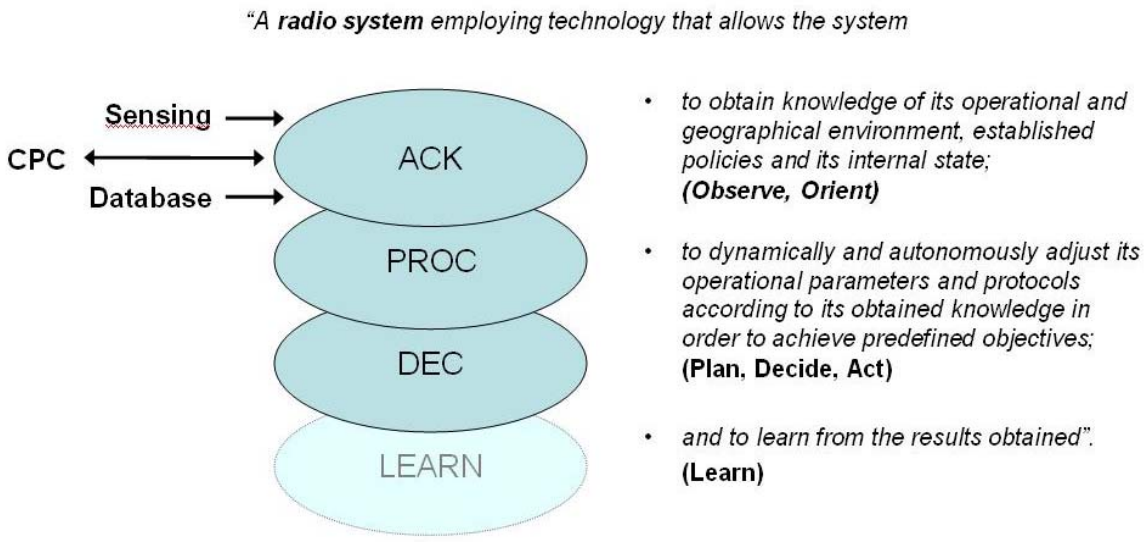


Figure 2-1: Cognitive Radio - definition in line with ITU-R SM.2152

As such, Cognitive radios have the ability to use spectrum which is already used by other spectrum users, i.e. they can share spectrum with other users. A Cognitive Radio is aware of its environment and uses this acquired information to decide on its transmission behaviour. An ideal CR will make its decisions not only based on information about the radio and geographical environment but also based on other information, such as the users’ needs, operational costs of the service or other criteria to be pre-defined by the spectrum band manager or licensed operator.

Work in CEPT and ETSI

After the finalisation of a roadmap on Cognitive Radio Systems (CRS) by an ECC correspondence group, the ECC distributed work within their subordinated groups. In their responsibility the WG's SE, FM and RA started related work:

- on identification of possible candidate bands for services implementing CRS and the assessment of the various categories of suitable bands for CRS in cooperation with ETSI (by WG FM CG); where two categories can be considered:
  - bands already used by systems evolving towards CRS through the introduction of cognitive functionalities, in particular to optimise spectrum use; and
  - bands, already used by primary systems (not necessarily cognitive systems), where secondary systems could be introduced avoiding interference to the primary systems by the use of cognitive functionalities.
- on the use of the white spaces in the 470 - 790 MHz frequency band by Cognitive Radio Systems (by WG SE PT43)
- on issues associated with the management, enforcement and placing of CRS equipment on the market as well as different authorisation models and possible harmonisation options (by WG RA CG)

ETSI have initiated various work items and project teams (e.g. TC RRS, ERM, BRAN etc) to look at standardisation issues around CR and SDR. A detailed view of the relevant project teams and their responsibilities are described in **Annex 1.**

Work outside Europe

In the long term both operators and manufacturers are considering using CR technology for various usage scenarios. Deployment scenarios such as the use of CRS technology by an operator of a radiocommunication service to improve the management of its assigned spectrum resource are also being considered. In the short term other regulators around the world (notably USA and Canada) are investigating and/or looking at implementing cognitive systems for the use of White Spaces in the UHF bands. In addition standards bodies such as IEEE 802 are working on standards that utilise cognitive techniques to provide both WRAN (802.22) and WLAN (802.11) services using White Spaces in the UHF bands. See **Annex 2** for more detail.

3 Regulatory implications

Under the framework directive, Member States have the right to set the conditions of use of spectrum which radio equipment has to meet. These conditions can include appropriate limits that aim to avoid harmful interference to other radio services. These conditions can be harmonised on a European-wide basis either through a European Commission Spectrum Decision (which is mandatory for EU member states to implement) or by implementing an ECC Decision or Recommendation. Alternatively if no mandatory harmonised guidance is available a regulatory deliverable can be developed on a national basis.

In all the above cases the conditions of use of radio frequencies are put in national regulations that are administered either through general or individual authorisation models (most administrations manage through use of individual licences and/or licence exemption).

The current regulation on spectrum usage already includes relevant mechanisms to address sharing arrangements and conditions. These existing mechanisms can also be used for the introduction of CR technologies. This has been explored in the RSPG report on CR, Chapter 5 (February 2010)[2]. We are not aware of any regulatory framework that requires accreditation of databases and conditions which the database has to meet.

It is assumed that the essential requirement of the R&TTE Directive fully applies to CR devices and they do not need to be amended. All the different possible stages of configurability of an apparatus with CR support have to fulfil the requirements of the R&TTE Directive. Therefore most of the test procedure and relevant measures aiming at ensuring the compliance at different stages of the CR device functioning should be included in harmonised standards. These specificities need to be described in a guide to be addressed to ETSI. This guide should therefore also be brought to the attention of the notified bodies.

In particular, harmonised standards should include specifications:

- for the exchange of information between the CR device and the database;
- to ensure that the CR devices will be connected with the relevant database;
- on the geolocation systems;
- on the need for the CR device to obtain the authorisation to emit from the database.

Except in case of databases managed by administrations there is currently no regulatory framework requiring accreditation of databases and conditions which the database has to meet.

4 Different Cognitive Functionalities

The RSPG considered three different cognitive functionalities that a Cognitive Radio can use to acquire information about the operational radio environment. These functionalities can be used separately but it is also possible to make use of a combination of these techniques.

4.1 Sensing

Sensing is a functionality whereby a scan of (a dedicated part of) the spectrum is made to provide a real-time “map” of the radio environment. Actual usage of the spectrum varies considerably, dependent on various parameters, e.g. the number of applications which are sharing the same frequency band and the number of users in a specific area. Furthermore, some parts of the spectrum are deliberately unused, such as guard-bands between users or within services. The main objective of spectrum sensing is to enhance spectrum usage efficiency by finding opportunities for spectrum access (in various dimensions: time, spatial and frequency) without interfering with other users of the band and adjacent bands. Sensing is a technology that is still under development. Furthermore, sensing may not be sufficient in all cases to adequately protect the incumbent users. Sensing becomes more challenging when a wider range of frequencies and/or a wider range of user applications need to be taken into

[2] RSPG10-306 Final, Radio Spectrum Policy Group report on "cognitive technologies", February 2010.

account. At the current state of technology, a case-by-case approach is required which takes into consideration the existing spectrum usage.

The current regulatory framework provides sufficient flexibility in terms of possible licensing regimes, ranging from general authorisation to individual authorisations. Therefore no additional regulatory actions are needed for the implementation of sensing as an interference mitigation technique. However as stated above guidance will have to be provided to ETSI and notified bodies.

Three types of sensing technologies were identified:

- "Stand alone" sensing, operating from radio terminal without a priori information nor databases, and thus addressing all use cases. Stand alone terminal embedded sensing capabilities seem a necessary "back up" capability to perform practical situations in the most flexible way, for example:
    a. when unexpected situations occur (database not available or not precise enough, unexpected transmitter present at the field, etc.),
    b. when the used frequency range includes numerous and/or versatile transmitters (numerous analogue modems, radio controlled alarms, non-intentional jamming sources, etc.), that make the use of a priori information or database not fully reliable.
- "oriented" sensing, operating with the help of a priori information and databases, improving performance and reliability for dedicated use cases of interest.
- "cooperative" sensing involving a set of terminals and/or dedicated disseminated sensing nodes within a given geographic area, ensuring an enhanced identification of transmitters thanks to exchange of collected data.

4.2 Cognitive Pilot Channel

A Cognitive Pilot Channel (CPC) is a dedicated carrier providing frequency usage information for the intended band in a given area. CPC as a concept is still very much in the equipment research phase. Both technical and business evaluations are currently ongoing on the implementation of a CPC. Some of these research activities on the CPC are ongoing in Europe, e.g. in the framework of FP7 and ETSI TC-RRS.

There would have be a dedicated allocation of spectrum either by regulatory action or by an incumbent to enable CPC to be used by a cognitive device to enable sharing. In addition there would have to be some input from the standards bodies either through a HS developed in ETSI or through a voluntary process of standardisation Various approaches exist for the dissemination of the information carried by the CPC, such as a broadcast mode versus an on-demand mode and a localised coverage approach versus a mesh approach whereby the information on spectrum usage and availability is distributed over a relatively large area. On top of that, various approaches exist for the information to be carried by a CPC. Information can be carried to protect existing users or to enable optimal use of spectrum resources.

Beacons are signals which can be used to indicate that particular channels are either in use by protected services or vacant. Beacons can be sent either on a dedicated CPC or as part of the protocol of a normal transmission from a digital device (e.g. recognisable header of a data

frame). The use of beacons can ease the performance requirements on devices that use spectrum sensing, by increasing the likelihood of detection at lower threshold values. The interference protection provided to licensed users when the beacon information is sent over a dedicated CPC can come at a cost in spectrum capacity which will relate to some sort of opportunity cost. In some digital systems beacons are already used as part of the normal protocol in order to manage throughput, scheduling etc. Although no detailed studies have been performed by CEPT the possibility that the use of beacon transmitter may be helpful for the protection of PMSE equipment using the braodacast white spaces has been discussed. In addition the IEEE 802.22 standard contains a proposal for beacons that can be recognised by 802.22 equipment.

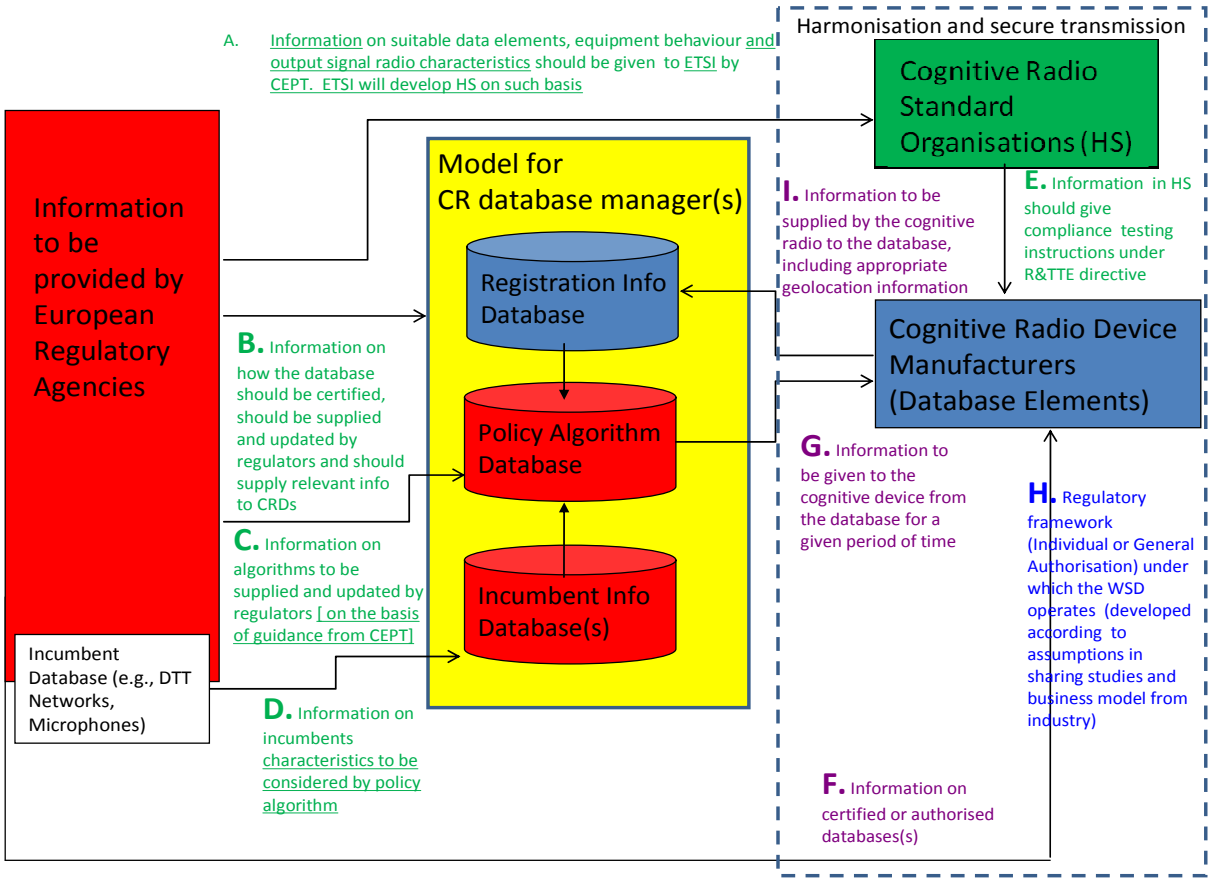
4.3 Database

Usage of a database seems to be the most feasible and flexible way forward to provide reliable real time information updates on spectrum usage. The manager of the CR database will have to collect information from regulatory agencies and from incumbent databases. It will exchange information with the CR device which will allow it to emit under certain conditions. The credibility of the system will rely on the accuracy of the information provided to the CR database by the device and the information provided by the database back to the CR device. In order to provide assurances over the credibility of this procedure and the accuracy of the information contained in the database suitable regulatory instruments and accreditation procedures will have to be further studied by administrations.

It should be very clear which party is responsible for the various components of the regulatory environment including the provision and updating of information.

Figure 4-1 below shows a diagram explaining the responsibilities associated with the different entities that will need to be addressed in order to set up a suitable regulatory environment to manage and update the flow of information necessary for setting up a cognitive radio database. Although Figure 4-1 below has been produced to represent CR systems implementation in a particular frequency band, it could be altered slightly to make it applicable for any bands where the combination of CR devices and database(s) could be used to provide sharing solutions. It is assumed that the diagram below is fully applicable to CR using the white spaces in the UHF band.

The level and extent to where harmonisation can be achieved with respect to the use and management of CR database(s) would be dependent upon how the services included in the sharing scenario are planned and rolled out. The example given below in Figure 4-1 is specific to describing the minimum actions (with respect to harmonisation) that would be needed to implement CR, e.g. in the white spaces in the UHF band.



Note: In some cases the database provider may be the National Administration

Figure 4-1: proposed database scheme

The section below uses references to Figure 4-1 above to describe the minimum actions that are needed in order to provide the common regulatory framework to enable implementation of CR devices.

The responsibilities that should be left to National administrators to develop autonomously are the following:

- Information needed from ADMIN to Database provider: to be provided and managed by administrations, groups of administrations or their nominated agents to database providers (see C and D). Although different national planning models are being used throughout Europe taking into account guidance from CEPT, Administrations where possible should try to harmonise the algorithms provided to database providers.
- Administrations should establish a certification or accreditation framework for databases (see B). It may be appropriate to develop guidance on this framework at a European level (see B)
- Administrations should set up a suitable authorisation regime (i.e. general or individual) under which the CR device should operate (see H).

Harmonisation exercises that should be undertaken by ETSI in co-operation with CEPT to provide a Harmonised Standard to address data format, content of data & possibly secure transmission are the following:

- Information to be provided by administrations or CEPT to Standards bodies (ETSI): guidance information on the compliance requirements that regulators would like to see included in the Harmonised Standard for the data exchange between the devices and any database provider (see A).
- Compliance Information for Device Manufacturers: the manufacturer will have to ensure that the CR device can connect to the suitable database(s) and provide the appropriate geolocation information and possibly other information that can be used to classify its use (e.g. fixed/mobile, indoor/outdoor, master/slave etc.). They will also have to ensure that the CR device can understand the information it receives and act accordingly. This can be demonstrated through compliance with an ETSI harmonised standard. (see E, I and G).
- Information from Regulators directly to the Device: information on where to find the certified/approved database(s) could be sent directly to the device by regulators or their representative agent e.g. ECO or could be publicly available for interested parties. The format of information may need to be standardised through ETSI (see F).
- The particular assumptions made above only apply to the management of white space devices in the UHF band. The level of harmonisation may be different for other sharing situations that use a database to enable sharing with cognitive devices.

4.4 Combination of the given cognitive features

Noting the above given information on the three basic cognitive features, any combination of them may be appropriate in any given sharing scenario which may give an advantage over using a single cognitive feature. In this case it will be important to identify which cognitive feature (if any) should take precedence over the other. It has to be noted that currently the combination of Geolocation and Sensing is under consideration within CEPT as approach for the usage of White Spaces in the UHF band. See draft ECC Report 159 for more information.

5 Opinion of the RSPG

The purpose of this Opinion is to address possible implications to the EU spectrum policy in relation to the implementation of CR technologies.

The RSPG notes

1. that in several European countries, licences have been given for the provision of digital terrestrial television in the UHF bands for the next 15 to 20 years;
2. that the licensing period, planning requirements and use of the incumbent services in the UHF band (i. e. Broadcast and PMSE) varies between different national administrations. This will have an impact on the timing and amount of white space that could be made avaiable for use by cognitive devices;
3. that CEPT is, in the first instance, the most appropriate entity to undertake any Europe-wide studies in order to identify spectrum available and develop sharing conditions in order to implement CR technologies;
4. that academia and researchers have already assessed the technical issues related to cognitive radio technologies;
5. that ETSI is the appropriate standardisation body to develop harmonised standard related to devices with CR technologies;
6. that, in case of databases, there does not seem to be any European regulatory framework applying to accreditation of databases;
7. that harmonisation of CPC at European level should remain on standardisation level until technical and commercial uncertainties have been solved.

The RSPG considers

1. that the R&TTE Directive covers all of the essential requirements that can be applied to CR devices;
2. that the existing regulatory framework already covers devices that implement sensing techniques to enable sharing between different services;
3. that technical and legislative options involved in this transisition should not be determined by economic factors alone but ought also to take account of social, cultural and political factors;
4. that promising new services fostering growth and innovation are seeking access to spectrum;
5. that the amount of spectrum available for cognitive radio use is still te be studied and evaluated;
6. that CR devices may enable and/or improve spectrum sharing in a number of bands;
7. that there does not seem to be any discernable support at this time to introduce harmonised frequency allocations to accommodate CPC, but some standard bodies have introduced the possibility of sharing with other services by recognition of beacons which could be part of the incumbent normal protocol;

8. that EU funded research covering the following activities:
    a. Evaluation of terminal radiofrequency hardware and computations constraints relevant to sensing, leading to specifications of suitable embedded hardware and computing capabilities;
    b. Definition of sensing scenarios, by taking into account several radio environments;
    c. Evaluation of communications resources that are necessary for interfacing sensing components in case of cooperative sensing and for connection to the database;
    d. Evaluating the safety mechanism to be implemented in order to ensure a safe data communication (for database and cooperative sensing) to prevent degraded functioning.

The RSPG recommends

1. that implementing measures to introduce the CR technologies in some bands could be left to Member states as long as border coordination issues are adressed and the following *recommends* are taken into account;
2. that a platform shall be created to allow reasearchers, academia and regulators to coordinate research activities;
3. that Administrations, when implementing CR technologies that require to utilise databases should (possibly with guidance developed in the CEPT):
    a. indicate how the databases should be certified or accredited, supplied and updated by national regulatory bodies, and to supply relevant information to CR systems;
    b. provide information to database managers on algorithms;
    c. provide information on incumbents directly or through a designated entity;
4. that Administrations and the EC should request ETSI to study the relevant means that could be implemented in order to secure the access from CR devices to the relevant database and the exchange of information between them;
5. that Administrations, in relation with the EC and TCAM, should give to ETSI relevant information on suitable data elements, equipment behaviour and output signal radio characteristics which will allow ETSI to develop harmonised standards;
6. that any Cognitive Radio harmonised standard developed by ETSI should include:
    a. compliance testing instructions under R&TTE Directive;
    b. relevant information on how CR device could access only certified or authorised databases;
    c. HS information that should be given to CR devices from the database for a given period of time;
    d. information to be supplied by the CR device to the database including appropriate geolocation information;
    e. means needed to secure transmission between the database and the CR device;
7. that TCAM should keep Notified Bodies up to date regarding specific requirements under the R&TTE Directive for CR devices;
8. that in order to provide some confidence to all stakeholders, EC should investigate if JRC facilities can be made available to carry out proof of concept testing on CR devices supplied by industry.

Abbreviations

BEM	Block Edge mask
BRAN	Broadband Radio Access Networks
CEPT	Conférence Européenne des Administrations des Postes et des Télécommunications
CPC	Cognitive Pilot Channel
CR	Cognitive Radio
CRS	Cognitive Radio Systems
CT	Cognitive Technologies
EC	European Commission
ECC	Electronic Communications Committee (CEPT)
ECO	European Communications Office
EMC	Electromagnetic compatibility
ERM	EMC and Radio Spectrum Matters
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission (USA)
FP7	Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013)
HS	Harmonised Standard
IEEE	Institute of Electrical & Electronics Engineers
ITU	International Telecommunication Union
JRC	Joint Research Centre
NOI	Notice of Inquiry
NPRM	Notices of Proposed Rulemaking
PMSE	Programme Making and Special Event
R&TTE	Radio and Telecommunications Terminal Equipment
RRS	Reconfigurable Radio Systems
SDR	Software Defined Radio
UHF	Ultra High Frequency
WG FM	Working Group Frequency Management (ECC)
WG RA	Working Group Regulatory Affairs (ECC)
WG SE	Working Group Spectrum Engineering (ECC)
WRAN	Wireless Regional Area Network

Annex 1

ETSI project teams and their responsibilities relevant to SDR/CR

Project Team	Title	Scope
TC BRAN	**Broadband Radio Access Network**	responsible for all aspects of standardisation for present and future broadband radio access networks, including: - radio and regulatory aspects, - lower layer protocol aspects, - architectures, transmission and inter-working aspects of access networks, - aspects of transport network interfaces.
TC ERM	**EMC and Radio spectrum matters** ERM TFES	primary responsibility for: - ETSI deliverables (in whole or in part) dealing with EMC; - ETSI deliverables (in whole or in part) dealing with radio spectrum parameters concerned with inter-system characteristics; - co-ordination of ETSI positions on the efficient use of the radio spectrum and spectrum allocations.
TC RRS	**Reconfigurable Radio Systems** Four Working Groups: - System Aspects - Equipment Architecture - Cognitive Management and Control - Public Safety	responsible of standardisation activities related to Reconfigurable Radio Systems encompassing system solutions related to Software Defined Radio (SDR) and Cognitive Radio (CR); - to collect and define the related Reconfigurable Radio Systems requirements from relevant stakeholders; - to identify gaps, where existing ETSI standards do not fulfil the requirements, and suggest further standardisation activities to fill those gaps; - to deliver its findings in the form of ETSI deliverables as appropriate; - to provide ETSI with a major centre of expertise in the area of Reconfigurable Radio Systems.

Annex 2

Work Outside Europe – FCC and IEEE

U.S. Federal Communications Commission (FCC)

The US Federal Communications Commission (FCC) established a Spectrum Policy Task Force (SPTF) in 2002. The SPTF's focus was on making more efficient use of spectrum. Based on SPTF's report, the FCC issued a Notice of Inquiry in 2002 concerning additional spectrum for unlicensed devices below 900 MHz and in the 3 GHz band. This opened up the possibility of using the "fallow" UHF TV bands for unlicensed devices. Between 2003 and 2010, a series of exploratory documents was followed by Notices of Proposed Rulemaking (NPRMs) and Reports and Orders. The most recent of these - FCC-10-174, Second Memorandum Opinion & Order - expresses their "final" position on the matter. This document addresses a wide variety of issues relating to unlicensed use of the TV bands, including:

- Protection criteria for Incumbent Authorized Services
- Technical rules for TV band devices
- Database Requirements for TV band devices
- Channels that can be used by TV band devices

In particular, FCC-10-174 eliminates the requirement that radios which incorporate geolocation and database access must first sense TV broadcast signals. The Order approves a number of measures to simplify coexistence with Wireless Microphones. Among these measures, the Order dedicates two vacant UHF channels for wireless microphones and other low power auxiliary service devices in all areas of the United States. In the event where the two reserved UHF channels are unavailable or insufficient, unlicensed wireless microphone users are required to register in the TV band databases to receive the same geographical spacing protections as licensed Wireless Microphone users.

FCC Documents on Cognitive Radio in US TV White Spaces

FCC Document #	Year	Title	Remarks
FCC-02-328	2002	Notice of Inquiry – "Additional Spectrum for Unlicensed Devices below 900 MHz and in the 3 GHz band"	Opened the question of using the TV band channels for unlicensed devices on a non-interference basis
FCC-03-289	2003	NOI & NPRM – "Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to expand available unlicensed operation in certain fixed, mobile & satellite frequency bands"	Proposed an interference temperature model for quantifying and managing interference
FCC-03-322	2003	NPRM & order – "Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies"	To advance CR technology as a candidate to implement negotiated or opportunistic spectrum sharing
FCC-04-113	2004	NPRM – "Unlicensed Operation in the TV Broadcast Bands"	To permit unlicensed use and to request comments on their proposed rules changes for opportunistic access to "white spaces" in the TV bands.

FCC Document #	Year	Title	Remarks
FCC-06-156	2006	First Report & Order & Further NPRM – "Unlicensed Operation in the TV Broadcast Bands"	The important first steps towards allowing the introduction of new low power devices in the broadcast television spectrum.
FCC-08-260	2008	Second report and Order and Memorandum Opinion and Order – "Unlicensed Operation in the TV Broadcast Bands"	Adopted rules to allow unlicensed "white space" devices to operate in the broadcast TV bands at locations where that spectrum is not being used by licensed users
FCC-10-174	2010	Second Memorandum Opinion & Order – "Unlicensed Operation in the TV Broadcast Bands"	"Final Opinion" on Cognitive Radio for Unlicensed Devices in TV White Spaces.

IEEE

Standardisation work is underway at the IEEE in a number of areas as a result of the FCC's action on Cognitive Radio. The IEEE has standardised Cognitive Radio techniques as part of 802.22 (WRAN). 802.22 was the first WRAN standard to incorporate CR techniques. The standard allows for three methods to ensure no interference with primary users - geolocation databases, beacons and spectrum sensing. It is clear from the recent FCC-10-174 "Final Opinion" that spectrum sensing will not be a mandatory requirement. A recently published component of 802.22 is 802.22.1 - "Standard for the Enhanced Interference Protection of the Licensed Devices". This standard, officially adopted by the IEEE on September 30th, 2010, specifies a Beaconing network. The network helps protect low-power, licensed devices operating in the TV bands from harmful interference from license-exempt devices, such as Wireless Regional Area Networks. The beaconing network can be employed by Wireless Microphones and other low-power devices.

Apart from 802.22, other standards that were recently published or are being developed by IEEE include:

- IEEE 802.11h is an extension to the 802.11a wireless LAN standard, incorporating CR techniques such as adaptive Transmit Power Control and Dynamic Frequency Selection. These provide better robustness to interference in the 5GHz band. This standard was adopted in 2003.
- IEEE 802.11af – will define modifications to both the 802.11 physical layers (PHY) and the 802.11 Medium Access Control Layer (MAC), to meet the legal requirements for channel access and coexistence in the TV White Space.
- IEEE 802.16h - an extension to 802.16 (Wireless Metropolitan Area Networks). 802.16h brings several improvements to basic 802.16 WiMax such as spectral and energy efficiency using some Cognitive Radio techniques. This standard was adopted in 2010.
- IEEE Standards Co-ordinating Committee 41 (SCC41) contains several IEEE 1900.X working groups on "DySPAN", or Dynamic Spectrum Access Networks, using Cognitive Radio technology. The focus of this effort is to develop supporting standards and advanced spectrum management techniques for next-generation radio. There are six P1900 working groups. Since 2008, working groups 1900.1, 1900.2 and 1900.4 have published standards. The working group on 1900.3 was disbanded, while groups 1900.5 and 1900.6 have yet to complete and publish their work.

The industry is considering using CR technology for various usage scenarios. In particular, deployment scenarios such as the use of CRS technology by an operator of a radiocommunication service to improve the management of its assigned spectrum resource should be considered.