CRS-i

FP7 – 318563
Coordination Action

Cognitive Radio Standardization-initiative: from FP7 research to global standards

D3.1
Plan for coordinated contribution to standards from QoSMOS, COGEU, SACRA and OneFIT

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Abstract:
This deliverable presents the main achievements from the first four months of tasks T3.1- “Coordinated standardization effort beyond projects lifetime: QoSMOS, COGEU, SACRA and OneFIT”.

Keyword list: Cognitive radio, Standardization, FP7 projects, TV White Spaces, Licensed Shared Access, Device-to-Device

Executive Summary

This deliverable presents the main achievements from the first four months of tasks T3.1-"*Coordinated standardization effort beyond projects lifetime: QoSMOS, COGEU, SACRA and OneFIT*".

The aim of this task is to facilitate and guarantee sustainability of the standardization efforts of current FP7 QoSMOS, COGEU, SACRA and OneFIT projects ending in December 2012. This extension will be done in a coordinated manner and will last 24 months, i.e., 2 years after the end of the projects.

This coordinated standardization action will have to build a technical consensus among the four projects in order to achieve a coherent contributions effort to the standards. The first step in this task is to develop a plan for coordinated contribution to standards from QoSMOS, COGEU, SACRA and OneFIT.

The standardization efforts addressed by the four projects are structure in three main streams:

- TV White Spaces (TVWS) access;
- Opportunistic Device-to-Device communications;
- Licensed Shared Access.

Technical contributions to the related standardisation bodies are expected throughout 2013 and 2014, which fits very well in CRS-i WP3 timeframe. Besides, CRS-i will have to coordinate with other projects from the FP7 RAS cluster on these standardization topics.

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List of Abbreviations

COGEU	FP7 Call 4 STREP: Cognitive radio systems for an efficient use of TVWS in the European context
CR	Cognitive Radio
DVB-T	Digital Video Broadcast – Terrestrial
DTT	Digital Terrestrial TV
DSA	Dynamic Spectrum Access
EU	European Union
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
ITU	International Telecommunication Union
LSA	Licenced Shared Access
LTE	Long Term Evolution
MBB	Mobile BroadBand
MNO	Mobile Network Operator
Ofcom	Office of Communications (UK)
OneFit	FP7 Call 5 STREP Opportunistic networks and cognitive management Systems for Efficient Application Provision in the Future Internet
PMSE	Program Making and Special Events
QoE	Quality of Experience
QoS	Quality of Service
QoSMOS	FP7 Call 4 IP: Quality of Service and Mobility driven cognitive radio systems
RAT	Radio Access Technology
SACRA	FP7 Call 4 STREP: Spectrum and Energy efficiency through multi-band cognitive radio
SDR	Software Defined Radio
TVWS	TV White Spaces
WSD	White Space Devices
WiFi	Wireless Fidelity
WRC	World Radiocommunication Conference
WiMAX	Worldwide Interoperability for Microwave Access, Inc

1 Introduction

Research into cognitive radio systems and cognitive radio networks has matured and many projects and initiatives have provided proof of concept implementations, demonstrators and showcases. In the military domain first products are shipped on the market. However, these vertical market products are not following widely agreed standards and there are no commonly approved testing and certification mechanisms in place. To date, there are only few standards that may be used as benchmark for the type approval or the certification of the operation of CR equipment and they are rather incomplete and rather fragmented. Notably, there are a range of standards in the IEEE 802 family, in the DySPAN (formerly SCC41) 1900.x family and significant efforts by the ETSI RRS technical committee and related working groups. At the same time, a range of projects have been funded as part of the FP6 and FP7 programmes, investigating the theoretical aspects of cognitive radios, developing demonstrators and producing contributions to one or the other standardisation effort. To achieve the biggest impact, either de-facto leadership of standards needs to be established (e.g. as happened with GSM, or IEEE 802.11), or concerted efforts (e.g. LTE) need to be undertaken. Thus, a support action to facilitate international cooperation on CR standardisation is needed.

Standardisation is only a side aspect in research projects, yet most related FP7 projects do participate in and contribute to standardisation bodies. However, all projects face the fact that it is difficult to achieve impact during the rather short (typically 2-3 years) life time of an FP7 project. Figure 1-2 illustrates the typical roadmap of an FP7 project, where it is shown that standardisation activities usually start in the second half of the project lifetime. Considering the long process of standardisation (typ. 3 years), it is impossible for projects to track the process right to its end and participate in the critical motions and ballot phase. WP3 of CRS-i will have a major role in leveraging on project results and standardisation activities triggered in FP7 projects to keep momentum an European influence in the whole standardisation process.

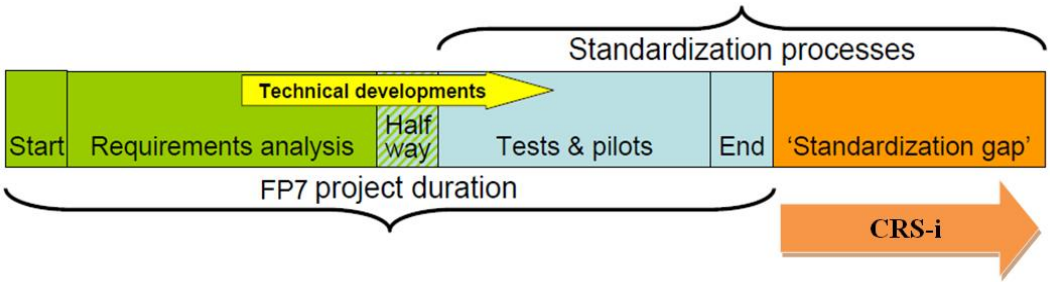


Figure 1-1: Typical FP7 project roadmap and CRS-I’s role for an extension.

In particular, CRS-i will collaborate with existing FP7 projects and will exploit the outcomes of the past related projects (QoSMOS, COGEU,SACRA and OneFIT) and will extend and coordinate their standardization activities beyond projects lifetime. The overall positioning of the coordination action is indicated in Figure 1-2.

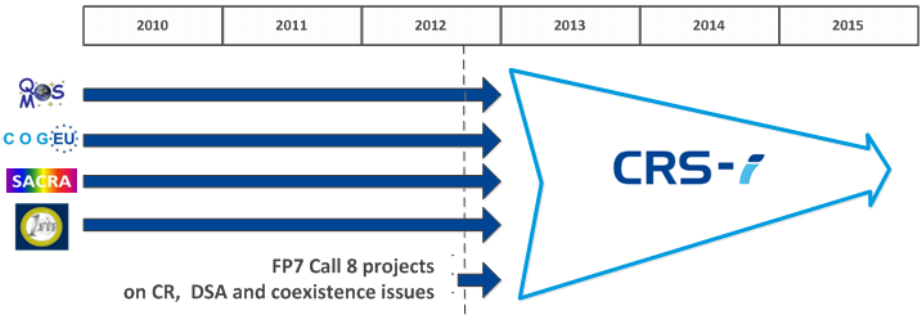


Figure 1-2: Extension of standardisation activities beyond the end of Project life time through CRS-i.

Moreover, CRS-i will derive a coherent standardization approach exploiting results from currently

running FP7 projects in order to give more momentum to the initiative. To this end, CRS-i has identified running projects as potential targets to join the CRS-i initiative.

The standardization efforts addressed by the four projects are structure in three main streams:

- TV White Spaces (TVWS) access;
- Opportunistic Device-to-Device communications;
- Licensed Shared Access;

In this deliverable, initial structure towards CRS-i standardisation strategy is presented. In Section 2, state of the art on CR standardisation is presented. This will be the ground for CRS-i strategy drivers towards standardisation. Then, in Section 3, 4 and 5, the standardisation activities in the field of the three aforementioned streams are presented. Each section starts summarizing the activities of QoSMOS, COGEU,SACRA and OneFIT, in the fields and then a coherent preliminary strategy for CRS-i standardisation plan is provided. Section 6 concludes this deliverable.

2 State of the art on CR standardization

The past decade up until now has ushered in a plethora of research and advances in the area of Reconfigurable Radio Systems (RRS) with Cognitive Radio (CR) technology as a driver to realise increased efficiency in spectrum utilisation and system performance when exploiting the radio spectrum. Advances in the field of cognitive radios would therefore help to cope with the deluge in the demand for wireless broadband applications.
Given the worldwide research effort into RRS and its promise of increased broadband penetration when utilising the so called TV white spaces (TVWS); the European commission (EC) under the FP7 framework has funded many projects (i.e. QoSMOS, COGEU, SACRA, OneFIT etc.) to provide the technical frame work, analysis, design and system requirements for exploitation of TVWS in an infrastructure and non-infrastructure based civil environment. With the aforementioned projects drawing to a close (or completed in most cases), exploitation of the results therefore becomes an evolutional consequence. The European commission therefore has the mandate in covering the harmonisation needs for CRs for commercial, public safety and military use, allowing for innovation and competitiveness which is in-line with the Europe 2020 strategy. This mandate will be conveyed to the European Standards Organisation (ESO) who is saddled with the responsibility of drawing out a harmonised framework in the exploitation of radio spectrum (i.e TVWS). Creating a harmonised standard which incorporates the needs of all stake holders (in Europe and possibly the rest of the world) would result in huge economics of scale for prospective CR products.
Standardisation deals with the definition of technical or quality specifications with which current or future products, production processes or services may comply. More importantly, standardisation bridges the gap between research proceedings and commercial realisation. The successful completion of FP7 projects (relating to the commercial aspects) and their resultant outcomes would inevitably set the pace for the realisation of the European digital agenda. Therefore, the responsibility of creating an acceptable framework for standardisation of European wide research outputs for cognitive radio systems lies with the ESO, so as to promote standards, vital for interoperability.

2.1 Regulatory and standardisation bodies for CR in Europe

In Europe, the main entities, which participate in spectrum regulation and related standardization processes, are:

- CEPT: The European Conference of Postal and Telecommunications Administrations, within which policy makers and regulators from 48 countries across Europe collaborate to harmonize telecommunication, radio spectrum and postal regulations.
- ECO: The European Communications Office which is the Secretariat of the CEPT. The ECO provides advice and support to the CEPT to help it develop and deliver its policies and decisions in an effective and transparent way.
- ETSI: The European Telecommunications Standards Institute , which is responsible for most of the European telecommunication standardization activities together with CEN(Comite´ Europeen de Normalisation) and CENELEC (Comite Europeen de Normalisation Electrotechnique). Within ETSI, the ETSI Technical Committee (TC) on Reconfigurable Radio Systems (ETSI-RRS) is working on the standardization of SDR and CR technologies, while the ETSI TC on Electromagnetic Radio Matters (ETSI-ERM) is working on radio-frequency and spectrum-related issues.
- EC: The European Commission, which is the Executive Body of the European Union and is composed of various departments or directorate generals (DG). One of the objectives of the DG CONNECT is to define and implement regulatory environment that enables rapid development of Information Communication Technology (ICT) services. The DG Enterprise (ENTR) is responsible for standardization and certification of communication devices.
- The Radio Spectrum Policy Group (RSPG), which is a high-level advisory group that assists the European Commission (i.e., DGCONNECT) in the development of radio spectrum policy.
- The Telecommunications Conformity Assessment and Market Surveillance (TCAM), which is an advisory and regulatory committee that assists the European Commission in matters regarding conformity assessment and market surveillance including the Radio and Telecommunications Terminal Equipment Directive (R&TTEDirective).

The relationships among the described entities are shown in Figure 2-1 Figure 1-2: Extension of standardisation activities beyond the end of Project life time through CRS-i(adapted from [21]).

Unbroken lines represent permanent activities/relationships and the broken lines represent temporary activities for a specific topic.

As indicated in Figure 2-1, the CEPT can request feasibility studies from the Electronic Communications Committee (ECC), which is composed of working groups (WGs), task groups, and project teams. In particular, WG SE43 (currently finalised) has the responsibility to define technical and operational requirements for the operation of CR systems in the TVWS of the UHF broadcasting band (470–790MHz). Representatives of national spectrum regulators participate to the activity of CEPT WGs. WGSE43 and the ETSI Technical Committees (TC) collaborate through Liaisons Statements (LS). The requirements specified in WG SE43 are the input for the definition of the standards created in ETSI TCs. As indicated in the picture, the EC can request specific standardization mandates from CEPT and/or ETSI on specific technologies. Both CEPT and ETSI TCs collaborate with TCAM for the revision of the R&TTE directive and they are in contact with international regulatory and standardization bodies.

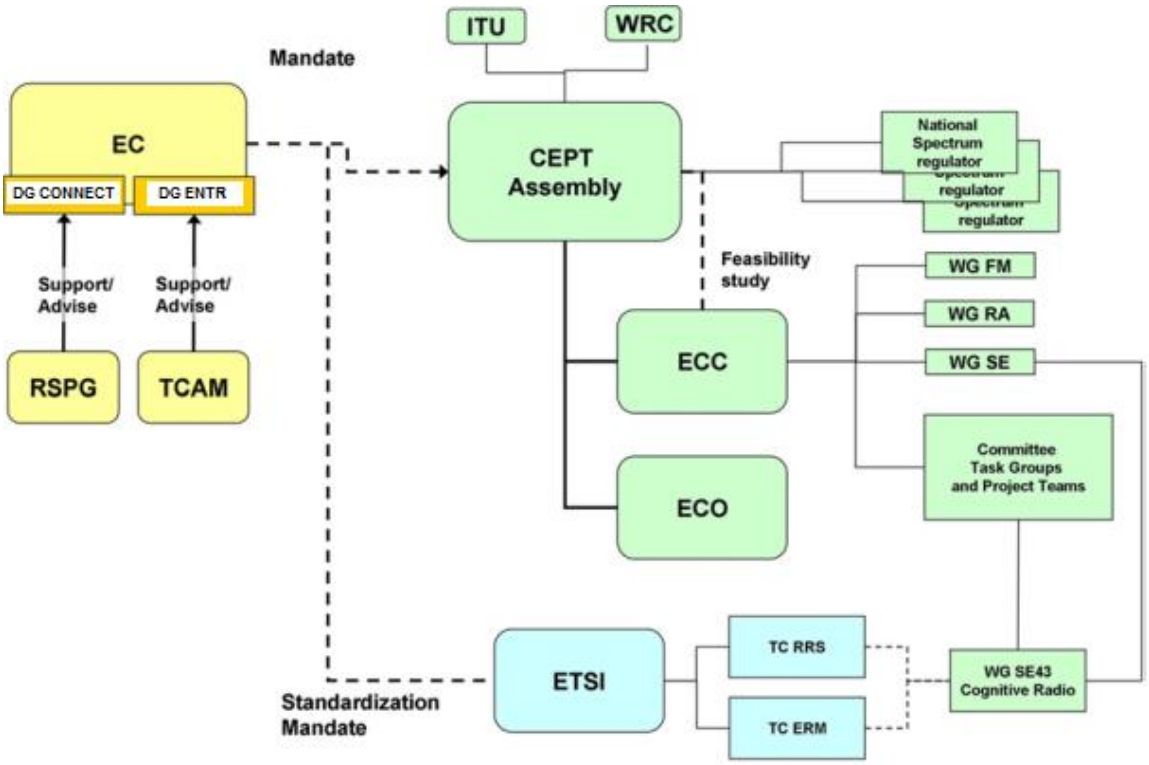


Figure 2-1: Relationship among entities involved in European spectrum regulation for CR (Adapted from [21]) .

2.2 EC standardisation mandate on CR

Given the European (or world) wide research effort and the accompanying successes in the field of RRS and as a direct consequence; cognitive radios, hitherto, the lack of standards has inhibited the deployment and commercial realisation of cognitive radio technology. The European Commission through the ESO therefore has the mandate to create harmonised standard for cognitive radios (or by direct implication TVWS devices) with the following objective [3]:

- To ensure CR devices in the market place adhere with European Union and member states legislation as well as conform with the directive on Radio Equipment & Telecommunications Terminal Equipment (R&TTE Directive) [11].
- To explore potential areas of synergy among commercial, public safety and Military applications.
- To ensure that deployment of CR technologies does not impede the Single Market;
- To ensure that standardisation of cognitive radio technologies happens timely in Europe in order to keep pace with global developments.

The EC has further given a description and fine time lines of the mandate to CEN, CENELEC and ETSI in [3], stipulating that these standardisation bodies should "develop harmonised standards providing presumption of conformity with Article 3(2) of the R&TTE directive covering cognitive radio systems (CRSs) dependent for their use of radio spectrum on information obtained from geo-location databases". These standards should support the use of CRSs in the UHF band in the short to medium term, taking into account the state of play in the industry.

In order to take into account the needs of existing radio services and users (e.g. rail/road communications, GSM-R, PMSE for TV White Spaces), CEN, CENELEC and ETSI are requested to collaborate with the European Conference of Postal and Telecommunications Administrations (CEPT) as necessary during the execution of the standardisation mandate. The standardisation work shall include the necessary coordination with international standardisation bodies, in particular with ITU-T, and consultation with other standards organisation such as IEEE, IETF-PAWS, ECMA etc. and organisations such as the Wireless Innovation Forum (WINNF) as appropriate.

For the EC directive to the ESO- CEN, CENELEC and ETSI, harmonized standards are mostly developed by ETSI while some safety and health standards are developed by CENELEC. ETSI therefore bears the bulk of responsibility in proffering standards for CRS through the ETSI Reconfigurable Radio systems (RRS) Technical Committee (TC). ETSI Board 74, approving the new term of reference, has formally given TC RRS, among other things; the mandate of standardisation activities related to RRS. The structure and objectives of ETSI-RRS is described in the sequel.

- **ETSI-RRS (Reconfigurable Radio systems)**
  In ETSI, standardization of CRS is performed in the TC RRS with a detailed structure and activities given in [10] [6]. ETSI RRS is constituted of four working groups (WGs). ETSI Technical Report (TR) 102 838 in October 2009 gave a summary of feasibility studies and potential standardization topics traversing WG1 to 4.

  - **ETSI-RRS WG1** deals with the "System Aspects" of CRS and develops proposals for a common systems framework in an effort to harmonise related activities amongst the WGs. Within WG1, ETSI RRS Technical report (TR) 102 802, "Cognitive Radio System Concept," was published in February 2010 with the view of articulating a harmonised technical framework for CRSs in infrastructure and infrastructure-less wireless communication networks while another report TR 102 803 "Potential Regulatory Aspects of Cognitive Radio and Software Defined Radio systems" published in March 2010 gives details from the regulatory point of view; cognitive system parameters.
  - **ETSI-RRS WG2** deals with "Radio Equipment Architecture" with notably TR 102 680 "SDR Reference Architecture for Mobile Device" and TR 102 681 "Radio Base Station (RBS) Software Defined Radio (SDR) Status" as the main documents that has ensued. However, the study has been limited to SDR architectures, while neglecting cognitive radio. Further activity, therefore would be done to support cognitive radio functionalities and other related standard development. Resultant harmonisation efforts when considering the extended functionalities e.g. CRS, are likely to further impact the standardisation of related aspects.
  - **ETSI-RRS WG3** on "Cognitive Management and Control" presumably has mostly impacted on cognitive radios and associated functionality. This group is split into two, namely:
    - Functional Architecture (FA) for the Management and Control of RRS.
    - Cognitive Pilot Channel (CPC)

    The FA group collects and defines the system functionalities for RRS related to spectrum management and radio resource management for interworking and coexistence across heterogeneous networks. The group has further, developed a functional architecture for the management and control of RRS, this includes functional architectures to support:
    i. Dynamic Spectrum Management (DSM) which contains and provides policies on spectrum usage, including the legal framework to supports dynamic spectrum assignment and spectrum trading.
    ii. Dynamic Self-Organizing Network Planning and Management (DSONPM) for the optimal configuration of the network.

iii. Joint Radio Resource Management (JRRM) for multi-standard radio resource management, selects the best radio access for a user and providing Neighbourhood information to the terminals.
iv. Configuration Control Module (CCM) to execute the reconfigurations either of a terminal or a base station.

Standardisation of the interfaces between functional blocks (JRRM, CCM, DSONPM, etc.) covered by the FA would help network operators and network business owners from various countries to face the increasing subscriber's need to reach a worldwide network, in a globalisation context. ETSI Technical Report (TR) 102 682, “Functional Architecture for the Management and Control of Reconfigurable Radio Systems” was published in July 2009 which gave the specification of the major functional entities that govern the operation of a reconfigurable radio system, as well as their operation and interactions.
ETSI-RRS WG3 also deals with the standardisation of a Cognitive Pilot Channel (CPC). Cognitive radios may gather information about their radio environment through a process known as spectrum sensing [13]. Spectrum sensing (SS) involves the “sniffing” of parts of the spectrum by CRs to ensure spectrum re-use or for other informative purposes. Spectrum sensing is usually power and time consuming, especially when the spectra portion to be sensed is large. This necessitates the proposition of a cognitive pilot channel as a solution to lead to a more efficient and reliable approach in conveying spectrum information to functional elements requiring information about the unused frequency channels, services, network policies, RAT etc. ETSI TR 102 683, “Cognitive Pilot Channel,” was published in September 2009. It provides a feasibility study on defining and developing the concept of the CPC for reconfigurable radio systems.

- **ETSI-RRS WG4** (Public Safety) focuses on public safety and collects and defines the related RRS requirements and system aspects for relevant stakeholders in the public safety and defence domain.

Proceedings from the above working groups has resulted in the adoption of two new work items which will result in the first ETSI normative deliverables (Technical Specifications, TS) in TC RRS: the first TS will focus on cognitive radio systems using UHF White Space frequency bands while the second one will be related to spectrum sharing in a public protection and disaster Relief network. In line with the first TS, use cases have been developed for TVWS usage, in ETSI TR 102 907 released in October, 2011. These comprise of long/mid/short range wireless access over TVWS, ad-hoc networking over TVWS, backhaul link using TVWS, and multimedia broadcast multicast services (MBMS) operating in TVWS. Normative System requirements are also under development in TS 102 946 “White Space System requirements for Operation in UHF TV Band”. **Figure 2-2** illustrates the normative process from a Use case definition to a Technical Specification (TS).

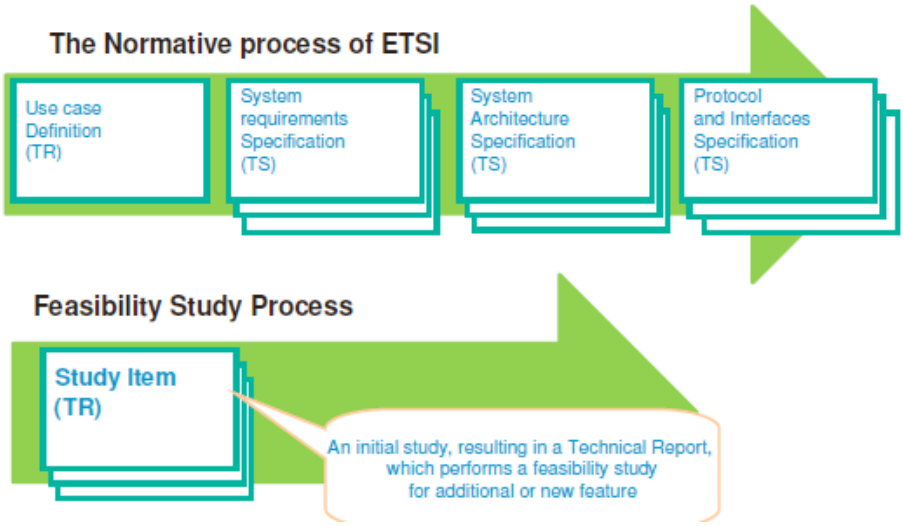


Figure 2-2: The normative process of ETSI.

- **ETSI Specialist Task Force (STF) 386**
  ETSI Specialist Task Force (STF) 386 [5] develops cognitive interference mitigation methods for program making and special events (PMSE) devices. Purpose is to achieve co-existence of PMSE devices with other radio services. Operational requirements and protocols for coexistence of PMSE with cognitive radios have been defined in ETSI TR 102 799 “Operation Methods and Principles for Spectrum Access Systems for PMSE technologies and the guarantee of a high sound production quality on selected frequencies utilising cognitive interference mitigation techniques” and ETSI TS 102 800 “PMSE - Protocols for Spectrum Access and Sound Quality Control Systems using Cognitive Interference Mitigation Techniques”. These two deliverables constitute the phase 1 and phase 2 technical specifications respectively. Phase 3 work is on-going and its purpose is to validate TS 102 800 protocols for PMSE protection using cognitive interference mitigation techniques. Institutions contributing to STF386 are: APWPT, Bosch conference systems, Sennheiser, Shure, University Erlangen, University Hannover and IRT (COGEU partner).

2.3 US and Japan standardisation activities on CR

2.3.1 Cognitive Radio System Standardisation Activity in the US

2.3.1.1 IEEE DySPAN Standards Committee

The IEEE DySPAN standard committee [8] (formerly known as IEEE Standards Coordinating Committee SCC41) develops standards for dynamic spectrum access networks. This includes techniques for managing interference, network management/sharing, and co-ordination of heterogeneous wireless systems.

In 2008, the 1900.1 WG developed IEEE 1900.1, “Standard Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management”. IEEE DySPAN also published the IEEE 1900.2 standard in 2008 relating to interference analysis in heterogeneous systems in IEEE 1900.2 “Working Group on Recommended Practice for the Analysis of In-Band and Adjacent Band Interference and Coexistence between Radio Systems”. It is worthy to note that the IEEE 1900.3 “Working Group on Recommended Practice for Conformance Evaluation of Software Defined Radio (SDR) Software Modules” has been dissolved.

IEEE 1900.4 defines the architecture of the management system to support the cognitive radio technology. In 2009, the group published the standard IEEE 1900.4 “IEEE Standard for Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks”. Further amendments were made to IEEE 1900.4 for more generic scenarios to enable opportunistic use in TVWS and other heterogeneous networks. The following standards therefore ensued: IEEE 1900.4a “ Standard for Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks - Amendment: Architecture and Interfaces for Dynamic Spectrum Access Networks in White Space Frequency Bands” and IEEE 1900.4.1, “ Standard for Interfaces and Protocols Enabling Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Networks”.

IEEE 1900.5 is concerned with vendor-independent policy-based control architectures and policy language requirements for managing the dynamic spectrum access systems. The working document standard IEEE 1900.5 “Policy Language and Policy Architectures for Managing Cognitive Radio for Dynamic Spectrum Access Applications” was approved in December, 2011 and published in January, 2012.

IEEE 1900.6 deals with the logical interface and data structures used for the information exchange between spectrum sensors and their clients without undermining the sensing technology or client design. IEEE 1900.6 “Working Group on Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communication Systems” has published a standard in 2011.
The WG6 is now continuing its work scheduled to develop initial system engineering documents that form the basis of the upcoming amendment P1900.6a.”IEEE Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio – Amendment: Procedures, Protocols and Data Archive Enhanced Interfaces”.

In 2010 the Standardisation Committee SCC41 (recently renamed DySPAN) opened an Ad hoc committee on whitespace Radios. The aim was to prepare a Project Authorization Request (PAR) on this topic. QoSMOS members have participated in discussions and telephone-conferences leading to the submission of this PAR entitled "Radio Interface for White Space Dynamic Spectrum Access Radio Systems Supporting Fixed and Mobile Operation". The PAR was accepted on June 16th, 2011 and the Working Group (WG) 7 was setup to work on this project (IEEE P1900.7). The WG's kick off took place on Sept. 29th, 2011 The scope of this WG is defined as follows: "This standard specifies a radio interface including medium access control (MAC) sublayer(s) and physical (PHY) layer(s) of whitespace dynamic spectrum access radio systems supporting fixed and mobile operation in whitespace frequency bands, while avoiding causing harmful interference to incumbent users in these frequency bands. The standard provides means to support P1900.4a for whitespace management and P1900.6 to obtain and exchange sensing related information (spectrum sensing and geo-location information)."

2.3.1.2 IEEE 802 LAN/MAN Standards Committee

The Notice of Inquiry by FCC in December 2002 in exploring the possibility of allowing access to the TV broadcast spectrum for license-exempt devices on a non-interfering basis created a plethora of research and developmental opportunities to allow efficient use of spectrum whilst allowing rural broadband.

The IEEE 802 local area network/metropolitan area network (LAN/MAN) [7] standards committee therefore created the 802.22 WG on wireless regional area networks (WRANs) charged with the development of the standards aimed at using CRS to share geographically unused TV spectrum (TVWS) on a spatial/temporal and non-interfering basis. IEEE 802.22.1-2010 "Standard for the Enhanced Interference Protection of the licensed Devices" published in November 2010. The standard allows for three methods to ensure interference free coexistence with incumbent systems namely; geo-location databases, beacons and spectrum sensing. The standard also helps protect PMSEs from harmful interference. In July 2011 the standards IEEE 802.22-2011 "Standard for Cognitive Wireless Regional Area Networks (RAN) for Operation in TV Bands" was published. This in line with the standards produced in ETSI TR 102 907. While the IEEE 802.22-2011 standard is more concerned on interference management, the 802.22.2 is concerned more about practices for deployment of CRS. Draft version of the 802.22.2 was also published in May 2012 in IEEE 802.22.2/D3.0 "Standard for Recommended Practice for Installation and Deployment of 802.22 Systems". Work is still on-going to finalise the normative standard.

Still in light of the decision of FCC to open up the TV bands for dynamic spectrum access, some other IEEE groups like 802.11 and IEEE 802.16 started to make amendments to their established standards for supporting the operations in TV White Spaces given that these groups are in themselves concerned with unlicensed use in the ISM bands. Apart from IEEE 802.22 standard, other IEEE standard constituted includes:

- The IEEE 802.19 working group within the IEEE 802 LAN/MAN Standards Committee has taken actions to work on the coexistence in TVWS. Task group (TG) 802.19 TG was formed in 2010 and has the mandate to develop a standard for TVWS coexistence methods.
- IEEE 802.11af was formed in January 2010 to adapt 802.11 (WiFi) to TV band operation. IEEE 802.11af will define modifications to both the 802.11 physical layers (PHY) and Medium Access Control Layer (MAC), to meet the legal requirements for channel access and coexistence in the TVWS.
- IEEE 802.16 (WiMAX) is the Working Group for Broadband Wireless Access Standards with the IEEE 802.16h chartered with the development of coexistence mechanisms for unlicensed operations of WiMAX at 2.4, 3.6 and 5GHz, with the inclusion of supports for cognitive capabilities in WiMAX systems. The amendment on the standard was published in July 2010 [2] to provide for co-ordinated and un-coordinated coexistence mechanisms. A mechanism called cognitive radio signalling is introduced to help co-channel 802.16 base stations to mitigate interference.
- IEEE 802.15 (Zigbee) Working Group for WPAN was constituted with 802.15.4 being the study group to harness cognitive functionalities in TVWS.

2.3.1.3 ECMA-392 Standards Committee

The ECMA 392 standard is the first standard for personal/portable devices in the TVWS that complies fully with the existing FCC rules whilst also embracing other international regulatory guidelines. It

specifies the framework for two network formation modes: master-slave mode and peer to peer mode. Standard ECMA-392, "MAC and PHY for Operation in TV White Space," was published in December 2009 [4]. It specifies MAC and physical layers for CRS operating in TVWS and identified mechanisms for protection of incumbent systems with strict regulatory adherence.

2.3.1.4 IETF PAWS Standards Committee

The mission of the IETF [9] is to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet. With much attention on the use of geolocation/database to provide spectra awareness to cognitive radios or TVWS devices, the internet may become the preferable means to get database information. The IETF PAWS (Protocol to access white space database) group is therefore involved with standardisation activity relating to providing protocols in accessing such TV databases. The overall goals of this WG are to [9]:

- Standardise discovery mechanisms and methods of communication with a TVWS Database
- Standardise the data formats to be carried over the already defined database communication method.
- Ensure that the discovery mechanism, database access method, and query/response formats have appropriate security levels in place.

IETF PAWS submitted an informational document in August 2012 on "Use Cases and Requirements for Accessing a Radio White Space Database" to the IESG while a draft version of the proposed standard draft-ietf-paws-protocol-01 "Accessing a Radio White Space Database" was submitted in December 2012. A time for publication of the finalised standard "Accessing a Radio White Space Database" is due in April 2013 [9].

2.3.2 Japanese Activities on Cognitive Radios Systems

Japan has over the years played an active part in research and development of cognitive radios. Research effort in Japan through the National institute of Information and communication technology (NICT) has contributed notably to many IEEE standards dealing CRS. NICT have contributed enormously to the activities of IEEE LAN/MAN by submitting many contribution papers to 802.11af, 802.15.4g, 802.19.1, 802.22, 1900.4a, 1900.6 and 1900.7 to foster standardisation in these areas [12]. In Yokosuka Research Park (YRP), Japan, NICT Research Centre, as a national research organization, has deployed several kinds of test beds in carrying out field tests, evaluations and demonstrations of cognitive radio technology. Several field experiments have been carried out using these test-beds from the early stages of CRS research and developments.

In April 2010, NICT started wide-area field trials of the developed cognitive routers in Fujisawa city, Kanagawa, Japan. The cognitive routers used in trials have incorporated the standard from IEEE1900.4, with the server which control network and terminal resource managements located at the NICT YRP. The main missions were to verify the technical function of the cognitive radio routers and to establish the operation method of cognitive radio systems. In order to simulate the real operation environments, NICT distributed 500 cognitive routers in Fujisawa city area and opened the internet access environments to any user needing internet access via the cognitive routers. These trials gave the opportunity to collect real life, real time traffic and control data which were analysed in order to collect useful data to improve the cognitive radio systems. The trials are expected to contribute to draft new regulations and standards based on real life data and to bring new business opportunities to the wireless communications industry.

Another effort towards CRS development in the area of public safety came to light after the tsunami waves hit Japan in March 2011. This had an enormously destructive impact on lives and infrastructures with communication becoming almost impossible. During such times devices with cognitive functionalities would play a key role in supporting the communication infrastructure towards disaster relief efforts and access to the internet. In an effort to improve communication in the tsunami affected areas, NICT deployed cognitive routers to evacuation places, which were seriously damaged by the disaster. The cognitive routers set by NICT greatly improved communication environments giving many refugees access to the internet while also supporting disaster relief efforts.

3 Coordinated effort towards standardization in the TV White Spaces

3.1 The overall concept of TV White Spaces

Television White Spaces (TVWS) are (mostly) regionally (sometimes temporarily) unused portions of spectrum in TV bands, i.e., guard bands between broadcasting channels (interleaved spectrum) as well as wireless channels that are released following an analogue TV switch-off and adoption of full digital broadcast service (cleared spectrum from digital switchover) [17][1]. The concept of unlicensed use of TVWS emerged with the proliferation of modern CR schemes that provide all the necessary tools for the efficient and accurate identification of the unused TV spectrum bands and the appropriate adaptation of the unlicensed mobile users' operational parameters in order to enhance the utilization of the available spectrum without causing any harmful interference to the incumbents, i.e., the TV broadcasting services.

TVWS were among the first spectrum bands to be considered for opportunistic unlicensed use. The main reason for this are the considerably favourable propagation characteristics of common TV spectrum bands, i.e, Very High Frequency (VHF) and Ultra High Frequency (UHF) TV broadcasting bands, especially between 470−698 MHz in the USA and 470−790 MHz in Europe, compared to common terrestrial communication systems, such as Wireless Local Area Networks (WLANs), typically operating in the 2.4 and 5 GHz bands, or Long Term Evolution (LTE) networks. Therefore, the following characteristics make the use of TVWS for unlicensed access more appealing [14]:

i. *Larger cell sizes:*
This is a result of the fact that common TV broadcasting frequencies are characterized by longer transmission ranges, compared to the cases of other typical terrestrial systems that operate in significantly higher frequencies. Thus, the coverage of large geographical areas is achieved with a reduced number of required Base Stations, resulting in significant reduction in capital and operational expenditure (CAPEX and OPEX) for network deployment and maintenance, respectively.

ii. *Increased spectral efficiency through favourable propagation characteristics:*
This is a result of the considerably reduced propagation and in-building penetration losses as well as the improved link budget due to lower in-band thermal noise of TVWS bands [15].

iii. *Increased spectral efficiency through extended macro diversity:*
Joint operation of neighbouring Base Stations can be considered in order to achieve a higher Macro-Diversity gain in the uplink, (multiple Base Stations are jointly decoding the received signals) or in the downlink direction (multiple Base Stations are contributing to jointly optimized transmission) [16].

However, the main challenge that TVWS systems have to address is the guaranteeing of the primary/incumbent users protection. In the US, FCC considers a geo-location capability of the white spaces devices combined with database access to identify vacant TV channels at specific locations as the primary method of preventing interference to TV and other services [18]. In the UK, OFCOM also adopts a similar approach on database-assisted access to white spaces [19]. In Europe, CEPT WG SE43 currently finalized a report that suggests an implementation combining a data-base oriented approach with collaborative sensing of cognitive radio devices, referred to as White Space Devices (WSDs) [20].

3.2 Overview of QoSMOS standardisation impact and future plan

ETSI RRS
The main focus of the QoSMOS contributions towards ETSI RRS has been related to the work items related to TV whitespace Frequency bands.

[1] Note: in most cases the white spaces that had been the result of the digital switchover have now been auctioned off for use by other services.

Some QoSMOS partners initiated the Work Item (WI). “Uses Cases for operation in whitespace Frequency bands “ during the RRS#9 meeting in Madrid in February 2010. It got support from two other ETSI members and was approved during the RRS#9 meeting.

The scope of this work item was to provide the Technical Report TR 102 907 describing on how radio networks can operate, on a secondary basis, in frequency bands assigned/licensed to one (or several) primary users(s). In particular, the work item covers the following topics:

- Operation of Cognitive Radio Systems in UHF whitespace Frequency bands
- Methods for protecting the primary/incumbent users
- System Requirements and Use Cases (including but not limited to the situation in Europe)

QoSMOS partners contributed to the use cases, mainly on mid-/long range wireless access as well as on short range wireless access. The technical report was approved by WG1 in the teleconference, June 2011. It was also approved during the ETSI RRS#15 plenary meeting in September 2011 and finally describes the following use cases:

- Mid-/long range wireless access over whitespace frequency bands
- Short range wireless access over whitespace frequency bands
- Ad-hoc networking over whitespace frequency bands
- Combined Ad-hoc networking and wireless access over whitespace frequency bands
- Sporadic use of TV whitespace frequency bands
- Backhaul link using TV whitespace frequency bands
- Multimedia Broadcast Multicast Service (MBMS) operating in TV whitespace frequency bands

QoSMOS partners have also shown interested by the WI proposal on the Feasibility study on Radio Frequency (RF) performances for secondary systems operating in UHF TV band whitespaces. The scope of the WI proposal is the RF performance analysis for systems operating in the TVWS. The three main aspects of this WI are to study:

- Advanced sensing techniques for incumbent protection (for instance multi-node sensing solutions have not been considered yet by CEPT).
- Sensing techniques that could be specific to the technology used in an area outside of Europe. ETSI addresses a global standard, thus it is relevant to investigate solutions for Asia, China and America, which have different incumbent wireless technology.
- RF Solutions for coexistence between secondary systems.

Some QoSMOS partners have considered advanced sensing techniques taking advantage of cooperation between several sensing nodes. These studies put QoSMOS partners in a position to contribute to this RRS Work item, disseminating the most promising cooperative sensing for incumbent protection. Several contributions have been discussed since the creation of the work item, such as combined sensing and geo-location, coexistence, spectrum broking, WSD parameters. The committee also discussed on whether TC RRS is allowed to work on coexistence studies concerning CRS to incumbent interference since it is the CEPT responsibility to study that. Anyway, these issues were not intended to be covered according TR scope. A QoSMOS partner contributed to this technical report describing Interference Monitoring as an advanced incumbent protection technique. This technique can be categorized in the combination of the spectrum sensing and geo-location database, but the purpose of the Interference Monitoring is different from that of ordinary spectrum sensing. The spectrum sensing is basically for detecting incumbent signals to determine if incumbent transmitters are operating around the opportunistic transmitter. On the other hand, the Interference Monitoring determines how much interference is actually caused to incumbent receiver. For this purpose, the interference signals are measured at spectrum sensors located near the incumbent receiver and are effectively used for the estimation of CIR at the incumbent receiver.

The Work Item on “System Requirements for Operation in whitespace Frequency Bands” (TS 102 946) is one of the major technical specifications relevant for the QoSMOS project. The scope of this technical specification is to define the system requirements for operation of secondary Reconfigurable Radio Systems within UHF TV band whitespaces. The requirements are based on the use cases

described in TR 102 907 "Use cases for Operation in whitespace Frequency Bands". A draft is available with requirements related to coexistence, carrier aggregation, radio access, spectrum management and advanced geo-location. The document has been also pointed as draft deliverable to CEPT SE43 for information by RRS, as information of the progress was requested by SE43. Currently, advanced geo-location requirements are foreseen as a way to facilitate the management of Terrestrial Broadcasting Service protection and coexistence function requirements are foreseen to facilitate the coexistence among TV whitespace CRSs in UHF TV band whitespaces. A QoSMOS partner contributed to TS 102.946 with the clarification of the terminologies to be used in the specification. Due to the rapporteur position of the QoSMOS partner NEC Technologies, there have been several submissions to this TS but only a few technical submissions. QoSMOS is expected to contribute to this TS based on the requirements defined in the technical WPs. QoSMOS partners focused on the definition of additional requirements for a geo-location database in TS 102 946. QoSMOS partners proposed to add requirements so that the advanced geo-location function shall support interference estimation and relevant information exchange to control spectrum sensors. These are fundamental functions to support spectrum management integrated with radiowave monitoring defined in the WP6 technical Work Package. As a result of discussion, this contribution was agreed as optional requirements. Furthermore, in order to improve spectrum efficiency in whitespace, QoSMOS partners defined additional requirements for advanced geo-location functions which will have to accurately know parameters of active WSDs. This knowledge enables the current level of interference from the active WSDs to be calculated, and accordingly enables a maximum power level for a new WSD to be calculated. In addition, operating transmit power levels of the active WSDs have to be controlled to accommodate the new WSD when the current interference level is approaching a limit.

One QoSMOS partner has also contributed to ETSI RRS WG4 TR 102 970 on "Use Cases for spectrum and network usage among Public Safety, Commercial or Military". The contribution is on spectrum micro-trading as a use case for spectrum sharing. Spectrum trading is an important tool that enables spectrum sharing, increases overall spectrum utilization and opens up opportunities for organizations such as telecom operators and public safety to get access to desired spectrum. A model for spectrum micro-trading referred to as the "Micro-Trading Pixelation Model" is described, which addresses three dimensions on the micro scale; spatial, temporal and frequency. The contribution is a result from technical work on spectrum micro-trading in WP1 Task 1.3 on Spectrum Micro-trading. A paragraph describing QoSMOS together with a relation to this contribution has also been included in TR 102 970 in a section on relevant projects.

As a next step, after having progressed with the work on use cases and requirements definition, ETSI RRS plans to create new work items on the definition of the architecture and protocols for Cognitive radio systems operating in TV WS band and associated Cognitive Management and Control mechanism definition.

IETF PAWS

The IETF Working Group 'Protocol for Accessing TV WhiteSpace) has a mandate to produce two documents that will specify the protocol that operates between a TVWS system and a database. The first document contains use-cases and requirements and was originally due for ratification in April 2012 but is running late. Version 4 of the draft was made available in May 2012 and is in a fairly mature state. QoSMOS contributed to this document, ensuring that the six use-cases that were found most relevant as part of WP1 activities were included.

The second document is the standard itself, which was originally due for publication in December 2012 but is likely to be delayed until mid-2013 since work will start on this in a serious manner only when the requirements document is ratified.

Another significant contribution from QoSMOS was to the scope of the PAWS charter. Originally, the group had no intention of including any mechanisms for fairness, but they were persuaded to include the provision of a feedback path from the TVWS base-station to the database. This informs the database which channels the base-station is using, plus optional information such as power and antenna patterns adopted. This breakthrough required some intensive lobbying and, in the end, Ofcom in the UK backed the proposal, not from a motivation to enable fairness, but from the motivation to be able to calculate aggregate interference. This change in the charter is still being debated in the PAWS group, with some members opposing it, on the basis that in the US this is not included. The members opposing it are US Companies who have business models that would suffer by having the database able to take advantage of feedback. It is not known how this will resolve, but if the PAWS group do not

adopt feedback in their scope, it reduces the ability of QoSMOS to contribute and we will reduce effort accordingly.

IEEE DYSPAN P1900.6 and 6a
In its deliverable D3.4, QoSMOS identified protocol stack messages based upon IEEE Std 1900.6-2011 and we extended them by additional fields identified by QoSMOS' requirements, especially in respect to quality of service parameters. To cope with the main requirements for LTE and 802.11 we were able to introduce a minimum set of additional messages as most of the messages were already incorporated in P1900.6. As an outcome we are planning to contribute the following two messages to the new standard's version P1900.6a:

- target probability of a false alarm (PFA),
- delivery latency of the sensing results.

IEEE DYSPAN P1900.7
QoSMOS has contributed to the SCC41 Ad hoc group on White Space Communication. This pre-working group gathered substantial contributions that lasted almost 18 months before the PAR was established. Thus, the QoSMOS partners contributed to the definition of the PAR and thus have ensured that relevant results and project outcomes from QoSMOS can be brought into the development of the standard. It is expected that P1900.7 will be a relevant body to push WP4 activities related to physical layer design for whitespaces. Since it has started, the WG mainly worked on the definition of relevant scenarios and specifications. WP1 and WP2 activities were therefore also relevant during these steps. So far the contributions have been as follows:

There have been 7 presentations from QoSMOS:

- "Regulatory and propagation conditions in the TVWS" (based on WP2 inputs), Vincent Berg, Dominique Noguet (CEA), Sept.2009.
- "Potential Use Cases For TVWS" (based on WP1 inputs), Richard MacKenzie, Michael Fitch (BT), Sept. 2009.
- "ACLR issues with OFDM for TVWS operation" (based on WP4 inputs), Vincent Berg, Dominique Noguet (CEA), Dec. 2011.
- "Merged Use Cases" (based on WP1 inputs), Junyi Wang, Hoang Vinh-Dien, Hiroshi Harada (NICT), Richard MacKenzie (BT), Feb 2012, March 2012.
- "Preliminary scenario and requirement analysis", Dominique Noguet, Vincent Berg (CEA), March 2012. "Low ACLR and flexibility with FBMC" Dominique Noguet, Vincent Berg (CEA), March 2012, June 2012.
- "FBMC spectrum efficiency" Dominique Noguet, Vincent Berg (CEA), March 2012, June 2012.
- "Consolidated Use Cases" (based on WP1 inputs), Hoang Vinh-Dien, Xin Zhang, Zhou Ming-Tuo, Hiroshi Harada (NICT), Richard MacKenzie (BT), Pawel Kryszkiewicz, Adrian Kliks, Hanna Bogucka (PUT), Oliver Holland (KCL), Faouzi Bader (CTTC), April 2012, June 2012."FBMC vs OFDM in fragmented spectrum" Dominique Noguet, Vincent Berg (CEA), June 2012.

3.3 Overview of SACRA standardisation impact and future plan

ETSI RRS considers the introduction of Cognitive Radio Systems (CRS) as a whole based on a top-down approach. ETSI RRS achieved major progress in the areas of TVWS usage, in particular with a focus on the adaptation of existing and/or evolving Radio Standards, such as 3GPP Long Term Evolution (3GPP LTE), to a possible operation in UHF White Space bands.

For the time being, ETSI RRS worked on several work items which are of interest for SACRA and in which SACRA consortium contributed:

- WI "Operation in White Space Frequency Bands", producing TR102.907. The scope of the present document is to describe Use Cases for the operation of Reconfigurable Radio Systems within White Spaces in the UHF 470-790 MHz frequency band and gives an

overview on methods for protecting the primary/incumbent users like TV broadcasts and wireless microphones.

SACRA partners already contributed to this technical specification. Various use cases have been included in the TR 102 907 "Operation in White Space Frequency Bands" classified in distance (e.g., short range, middle range and long range) and in applications (e.g., ad-hoc). As foreseen for SACRA system, carrier aggregation, known as the main feature of 4G systems which is being standardized in 3GPP as part of Release 10, could be extended to include the aggregation of the opportunistic UHF TVWS band to provide maximum flexibility in utilizing the scarce radio spectrum.

This report is finalized and approved by WG1 in the teleconference, June 22 2011. It is also approved during the ETSI RRS#15 plenary meeting in September 2011.

- WI proposal on Feasibility study on Radio Frequency (RF) performances for secondary systems operating in UHF TV band White Spaces. The scope of WI proposal is the RF performance analysis for systems operating in TVWS. The three main aspects of this WI are to study:
    - Advanced sensing techniques for incumbent protection (for instance multi-node sensing solutions have not been considered yet by CEPT).
    - Sensing techniques that could be specific to the technology used in an area outside of Europe. ETSI addresses a global standard, thus it is relevant to investigate solutions for Asia, China and America which have different incumbent wireless technology.
    - RF Solutions for coexistence between secondary systems.

- WI on TS 102 946 "System Requirements for Operation in White Space Frequency Bands"

  The scope of this technical specification is to define the system requirements for operation of secondary Reconfigurable Radio Systems within UHF TV band white spaces. The requirements are based from the use cases described in Technical Report 102 907 "Use cases for Operation in White Space Frequency Bands". SACRA partners contributed to the definition of functional requirements for carrier aggregation in TVWS which fall into the Spectrum Management Requirements section of TS 102 946. In addition, requirements for LTE operation in TVWS are presented for the Radio Access Requirements Section.

As a next step, after having progressed with the work on use cases and requirements definition, ETSI RRS plans to create new work items on the definition of the architecture and protocols for Cognitive radio systems operating in TVWS band and associated Cognitive Management and Control mechanism definition.

3.4 Overview of COGEU standardisation impact and future plan

COGEU project has followed and participated in ETSI RRS standardization activities. The following content from COGEU have been presented to ETSI RRS WG1/WG3:

The novel geo-location database concept developed by COGEU has been introduced to ETSI RRS. The COGEU geo-location database allows separation of bands for sharing, i.e. commons usage, and for secondary trading. The commons bands are shared; thus there is no guarantee of the quality of service. The traded bands are exclusively used; hence there is guarantee of the quality of service.

COGEU has introduced the concept of Broker based secondary spectrum trading to ETSI RRS. The COGEU Broker model for usage of TV white spaces with temporary exclusive rights as well as related message flow chart with respective information flow description for the proposed broker model has been included in the ETSI RRS TR 102 907 document. In the main part of this technical report, the assumption is on a regulatory environment where the TV White Spaces can be used for free (spectrum commons). This assumption is based on currently existing regulation e.g. by FCC as well as based on CEPT SE43 studies. COGEU introduced an alternative to the free usage of TV white spaces which is based on the concept of allowing secondary spectrum trading (paid with some sort of exclusivity).

In the TVWS concept introduced by COGEU, access to the white space frequency bands is acquired as temporary exclusive rights where the white space frequency bands are managed by an intermediary (for example a "broker") that issues these temporary exclusive rights to access the white spaces. The broker operates to ensure the availability in order to support the QoS of systems. Figure

3-1 shows the high level concept diagram for using temporary exclusive access rights for TV white space frequency bands.

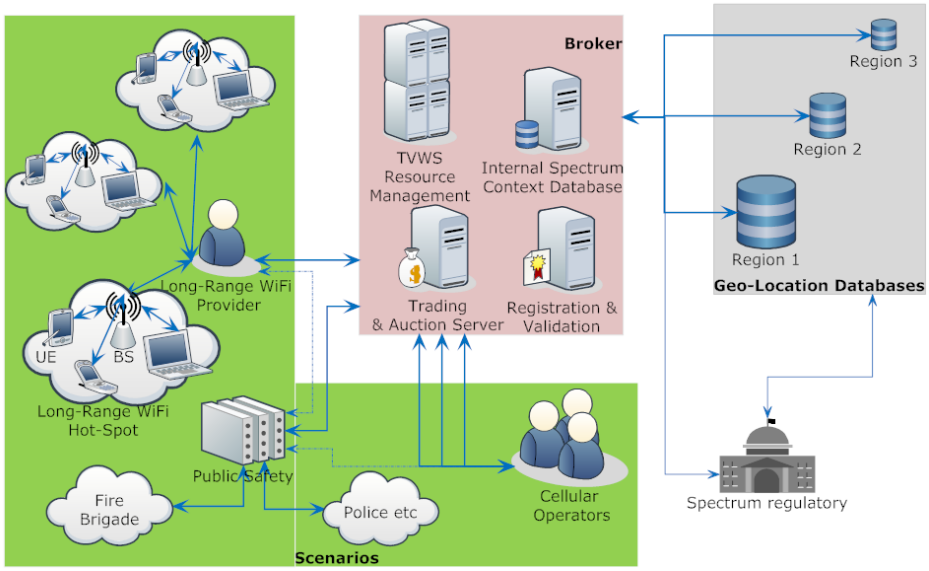


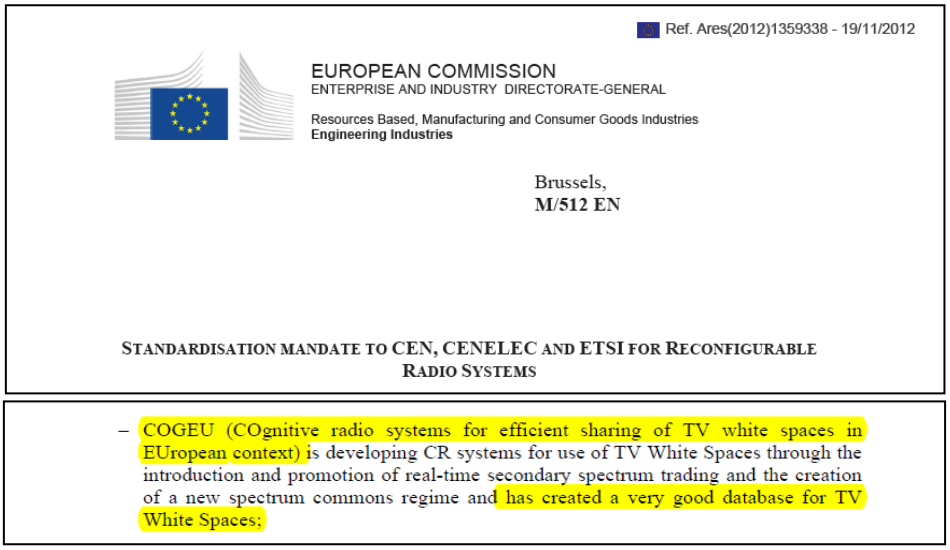
Figure 3-1 High level depiction of scenarios for temporary exclusive rights usage of the WS frequency bands.

In the ETSI RRS WG1 technical meeting, COGEU is engaged in the development of the "Use Cases for Dynamic Declaration of Conformity" work item (TR 102 967) where COGEU is leveraging its accumulated work in the TV white spaces to contribute on approaches for the dynamic declaration of conformity for cognitive radio devices.

Standardization body\event	**Date**	**Venue**	**Contribution**
ETSI RRS #13 meeting	9-10 Feb. 2011	Paris, France	Contribution to ETSI RRS WG1 document RRSWG1(11)0053 – Discussion on Usage of TVWS with Temporary Exclusive Rights that was included in TR 102 907 – Reconfigurable Radio Systems (RRS); Use cases for Operation in White Space Frequency Bands.
ETSI RRS #15 meeting	8-9 Sep. 2011	Sophia Antipolis, France	Contribution to the WG1 technical meeting, on the "Use Cases for Dynamic Declaration of Conformity" work item (TR 102 967) with contribution number RRSWG1(11)0143 entitled: "Use Case for Multi-Stage Digital and Dynamic Declaration of Conformity"
ETSI RRS #16 meeting	24-25 Nov. 2011	Ispra, Italy	Contributions were made in the context of the ETSI TR 102 967 "Use Cases for Dynamic Declaration of Conformity". The use case is related with COGEU project Task 4.4.
ETSI RRS #17 meeting	27th of Feb.– 2nd of March, 2012	Paris, France	During the ETSI RRS WG1 Meeting, COGEU main contribution was in TR 102 967 "Use Cases for Dynamic Declaration of Conformity". The TR is a joint work between IT representing COGEU, RIM (COGEU project EAB Member) and Intel (ETSI RRS Chair). The TR focuses on adapting the certification procedure to the anticipated changes in the R&TTE directive regarding reconfigurable radio devices.

3.4.1 COGEU and the EC standardisation mandate for reconfigurable radio systems

In November 2012, the EC issued a standardisation Mandate to CEN-CENELEC-ETSI on Reconfigurable Radio Systems (M/512) [3], which, among other tasks, requests the development of European SDR architecture (and related interfaces with spectrum geo-location databases) for the civil and security markets. In Section 1.3 of the mandate (R&D Environment) there is a reference on the COGEU geo-location database. COGEU is committed to contribute to ETSI RRS in the response to this mandate. In particular COGEU is interested in contribute to a Protocol to Access White Space Databases that fits EU requirements, in addition other issues such as security, enforcement, management of cross-border issues, interconnection of national data bases and database discovery are also of COGEU interest.



Ref. Ares(2012)1359338 - 19/11/2012

EUROPEAN COMMISSION
ENTERPRISE AND INDUSTRY DIRECTORATE-GENERAL

Resources Based, Manufacturing and Consumer Goods Industries
Engineering Industries

Brussels,
M/512 EN

STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI FOR RECONFIGURABLE RADIO SYSTEMS

– COGEU (COgnitive radio systems for efficient sharing of TV white spaces in EUropean context) is developing CR systems for use of TV White Spaces through the introduction and promotion of real-time secondary spectrum trading and the creation of a new spectrum commons regime and has created a very good database for TV White Spaces;

Figure 3-2 Excerpt from the EC Mandate to CEN-CENELEC-ETSI on Reconfigurable Radio Systems.

3.4.2 COGEU and IETF PAWS – Protocol to Access White Space Database

The Internet Engineering Task Force (IETF) is currently working on the definition of a protocol to access white spaces databases – PAWS (“Protocol for Communication between White Space Device and White Space Database”). Ofcom UK has also published a draft document on the definition of a similar protocol, including a detailed list of parameters to be exchanged between WSDs and a database. Ofcom solution is a protocol tailored for the UK scenario, with different requirements than the IETF proposal that is more comprehensive and less specific on details. Therefore, the IETF draft protocol and data model was chosen and considered flexible enough to be adapted for the COGEU project and its requirements.

A signalling protocol “PAWS” modified for COGEU requirements was developed using a web-based environment. Several programming languages, from MySQL, PHP and JavaScript, were used to develop this implementation of COGEU-PAWS. Three services are defined and implemented on the interface between the geo-location database and WSDs: Registration, Channel List Request and ID Verification.

- Registration : A fixed WSD must register with the geo-location database prior to operating for the first time, or after changing location, or if any of the registration data changes. Only fixed WSDs register with the geo-location database.
- Channel List Request : The geo-location database will provide, upon request, the available TV channels at the WSD's location, the channel list is also combined with information of the TV channels that needs sensing, the power available for each channel and the time to refresh all the information (Figure 3-3).
- ID Verification : The “ID Verification Request” provides a method for WSDs to verify the validity of Slave WSDs that are dependent upon a master WSD for channel lists.

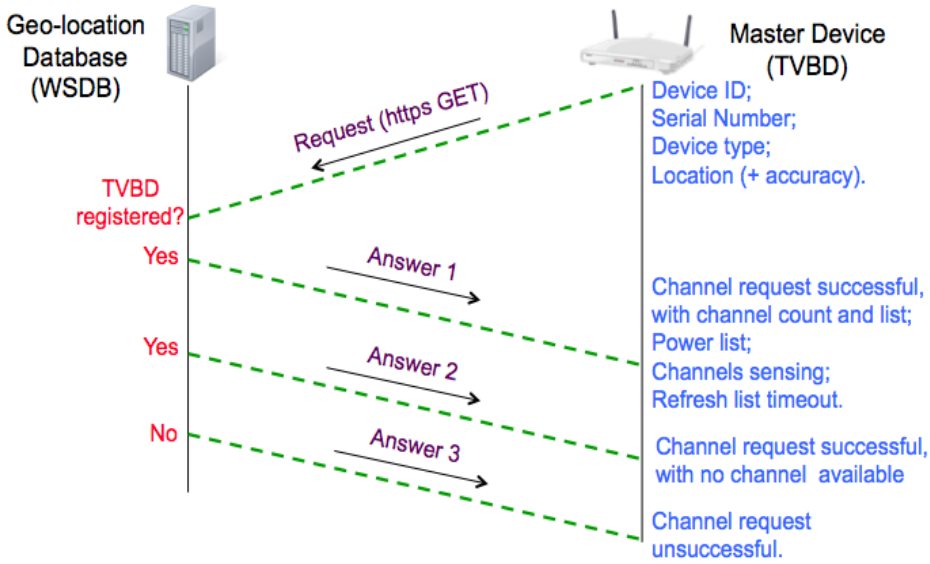


Figure 3-3 Message exchange for a channel list request from the WSD to the geo-location database. All possible answers are represented, but only one is sent at each request.

To give a glimpse of the protocol implementation to the interested user, with the possibility to test the protocol implementation, a web-based Graphical User Interface (GUI) was developed and is public available. All messages presented are XML code that contains all relevant parameters defined from the protocol and data model requirements. In order to disseminate COGEU-PAWS implementation the source code is online available in the COGEU geolocation database web site. This work is a good basis for COGEU contributions within ETSI RRS on the Protocol to Access a White Spaces Database.

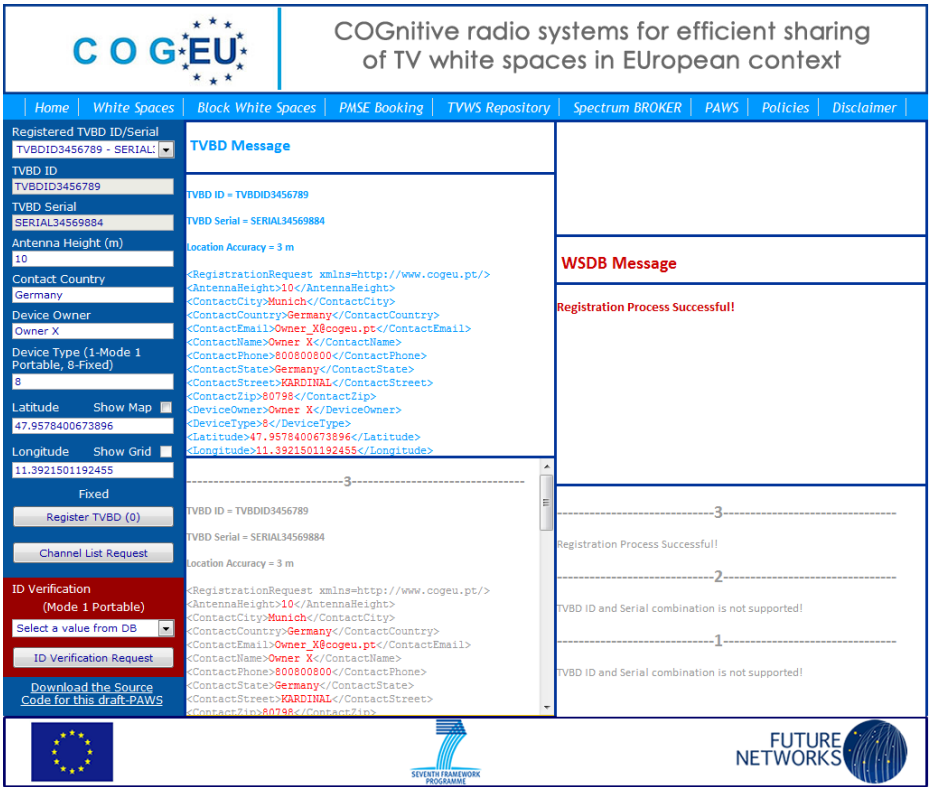


Figure 3-4 Graphical web interface to demonstrate COGEU PAWS between a geo-location database and a WSD (fixed or Mode 1 Portable)

3.5 Plan for coordinated contribution towards TVWS standardization

ETSI RRS
As a next step, after having progressed with the work on use cases and requirements definition, ETSI RRS plans to create new work items on the definition of the architecture and protocols for Cognitive radio systems operating in TVWS band. Since the requirements from ETSI TS 102 946: "System requirements for Operation in UHF TV Band White Spaces." are quite mature, ETSI RRS is currently discussing the way forward and the approval of new work items.

Potential work item will deal with the definition of the system architecture for the use of spectrum by White Space Devices (WSDs), specifically in the UHF TV Bands. The scope of the work will be to define the architecture of a system which can allow operation of WSDs based on information obtained from Geo-location databases. The architecture will consider both uncoordinated use of White Space (where there is no attempt to manage the usage of channels by different WSDs) as well as coordinated use of White Space (where some form of channel management and/or coexistence techniques are employed to efficiently use the White Space).

ETSI RRS is also discussing a second work item defining the system architecture for the information exchange between different Geo-location Databases (GLDBs) enabling the operation of White Space Devices (WSDs). The architecture stems from the system requirements described in the section 7.1 (Terrestrial Broadcasting Service Protection Requirements) of ETSI TS 102 946 "System requirements for operation in UHF TV Band White Spaces".

The architecture work will serve as an input for defining the Harmonized Standards and European Standards that are part of the EC mandate for Reconfigurable Radio Systems (M/512).

It is good example of where CRS-i partners could contribute to continue the standardization effort started in QoSMOS, SACRA and COGEU projects.

IEEE DYSPAN P1900.6 and 6a
The P1900.6a draft has been sent to SCC DYSPAN for readiness approval before going for the sponsor ballot. Hence, the draft can be considered as fairly mature and CRS-i plans to track the evolution of the ballot and bring some contribution to help answer the comment. Therefore no substantial work is planned except from monitoring that the standard will be accepted.

IEEE DYSPAN P1900.7
In October 2012, the WG opened a call for technical contributions on PHY and MAC layers. Together with this open call a timeline for contribution was proposed. It is clear that also QoSMOS had some substantial contribution and involvement in the creation of the working group and the definition of the PAR, the technical contributions to the WG was impossible during the course of the project. As mentioned in section 3.2, QoSMOS initiated some actions to steer the activities of the WG, namely through the preparation of the WG requirement document and some preliminary documents.

This is clearly a good example where CRS-i can and will help go forward with these actions. Technical contributions are expected throughout 2013 and 2014, which fits very well WP3 timeframe. Besides, CRS-i has already contacted the FP7 Call 8 project 5GNOW, which plans contribution to P1900.7 too. A concrete result of this collaboration and the actions towards the extension of QoSMOS roadmap were the two contributions presented at the P1900.7 phone conference on Feb. 20th 2013:

- "PHY layer based on FBMC", N. Cassiau*, J-B. Doré*, D. Noguet**
- "White Space Dynamic Spectrum Access Radio Systems", B. Mawlawi**, J-B. Doré*, D. Noguet**

  * 5GNOW ; ** CRS-i

Future plan is to continue to participate in the WG activities through meeting participation and contribution submissions in the field of PHY and MAC for TVWS.

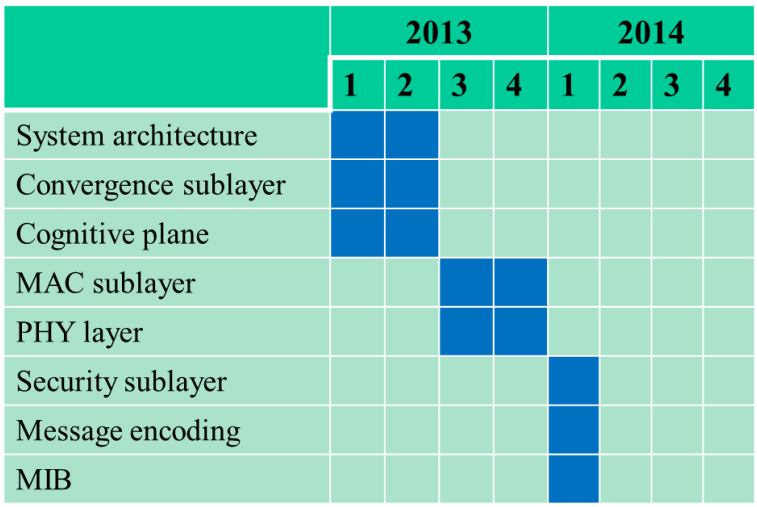


Figure 3-5: IEEE P1900.7 contribution timeline.

4 Coordinated effort towards standardization of opportunistic device-to-device communications

4.1 The overall concept of opportunistic D2D

Proximity-based applications and services represent a recent and enormous socio-technological trend. These Proximity-based applications rely on two principles: the discovery of proximity-based User Equipments (UEs) that are within proximity of each other and the direct communication between UEs to exchange application-related data. 3GPP technology has the opportunity to become the platform of choice to enable proximity-based discovery and communication between devices, and promote a vast array of future and more advanced proximity-based applications. There are also others indirect benefits for 3GPP network as increasing the spectral efficiency, reducing power consumption and extending the cellular coverage.

The device to device (D2D) communications concept is based on the fact that when two UEs are communicating together, the user data are classically exchanged through the network infrastructure. With the addition of device to device communication, the two UEs establish a direct radio communication path. The typical data path for this type of communication is shown in Figure 4-1: Default data path setup and Direct mode for communication between two UEs., where eNB(s) are involved.

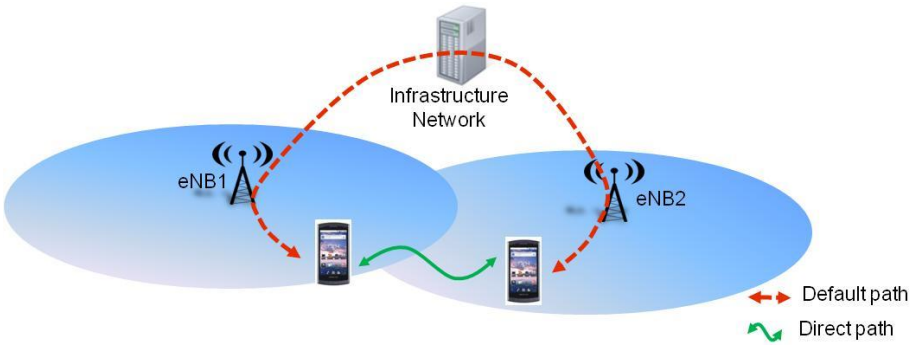


Figure 4-1: Default data path setup and Direct mode for communication between two UEs.

Cellular networks continue announcing growth of data traffic, indirectly requiring more spectrum. Introducing D2D communications will add new usages and demands for traffic and spectrum. Device to Device applications require reliable and efficient ubiquitous connectivity and greatly contribute to the increase of data traffic, thus posing a renewed need for efficient spectrum use. Furthermore, it is foreseen that Device-to-Devices communications will be enable with devices belonging to different operators which raise again the issue of spectrum to be used for this new type of communications. Therefore, dynamic spectrum sharing is seen as a key enabler for D2D communications and it will ensure the economy of scale of the D2D applications.

4.2 Overview of OneFIT standardization impact

FP7 OneFIT project joined the initiative (Study Item) in 3GPP dedicated to the “proximity-based services” on the basis of device-to-device communications as an enabler of the concept of Opportunistic Networks. Consortium members provided Contributions related to device-to-device communication towards TR 22.803 “Feasibility Study for Proximity Services (ProSe)”. OneFIT project contributed to the discussion for the definition of the Study Item, ensuring that the key options of OneFIT, that is the RAT-independency and the operator’s control, were included in the scope of the Work Item. OneFIT project proposed at the same time two options for enabling proximity services in a 3GPP operator networks. The first option is to enable direct communications between the 2 UEs over the licensed LTE spectrum under the control of the mobile operator. The second option is to enable direct communications between the 2 UEs over an alternative RAT than LTE. Such an alternative RAT may be deployed over unlicensed spectrum, one such example being WiFi and another such example is Bluetooth. OneFIT project also addressed different use cases for public safety and network offloading situations and defined service requirements related to these use cases. Public safety like police forces, firemen, ambulance drivers belong to the same group and need to communicate each

other within the group even in absence of network infrastructure or network infrastructure congestion. In order to address such case, a device shall make use of another device acting as a relay to address network coverage problems and in case of network congestion. The documents (table below) were directly accepted or "noted" as needing to be merged with other proposals in order to prepare a selection process in next SA1 meeting (February 2012).

Table 4-1: OneFIT Standardization Contributions towards 3GPP

Author	Contribution Title	Event Name	Loc.
NEC Technologies (UK)	Use cases for Proximity-based Services study	TSG-SA1 Meeting #56	San Francisco, CA (US), 2011
IMC	Enabling Proximity services in a LTE network under operator control	TSG-SA1 Meeting #56	San Francisco, CA (US), 2011
IMC	Enabling Proximity services with inter-RAT capabilities	TSG-SA1 Meeting #56	San Francisco, CA (US), 2011
IMC	Use Case: Proximity Services Enabled MTC scenarios	TSG-SA1 Meeting #56	San Francisco, CA (US), 2011
IMC	Range extension scenarios for Proximity services	TSG-SA1 Meeting #56	San Francisco, CA (US), 2011
NEC Technologies (UK)	use case and associated requirements for extending 3GPP network coverage by using a user terminal acting as a relay node. Contribution to the 3GPP SA1 #59 Meeting, for the work item ProSe (Proximity services)	TSG-SA1 Meeting	Chicago (US), 2012

4.3 Standardization opportunities for opportunistic D2D

Device to Device communications applied to LTE came firstly from the US with public safety applications. The National Public Safety Telecommunications Council (NPSTC) and other organizations recognized the desirability of having an interoperable national standard for a next generation public safety network with broadband capabilities. In June 2009 the NPSTC decided on LTE as their platform for this national network. The US has reserved spectrum in the 700MHz band for an LTE based public safety network and in early 2012 committed US$7billion in funding.

3GPP started work in Release 12 enhancing LTE to meet public safety application requirements for D2D communications. After their decision to adopt LTE the NPSTC started an active engagement with the LTE standards community in 3GPP to create the system improvements needed to meet public safety requirements. Throughout this work the NPSTC have expressed a strong desire, which has been welcomed by the commercial cellular community, to implement as many of the public safety requirements as possible in a way that is also attractive for consumer and business applications.

Cooperation has been established between 3GPP and other groups such as ETSI TC TETRA, TCCA and US National Institute of Standards and Technology (NIST) to ensure broad representation of the public safety community. 3GPP's objective is to preserve the considerable strengths of LTE while also adding features needed for public safety. A further goal is to maximise the technical commonality between commercial and public safety aspects to provide the best and most cost effective solution for both communities.

So far, two main areas of 3GPP LTE enhancement have been agreed in 3GPP to address public safety applications:

- Proximity services that identify mobiles in physical proximity and enable optimized communications between them.
- Group call system enablers that support the fundamental requirement for efficient and dynamic group communications operations such as one-to-many calling and dispatcher working.

Proximity services consist of two main elements: network assisted discovery of users with a desire to communicate who are in close physical proximity and the facilitation of direct communication between such users with, or without, supervision from the network (examples in Figure 4-2). Direct communication means a radio connection is established between the users’ mobiles without transiting via the network. This saves network resources and can also permit public safety communication in areas outside network coverage.

Proximity services meet the need for communication among public safety users even if they are not in coverage of the network. In the commercial area proximity services can support features like new modes of social networking, convenient file transfer between devices belonging to the same user and targeted advertising. In the commercial context 3GPP’s standards will ensure that use of licensed spectrum is controllable and billable by the network operator.

-Current LTE communication path;

-Direct communication with proximity service;

-Locally routed communication with proximity service;

Figure 4-2: Proximity Service Examples.

Since the end of 2011, 3GPP has studied use cases and identified potential requirements for an operator network controlled discovery and communications between devices in proximity. Four types of scenarios where identified:

- Commercial/social, network offloading and finally Public Safety.
- Device to device Communication scenarios for commercial use: The network operator offers a service allowing UEs to discover themselves and to communicate directly for realizing social networking type applications or gaming/video sharing.
- Network off-loading scenarios: in order to optimize mobile networks resources, the network operator control the use of a direct communication between UEs, allowing a decrease of the RAN and core network resources.
- Device to device communications scenarios for Public Safety.

Further to this, 3GPP decided that a full definition of the system architecture and protocols for this feature will be defined in the 2013-2014 timeframe. The future work is now to focus on the definition of the architecture solutions done by the SA2 group, enhancing 3GPP functions and network elements. SA2 group starts with a technical report defining the architectural requirements and solutions which will be documented in a normative specification later. Furthermore, RAN groups agreed to start normative work at the beginning of 2013 with a feasibility study. This first study will identify the physical layer options and enhancements to be incorporated in LTE, and evaluate options/solutions for enhancements to the LTE RAN protocols. For the purposes of addressing public safety requirements, the study will identify the additional enhancements and control mechanisms required to realize discovery and communication outside network coverage.

Work in 3GPP is structured using work items that define the objectives and roadmap for each technical area. The table below shows the currently approved Device-to-Device work items in 3GPP.

Work Item	3GPP Release	Work Item Document Reference
Proximity-based Services Specification-SA1 (ProSe)	12	SP-120883
Proximity-based Services- SA2	12	SP-120935
Study on LTE Device to Device Proximity Services	12	RP-122009

The final technical development and decision making will follow normal 3GPP processes based on member organization inputs brought directly to 3GPP meetings.

The approved ProSe work items are targeted for 3GPP Release 12 which is currently in development. 3GPP conducts its technical work in three stages which are described below together with the planned freezing dates for Release 12. Past experience with 3GPP standards is that commercial systems start to become available between 12 and 24 months after the freezing of the stage 3 standard.

Stage Number	Description	Planned Release 12 Freezing Date (as at January 2013)
1	Requirements	March 2013
2	Architecture and system design	December 2013
3	Protocol development and solution implementation	June 2014

4.4 Plan for coordinated contribution towards D2D standardization

This first 3GPP standardization phase for device to device communications will focus on simple use cases and basic performances without any dynamic spectrum allocation scheme. It is envisaged that this initial standardization phase (3GPP Release 12) need to solve the basic issues of D2D communications before going beyond more advanced spectrum sharing schemes as LSA and TVWS for the direct communication between UEs. OneFIT project was involved in the definition of the use cases and requirements for Device to Device communications. CRS-i clearly will continue the effort made by OneFIT project, initiating contributions for the definition of architecture and RAN solutions for the support of D2D communications. Technical contributions are expected throughout 2013 and 2014, which fits very well in CRS-i WP3 timeframe. Besides, CRS-i will have to coordinate with other projects from the RAS cluster, e.g., on public safety domain such as call 8 projects FP7 ABSOLUTE and FP7 EMPHATIC.

5 Coordinated effort towards standardization of Licensed Shared Access

5.1 The overall concept of LSA

5.1.1 Motivation of LSA

Mobile and wireless communications networks will have to cope with a tremendous increase of traffic volume within the next decade. Hence, more radio spectrum for mobile networks is needed to fulfil this capacity and coverage demand. In addition, Reconfigurable Radio Systems (including Cognitive Radio (CR) and Software Defined Radio (SDR)) enable new ways to share spectrum more efficiently by considering radio environmental awareness. Interference management functions allow multiple networks with different Radio Access Technologies (RATs) to benefit from the same spectrum resources and thus to increase spectrum utilization.

While the dedicated exclusive spectrum is still preferred by the Mobile Network Operator (MNOs), it is essential for the fast growth of Mobile Broadband (MBB) that new flexible spectrum management and dynamic schemes are introduced to enable access to additional spectrum and to meet future traffic demands. Within a mobile operator's network, RRS solutions will provide a greater flexibility for spectrum sharing among different RATs and thus enabling optimized utilization of available dedicated bands within existing networks.

New regulatory paradigms for spectrum authorisation will allow shared use of spectrum in a more flexible way for optimizing the utilization of this scarce resource. Novel access models such as Licensed Shared Access (LSA) are increasingly discussed in regulatory and standardization bodies as well as in policy making institutions. The LSA concept is a regulatory framework that preserves Quality of Service (QoS) - a requirement that will continue to play a vital role for many mobile applications. LSA will also secure the operators' investment.

Traditionally, the access and use of spectrum for radio communication services has been authorised in two ways: either licensed or licence-exempt:

- "Licensed" means that the usage rights are granted in time, frequency and geography; these usage rights are usually exclusive.
- "Licence-exempt" means that devices which meet certain technical conditions can share the spectrum, to be used anywhere and at any time, but without guarantee of predictable Quality of Service (QoS).

5.1.2 Concept and reference LSA architecture

LSA provides a framework to share spectrum between a limited number of users. The existing spectrum users ("the incumbents") share spectrum with one or several licensed LSA users ("LSA licensees") in accordance with a set of pre-defined conditions. These conditions may be static (e.g. specific exclusion zone or time allowed for operation) or dynamic (e.g. geographic/time sharing, on-demand authorisation by LSA licensees or on-demand restrictions imposed by incumbents). Dynamic implementation of LSA could take advantage of the recent advances in cognitive technology, allowing spectrum sharing on a frequency, location and time basis.

The LSA concept is primarily about granting "individual authorisations" of the use of a frequency band (which is already licensed) to other incumbent usages. These authorisations will be based on explicit sharing arrangements to ensure the protection of incumbents but also taking into account specific operational requirements.

Following a regulatory framework to be specified by CEPT WG FM52 and 53, the spectrum use will be possible for authorized secondary users:

- CEPT WG FM52: The new ECC Decision should aim at harmonising implementation measures in the frequency band 2300-2400 MHz including the least restrictive technical conditions (LRTC), taking into account the existing standardisation framework and activities at

the worldwide level, and an appropriate frequency arrangement as well as regulatory provisions based on LSA ensuring the long term incumbent use of the band in the territory of the administrations that wish maintain such use.

- CEPT WG FM53: proposes to WGFM to develop an ECC Report on “Licensed Shared Access Regulatory Framework”. The scope of work carried by FM53 focuses on the mobile broadband application case within the time frame proposed for this ECC Report.

Figure 5-1 gives the framework for an LSA architecture, based on an existing licensed (e.g. 3GPP) network. A data base outside the domain of the incumbent will contain the necessary rules and data to decide for each usage about the permission to use the network. Sensing of the available spectrum may give actual input to the database. A controller in the domain of the incumbent will then make the decision about acceptance of an LSA licensee on a case-by-case basis.

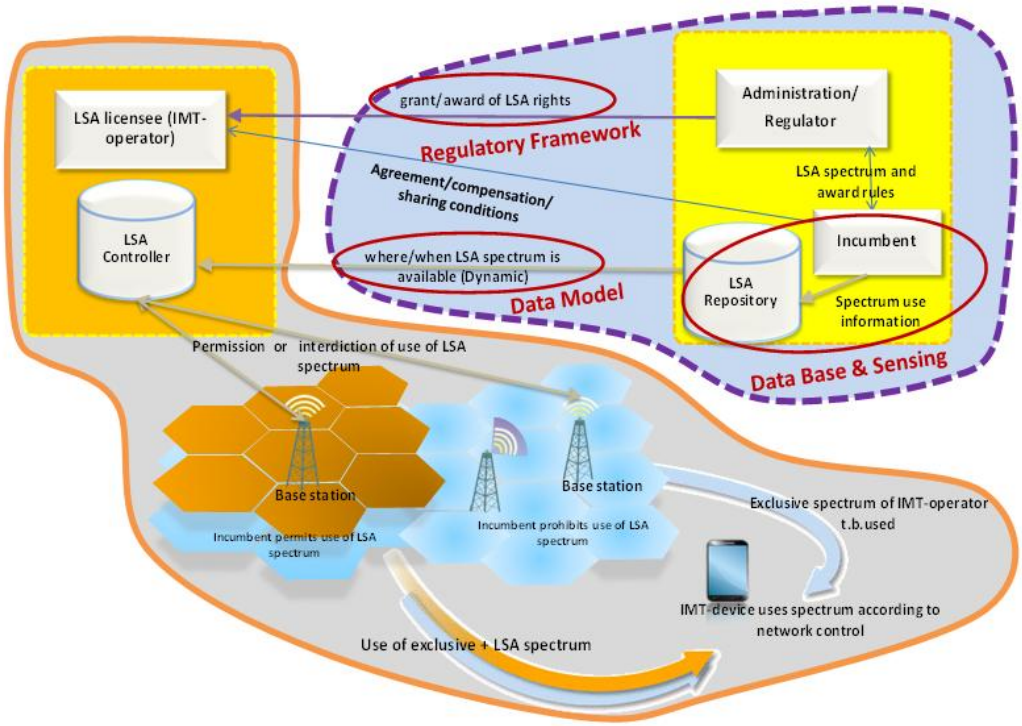


Figure 5-1: LSA regulation and standardization framework

Clear conditions are crucial to ensure proper spectrum usage by the incumbent and LSA licensee. LSA must ensure full certainty, without operational restrictions, for the incumbent. Especially, the LSA licensee must not cause harmful interference to the incumbent.

Current 3GPP mobile networks are based on exclusive spectrum owned by MNOs. Access to exclusive spectrum is fully controlled by the operator and thus availability of the spectrum is guaranteed. The new sharing opportunities will not change this basic setup. However, sharing of radio spectrum will enable new opportunities to achieve higher capacity.

LSA implementation can be a way for an incumbent MNO to make business out of its spectrum on a trading or leasing basis. For the LSA user it this concept will be interesting if availability of the spectrum is for a sufficiently large area and percentage of time is guaranteed.

5.1.3 LSA standardization efforts and future work

After more than 10 years of fundamental academic research, RRS principles are now increasingly discussed in regulation and standardization and will soon be adopted in the development of modern radio access systems as e.g. future releases of LTE.

A system needs to be established for updating, maintaining and providing the spectrum access conditions, in the case that incumbents impose restrictions on spectrum use and depending on the pre-defined conditions for spectrum access by LSA licensees (e.g. sharing in time/frequency/location

and/or static/dynamic sharing). For this purpose, the interfaces between the components of the LSA system as well as the mechanisms necessary for system operation must fulfil specific requirements. These requirements and appropriate solutions need to be standardized. A number of international standardization projects on RRS and CR are currently working on such standards with participants from MNOs, industry and academic partners, in order to develop and deploy innovative concepts and to drive the most economical and powerful technologies and solutions.

5.2 COGEU and the LSA model

COGEU has developed a framework for sharing the TVWS spectrum, which is very much in line with the emerging concept of Licensed Shared Access (LSA). This licensing paradigm envisages the kind of mixed-use licensed access to spectrum, which has primarily been used, heretofore, by an incumbent service.

The COGEU licenses issued by the Broker will be issued under circumstances that provide for certainty on the behalf of all participants. As this spectrum is being shared by incumbent services, i.e. the DVB-T and PMSE community, and new users, i.e. those that buy temporary spectrum rights from the broker, the license terms must account for this mixed use scenario. While the COGEU Broker model predates the formalization of the Licensed Shared Access (LSA) concept by the RSPG in COGEU model the Broker undertakes the role of a LSA authority.

Specifically, modifications to the standard license are required to address the nature of the delegation of licensing authority to the COGEU Broker, to address the concept of LSA and to allow for the use of electronic communication techniques between the Broker and the licensees.

The COGEU Broker takes on the role traditionally held by the National Regulatory Authority in this license as this authority that been delegated to it subject as the LSA and Spectrum. The Relevant Statutory Acts refers to any acts underpinning the COGEU Broker regime. These acts would include the Wireless Telegraphy Acts of a jurisdiction, acts enabling Spectrum Trading and acts enabling Licensed Shared Access.

LSA users would use the vacant TV spectrum under individual authorizations with temporally exclusive rights and for a specific local area. The LSA repository contains geo-location information about the incumbent users of TV spectrum: broadcast coverage data and PMSEs (Programme Making and Special Events) in use. The LSA Controller computes the TV White Space maps based on protection requirements and restrictions set by the incumbents.

The following table associates the LSA building blocks architecture presented in Figure 5-1 with the COGEU model.

Table 5-1: LSA building blocks association with COGEU architecture

LSA	COGEU secondary spectrum trading model
Incumbent: generic /not specified	Incumbent: Broadcasters and PMSE operating in UHF TV band.
LSA repository	Broadcast data (coverage information) managed by the regulator and related DVB protection requirements.
LSA controller	Algorithm to compute TVWS availability; Auction mechanism to trade temporally exclusive licenses.
OA&M	Radio Resource Management (e.g. management of extra TVWS carriers by a LTE operator to support downlink capacity)

A COGEU automatic spectrum-trading platform was designed for the Munich (Germany) area. In the demonstration scenario a Mobile Network Operator is looking for extra spectrum to increase LTE downlink capacity. For illustrative purpose, Figure 5-2 shows the TV White Space map for TV channel 60 (782-790 MHz,) computed with data provided by the German broadcasters. In order to protect digital TV reception, the max. transmit power is limited to 1 W EIRP (30 dBm). **Figure 5-2** (b) shows the coverage maps of three LTE eNodeB using TV UHF spectrum for downlink extra capacity in the Munich area: urban location in Neuperlach, suburban location in Freimann and rural location in Parsdorf.

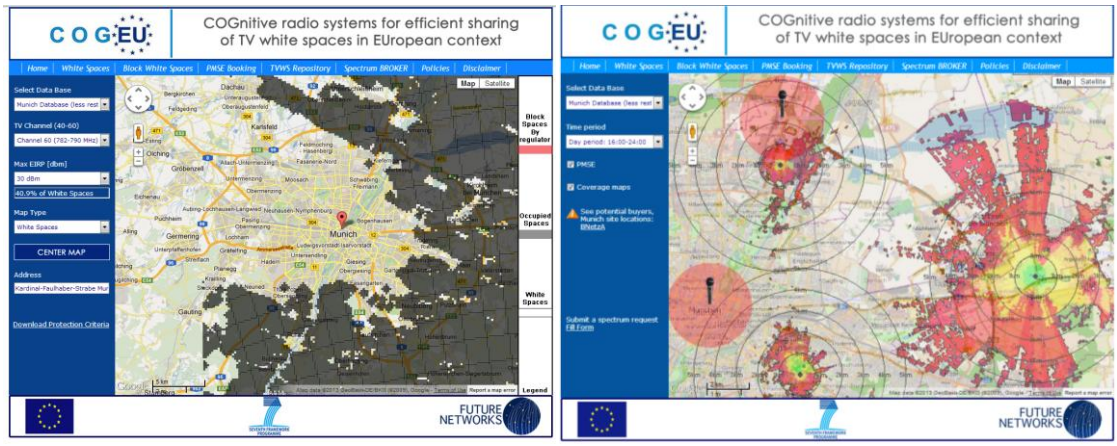


Figure 5-2: (a) TV White Space map for channel 60 and 30 dBm EIRP. (b) LSA repository: coverage of LTE base stations over TVWS and PMSEs in the Munich area.

5.3 Standardization opportunities for LSA in ETSI

ETSI Technical Committee Reconfigurable Radio Systems (RRS) is developing a System Reference Document for mobile broadband services in the 2300 MHz – 2400 MHz band under LSA regime with the objective to outline:

- expected usage scenarios;
- technical characteristics and parameters necessary to describe the spectrum needs and performance requirements for the deployment of mobile broadband services under LSA regime while meeting the constraints of mutual coexistence between mobile broadband services and incumbent users based on already existing/further CEPT spectrum sharing and compatibility studies,
- high level functions required to manage/comply with the requirements for the deployment of mobile broadband services under LSA regime.

The aim of the SRdoc is to provide CEPT FM PT52 with technical information on the LSA system which are required to develop an ECC Decision aimed at harmonizing implementation measures for mobile and fixed communications networks in the frequency band 2300-2400 MHz including:

- least restrictive technical conditions (LRTC), taking into account the existing standardisation framework and activities at the worldwide level, and an appropriate frequency arrangement;
- regulatory provisions based on LSA ensuring the long term incumbent use of the band in the territory of the administrations that wish maintain such use.

ETSI RRS has approved the TRDoc on LSA (TR 103 113) during its 14-15 March 2013 Meeting in Maison Alfort, France, to be forwarded to ETSI TC RM and to CEPT FM PT52. Further documents on LSA will follow depending on ETSI RRS decision during April 2013. Time Schedules and details of the related new work items are not available yet.

5.4 Standardization opportunities for LSA in IEEE DySPAN-SC

Another standardization group working on this subject is IEEE DySPAN-SC which develops supporting standards dealing with new technologies and techniques for next generation radio and advanced spectrum management. Its working group 1900.6 specifies spectrum sensing interfaces and data structures that are useful for LSA (**Figure 5-3**). The approved standard (IEEE 1900.6-2011) and the currently developed amendment (1900.6a) specify the logical interfaces and data structures (service primitives and generic procedures) to exchange sensing-related information, without constraining the sensing technology, client design, or data link between sensor and client.

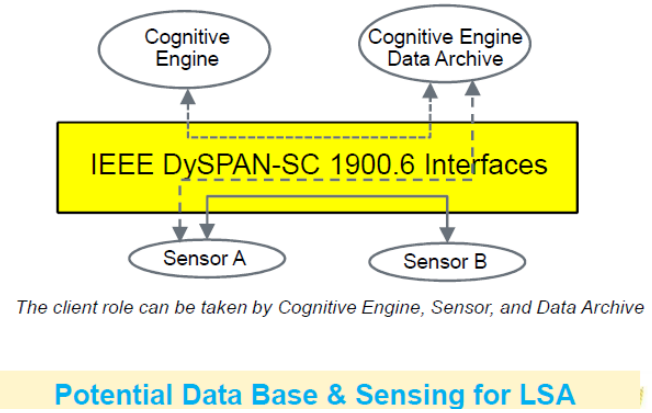


Figure 5-3: IEEE 1900.6 Interfaces

The Data Archive (DA) can be a part of a CR system; it stores sensing-related information obtained from multiple sources such as spectrum sensors, CEs, other DAs, or other external data repositories. The DA also stores regulatory and policy information obtained from regulatory repositories. The IEEE 1900.6 logical interface can be used to convey sensing-related information and processed information. However, regulatory information exchange may need another interface.

In addition, the work of working group IEEE 1900.5 on a policy language, especially the new work item on a Spectrum Consumption Model (SCM), may be used to define a data model for LSA (Figure 5-4). SCMs capture the consumption of spectrum identifying the boundaries of spectrum use, not the details of systems. New work items dealing more specifically with the needs of LSA may be proposed soon.

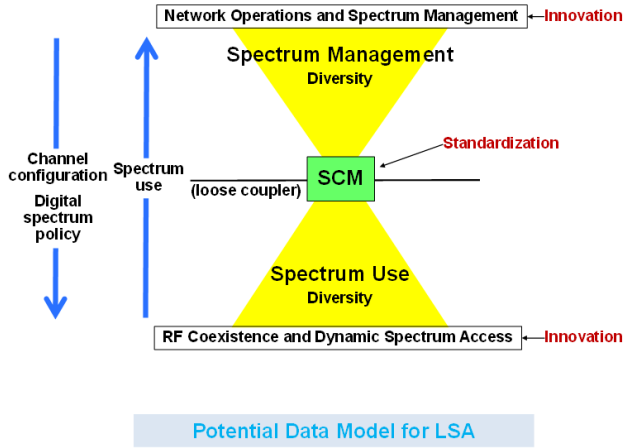


Figure 5-4: IEEE 1900.5 Data Model

5.5 Plan for coordinated contribution towards LSA standardization

As pointed out in Section 5.1, to implement LSA a system needs to be established for updating, maintaining and providing the spectrum access conditions, in the case that incumbents impose restrictions on spectrum use and depending on the pre-defined conditions for spectrum access by LSA licensees (e.g. sharing in time/frequency/location and/or static/dynamic sharing). For this purpose, the interfaces between the components of the LSA system as well as the mechanisms necessary for system operation shall fulfill specific requirements. These requirements and appropriate solutions need to be standardized.

A number of international standardization projects are currently working on such standards with participants from Mobile Network Operators (MNOs), industry and academic partners, in order to develop and deploy innovative concepts and to drive the most economical and powerful technologies and solutions.

In the context of CRS-i, NSN partner and the FP7 COGEU project will work together towards the next steps for ETSI TC RRS on the development of detailed technical specifications for LSA systems including requirements, functional architecture and potentially protocol details of the interfaces (e.g. data content and security procedures). Technical contributions are expected throughout 2013 and 2014, which fits very well in CRS-i WP3 timeframe. Besides, CRS-i will have to coordinate with other projects from the RAS cluster such as FP7 METIS.

6 Conclusions

This deliverable was finalized four months after the start of CRS-i. It provides initial directions to steer standardisation activities considering the background of previous FP7 projects related to cognitive radio. Namely, these projects are: QoSMOS , COGEU , SACRA and OneFIT. This first plan highlights clear and strong directions where topics, standardisation groups and potential partners involved have been reported. The potential future contributions have been categorized into three major items:

- TV White Space (TVWS) access;
- Opportunistic Device-to-Device communications;
- Licensed shared access.

From this deliverable, the mapping of the project that shall impact standards onto these items can be summarizes as presented in Table 6-1. For each of these four projects, the standardisation groups where actions are to be continued and the topics into which they fall are provided in this table.

Table 6-1: Standardisation activities to be continued from previous projects

	TVWS access	Opportunistic Device-to-Device communications (D2D)	Licensed shared access (LSA)
QoSMOS	ETSI RRS P1900.6a P1900.7		
COGEU	ETSI RRS		ETSI RRS
SACRA	ETSI RRS		
OneFIT		3GPP LTE	

Furthermore, some initial collaboration with new (FP7 call 8) projects have been carried out. The example of the cooperation between CRS-i and 5GNOW in IEEE P1900.7 was stressed as a first concrete example of the momentum provided by CRS-i, as 5GNOW would have had difficulties to impact P1900.7 so early in its standardisation process without the expertise from CRS-i.

Another planned cooperation is between the public safety projects (FP7 call 8 EMPHATIC and FP7 call 8 ABSOLUTE) and CRS-i under the scope of D2D standardization in 3GPP. Finally LSA standardization in ETSI RRS will be supported by FP7 COGEU in cooperation with FP7 METIS through NSN (CRS-i partner).

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