CRS-i

FP7 – 318563
Coordination Action

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

D3.3
Report on contribution to standards from QoSMOS, COGEU, SACRA and OneFIT

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Abstract:
This deliverable presents the main achievements of task 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 reports the achievements of task T3.1: “Coordinated standardization effort beyond projects lifetime: QoSMOS, COGEU, SACRA and OneFIT” carried out during the period from Nov. 2013 to Oct. 2014.

The aim of this task was to facilitate and guarantee sustainability of the standardization efforts of FP7 QoSMOS, COGEU, SACRA and OneFIT beyond projects lifetime. This extension was carried out in a coordinated manner and this deliverable completes this task. For that particular reason, the deliverable also captures results of some experiments that have been carried out through CRS-i and based on the legacy of such projects. These experiments are linked with the standardisation activities and aim at supporting the success of CRS-i contributions in standards.

As a continuation of the initial activity reported in D3.1, the topics streamlined from the legacy projects in the standardisation process have focussed on the following three main streams:

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

In addition a new topic, where legacy cognitive radio can have impact was introduced. It relates to the activities on public safety, and in particular. This new topic is a consequence of the mandate M/512 which has one objective (objective C) to “Explores potential areas of synergy among commercial, civil security and military applications”.

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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
FBMC	Filter Bank Multi-Carrier
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)
OFDM	Orthogonal Frequency Division Multiplex
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
WM	Wireless Microphone
WSD	White Space Devices
WiFi	Wireless Fidelity
WRC	World Radiocommunication Conference
WiMAX	Worldwide Interoperability for Microwave Access, Inc

1 Introduction

CRS-i is a FP7 Coordination and Support action with the main objective to facilitate the exploitation of results from Cognitive Radio and Dynamic Spectrum Access research projects by strengthening their impact on standardization.

The aim of task T3.1 is to facilitate and guarantee sustainability of the standardization efforts of the cognitive radio projects FP7 QoSMOS, COGEU, SACRA and OneFIT that ended in December 2012. This coordinated standardization action started with a technical consensus among the four projects in order to achieve a coherent contributions effort to the standards. The first step in this task was to develop an action plan for coordinated contribution to standards from QoSMOS, COGEU, SACRA and OneFIT described in D3.1.

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

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

It should be noted that the consortium decided to extend the scope of the CRS-i standardization efforts in the Amendment of the DoW submitted to the EC in the second year of the project, as a consequence of NTUK withdraw of the CRS-i consortium. In the new DoW the consortium decided to include the emerging area of Cognitive Radio for Public Safety carried out by ETSI RRS WG4 under Objective C of the European Commission mandate on Reconfigurable Radio Systems M/512. This new standardization stream is led by the partner IT. Currently the technology introduced from the EMPHATIC project relates to FBMC and is therefore related to the activities carried out as a continuation of QoSMOS in IEEE P1900.7

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

Table 1: Standardisation activities to be continued from previous projects.

FP7 project	TV White Space access	Device-to-Device communications (D2D)	Licensed shared access (LSA)	CR for Public Safety (New item)
QoSMOS	P1900.6a P1900.7			ETSI RRS WG4
COGEU	ETSI RRS WG1 IETF PAWS		ETSI RRS WG1	
SACRA	ETSI RRS WG1 ETSI RRS WG2			
OneFIT		3GPP LTE RAN		

2 CRS-i effort towards standardization in the TV White Spaces

2.1 Contributions to PHY and MAC in IEEE P1900.7

2.1.1 Scope of the standardization work

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 the work to be undertaken 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)."

IEEE P1900.7 enables the development of cost-effective, multi-vendor white space dynamic spectrum access radio systems capable of interoperable operation in white space frequency bands on a non-interfering basis to incumbent users in these frequency bands. This standard facilitates a variety of applications, including the ones capable to support high mobility, both low-power and high-power, short, medium, and long-range, and a variety of network topologies. This standard is a baseline standard for a family of other standards that are expected to be developed focusing on particular applications, regulatory domains, etc.

The initial planning for contributions as issued in the call for contribution by the Chairperson is as described in Figure 2-1.

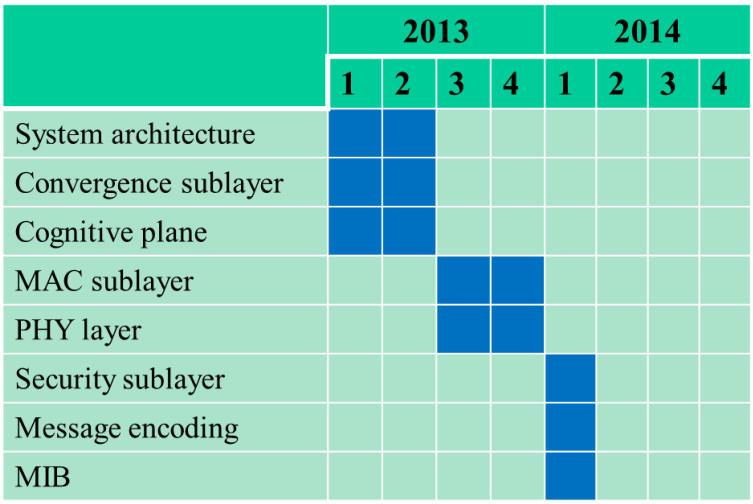

Figure 2-1: IEEE P1900.7 contribution timeline.

2.1.2 Legacy from QoSMOS

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 a PAR was established. The QoSMOS partners, namely CEA, 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. QoSMOS has provided 7 contributions to the WG. They are recapped in CRS-i's deliverable D3.1. After the end of QoSMOS, CRS-i continued the standardisation process of PHY and MAC technology for white spaces as described in the next section.

2.1.3 CRS-i involvement

For the Physical layer, the FBMC waveform was suggested as a good candidate for TVWS radios [1]. The main advantages over OFDM are a better spectral localisation, which directly translates into the ability of the air interface to provide very low leakage in adjacent channels and the ability to address fragmented spectrum. In [1], the need for a flexible radio approach is required in the context of TVWS, since the UHF band spans across a large frequency range (typ. 450MHz to 790MHz).

Besides, the FCC requires an ACLR level of at least 55dB. Unfortunately, high ACLR values are usually obtained with SAW or BAW filters which frequency agility is very limited. Therefore, a new radio architecture to address dynamic spectrum access (DSA) in the TVWS band is needed. With FBMC, ACLR and flexibility constraints can be met without the need of analogue filters. To validate the performance of FBMC, a testbed was designed [2]. The testbed setup implements a TVWS transmitter implemented in QOSMOS and based on the T-FleX hardware also designed in QoSMOS [3]. It involves the TVWS transmitter and a DVB-T modulator, which signals are combined to share the same medium. Then, the compound signal is split to be visualized on a spectrum analyser on one hand and to a TV demodulator on the other hand.

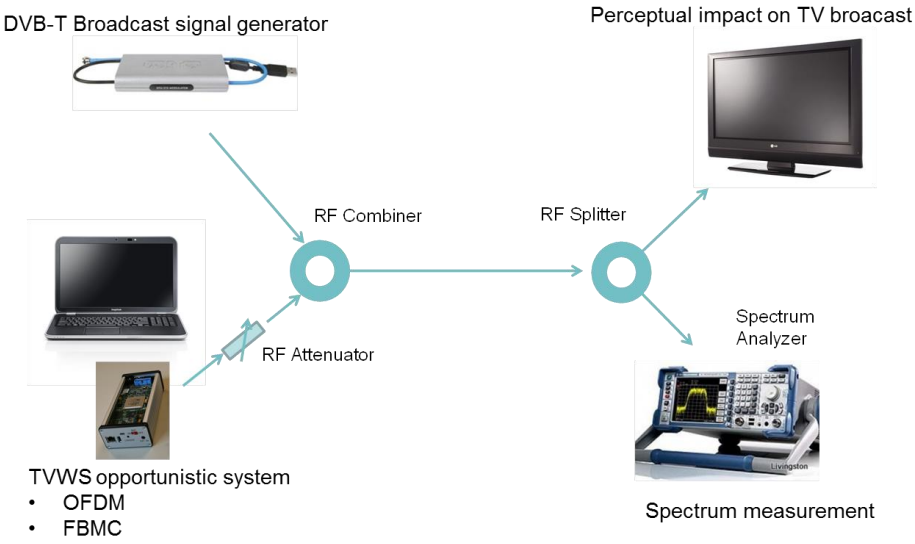

Figure 2-2: FBMC validation testbed.

First, a comparison between OFDM and FBMC was performed and measured with the spectrum analyser. The right plot in Figure 2-3 shows a single channel spectrum with OFDM (dark green) vs FBMC (light green). ACLR of 55.6dB could be measured with FBMC. Also, it was demonstrated that steep and deep notches could be carved with the flexible FBMC modulation by cancelling the subcarriers in the notch, whereas OFDM exhibits higher leakage in the same condition (right plot).

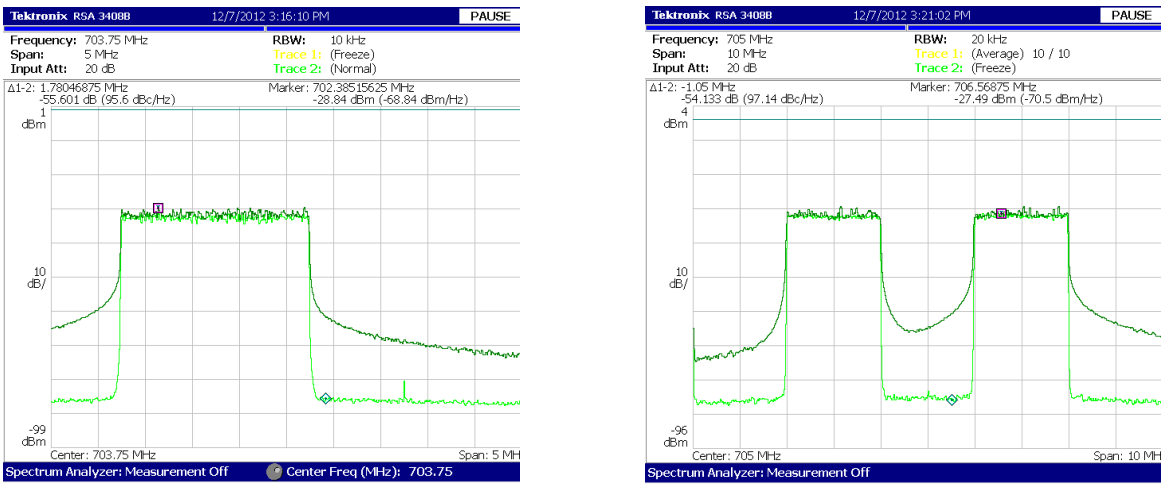

Figure 2-3: FBMC / OFDM comparison.

A comparison with OFDM is also performed to measure the impact on a DVB-T reception and the potential interference of the TVWS transceiver onto the incumbent signal. When using direct adjacent channels on both sides of the DVB-T signal (64QAM 7/6), the OFDM signal must be attenuated by 9 dB in comparison to the FBMC signal in order to get a quasi-error-free DVB-T service. Figure 2-4 shows a measured plot where the DVB-T signal (at the centre) is combined with either an OFDM signal (yellow plot) or an FBMC signal (green plot). In both cases, the power is adjusted to get the quasi-error-free situation [2].

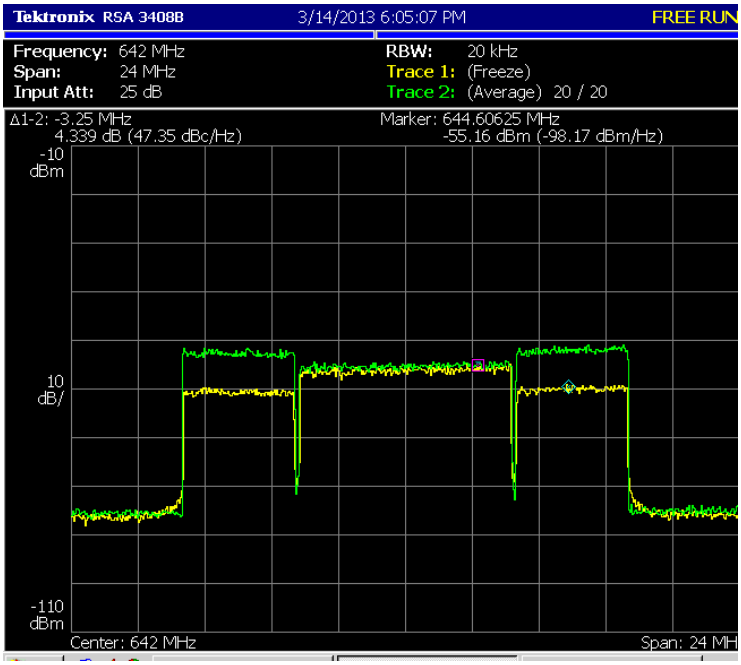

Figure 2-4: FBMC / OFDM comparison with DVB-T adjacent service.

Based on the FBMC benefits described above, this modulation scheme was proposed to the IEEE P1900.7 WG. After QoSMOS had introduced this technology to the group (see D3.1), CRS-i carried out to promote the approach, either jointly with 5GNOW, or under its own name. Also, CEA contributed on the design of the MAC layer for IEEE P1900.7. The MAC parameters were adapted to meet FBMC specification, in answer to the call for contribution issued by the IEEE P1900.7 Chairperson. The contributions were as summarized in Table 2.

Table 2: P1900.7 meeting attendance (White Spaces PHY/MAC) and contributions from CRS-i

Date	Meeting	Meeting work item(s)
13/01/2013	P1900.7 PhC	CEA participated in the WG discussion
20/02/2013	P1900.7 PhC	CEA gave presentation 7-13-0010r2 on FBMC technology. This presentation was carried out as a follow up of CEA's standardization activities in QoSMOS and as technology research extensions held in 5GNOW. CEA gave another presentation (7-13-0011r1) on MAC options for P1900.7.
13/03/2013	P1900.7 PhC	CEA presented contribution 7-13-0015 which aimed at refining the WG use cases with some performance figures. The aim was to categorize the use cases according to key parameters. CEA also presented 7-13-0016 on FBMC simulation performance.
23-24/04/2013	DYSPAN-SC P1900.7 F2F London	CEA presented a contribution on FBMC as an option for P1900.7 PHY. The main principles of FBMC were recapped.
06/06/2013	P1900.7 PhC	Discussion on PHY
26/06/2013	P1900.7 PhC	CEA gave an overview of MAC schemes suitable for P1900.7 (7-13-0035)
31/07/2013	P1900.7 PhC	CEA participated in the WG discussion

28/08/2013	DYSPAN-SC P1900.7 F2F Arlington	CEA presented how FBMC and OFDM can address fragmented spectrum (7-13-0047) CEA presented contribution 7-13-0048 on MAC techniques. CEA proposed some coding schemes for the P1900.7 PHY in 7-13-0049.
02/10/2013	DYSPAN-SC P1900.7 F2F Yokosuka	CEA presented MAC approached for P1900.7 (7-13-0067)
06/11/2013	P1900.7 PhC	CEA participated in the WG discussion
02/12/2013	P1900.7 PhC	CEA participated in the WG discussion
15/01/2014	P1900.7 PhC	CEA participated in the WG discussion
18/07/2014	P1900.7 PhC	CEA participated in the WG discussion
12/02/2014	P1900.7 PhC	CEA participated in the WG discussion
08-10/04/2014	DYSPAN-SC P1900.7 F2F Grenoble	CEA hosted the IEEE DYSPAN meeting and presented 2 contributions on MAC (7-14-0012 and 7-14-0013).
21/05/2014	P1900.7 PhC	CEA participated in the WG discussion
18/07/2014	P1900.7 PhC	CEA participated in the WG discussion
25-26/08/2014	DYSPAN-SC P1900.7 F2F Piscataway	CEA presented a MAC contribution (7-14-0025)
01/10/2014	P1900.7 PhC	CEA participated in the WG discussion

2.1.4 Roadmap for the third year

The draft preparation process is planned as follows:

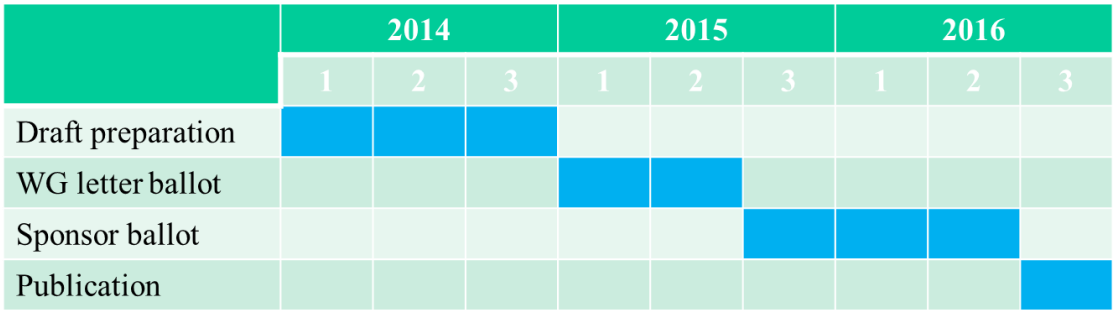

Figure 2-5: IEEE P1900.7 standardisation steps and roadmap

CRS-i will continue to streamline the proposed technology throughout the approval process. Some additional contributions are planned before the draft is finalized. Then CRS-i will contribute to the comment resolution process of the WG Letter ballot and the Sponsor ballot phases.

2.2 Contributions to ETSI RRS WG1 – White Spaces

2.2.1 Scope of the standardization work

TV White Spaces technology is a means of allowing wireless devices to opportunistically use locally-available TV channels (TV White Spaces), enabled by a geolocation database. The geolocation database informs the device of which channels can be used at a given location, and which transmission powers (EIRPs) can be used on each channel based on the technical characteristics of the device, given an assumed interference limit and protection margin at the edge of the primary service coverage area(s).

In order for TVWS devices to operate in Europe, they need to obtain a CE marking that shows that they operate in an appropriate manner. To do so they need to conform to any appropriate regulations. However, at present there are no specific regulations in Europe for the operation of TVWS devices, although the CEPT Reports 185 and 186 provide guidance on how such devices would be expected to operate, and these are expected to provide the basis for national Regulations.

For the benefit of equipment vendors, the framework for operation given in the CEPT Reports 185 and 186 has been used by ETSI to develop European "Harmonised Standards" for such devices. The Harmonised Standards are actually intended to ensure that the TVWS devices comply with Article 3.2 of the European Radio and Telecommunications Terminal Equipment (R&TTE) Directive, which stipulates that all equipment " … shall be so constructed that it effectively uses the spectrum allocated … so as to avoid harmful interference". Compliance with Article 3.2 of the R&TTE Directive is a key requirement for enabling the equipment to be labelled with a "CE Mark", and hence being permitted to be placed on the market in Europe. In the following section the involvement of CRS-i in the ongoing ETSI RRS WG1 TVWS activities is described.

ETSI RRS WG1 is defining the architecture of a system, which can allow operation of WSDs based on information obtained from Geo-location databases. The architecture considers 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). The high level architectures are shown in Figure 2-6.

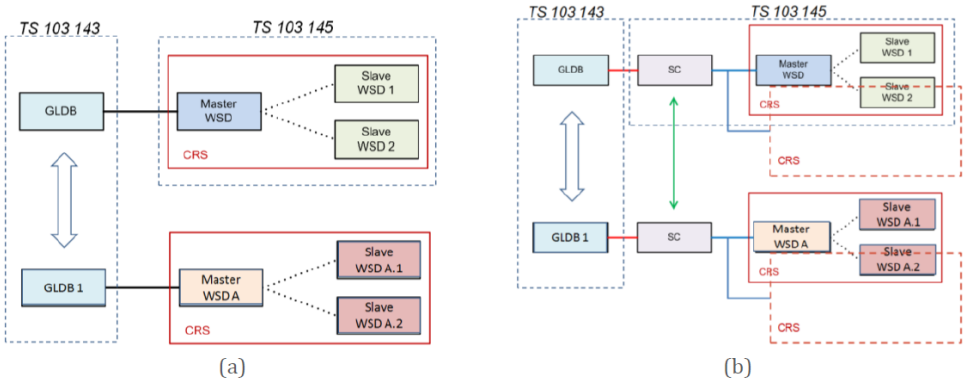

Figure 2-6: (a) Architecture for uncoordinated use of White Spaces. (b) Architecture for coordinated use of White Spaces SC: Spectrum Coordinator [source ETSI RRS WG1].

2.2.2 Legacy from COGEU and SACRA

The COGEU and SACRA projects supported ETSI RRS WG1 progress in the areas of TVWS usage with several contributions to the followings Work Items:

- TR 102 907: Use Cases for Operation in White Space Frequency Bands;
- TR 103 067: Feasibility study on Radio Frequency (RF) performance for Cognitive Radio Systems operating in UHF TV band White Spaces;
- TS 102 946: System requirements for Operation in UHF TV Band White Spaces;

2.2.3 CRS-i involvement

CRS-i supported the setting up a new Work Item in ETSI RRS WG1, the EN 303 387-1 "Signaling Protocols and information exchange for coordinated use of TV White Spaces; Part 1: Interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC)". This European Norm defines the interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC) in coordinated use of TV White Spaces. This interface has been identified as a standardization candidate in ETSI TS 103 145 following the TC RRS work flow recommendation (Protocol and Interfaces Specification).

This activity falls under EC Mandate M/512. In particular CRS-i has contributed to the description of the primitives related with the following services:

- Service access points
- Control Service Access Point (C-SAP)
- Spectrum Coordination Service Access Point (SC-SAP)
- Communication Service Access Point (Com-SAP)

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Details of 'DEN/RRS-0142-1' Work Item

	Work Item Reference	ETSI Doc. Number	STF	Technical Body in Charge	Standard Not Ready For Download
	DEN/RRS-0142-1	EN 303 387-1		RRS 01	
	Current Status (Click to View Full Schedule)	**Latest Version**	**Cover Date**	**Standstill**	**Creation Date**
	Start of work (2014-02-07)			View Standstill Information	2014-03-05
	Rapporteur	**Technical Officer**		**Harmonized Standard**	
	Naotaka Sato	Andrea Lorelli		No	

Title	Reconfigurable Radio Systems (RRS); Signalling Protocols and information exchange for Coordinated use of TV White Spaces; Part 1: Interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC) Interface between CRS and SC
Scope and Field of Application	This European Norm defines the interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC) in Coordinated use of TV White Spaces. This interface has been identified as a standardisation candidate in ETSI TS 103 145 following the TC RRS work flow recommendation (Protocol and Interfaces Specification). This activity falls under EC Mandate M/512.
Supporting Organizations	INTERDIGITAL COMMUNICATIONS, Sony Europe Limited, ZTE Corporation, Instituto de Telecomunica es

Figure 2-7: CRS-i partners joined a task force to trigger a new working item in ETSI RRS WG1.

Table 3: ETSI RRS WG1 meeting attendance (White Spaces)

Date	Meeting	Meeting work item(s)
3-7 March 2014	ETSI RRS #25 Maison-Alfort, France	Proposal text for Section 5.4 - Potential Interaction of Functionality within the spectrum coordination function for TS 103 145
23-27 June 2014	ETSI RRS #26 F2F meeting in Montreal (CA)	Proposal text for Sensing and Measurements Primitives in EN 303 387-1, RRSWG1(14)100095r1
31-July 2014	RRS1-Phone Call	Contributions on ETSI EN 303-387-1. Analysis of the RRSWG1(14)027011r1_Device_parameter_reconfiguration_request_from_SC_to_CRS_proc
22-24 Sep. 2014	ETSI RRS #27 F2F meeting in Mainz, Germany	Proposal text of SC-SAP for EN 303 387-1 RRSWG1(14)028006_SC-AP_for_EN_303_387-1

2.2.4 Roadmap for the third year

CRS-i will continue to actively participate in ETSI towards finalizing the EN 303 387-1 document. Monitor and contribute to the specification of Signaling Protocols for information exchange in TVWS systems. Ensure that the standardized architecture allows coordinated use of White Space where some form of channel management and/or coexistence techniques are employed to efficiently use the White Space. Moreover, CRS-i will continue to push to the ETSI RRS WG1 standards the option of combing white spaces database access with spectrum sensing information and not only static white space maps.

2.3 Contributions to ETSI RRS WG2 – SDR architectures

2.3.1 Scope of the standardization work

ETSI RRS WG2 focuses on the Software Defined radio (SDR) technology with a particular interest in radio equipment architectures for SDR as an enabling technology for CRS. The overall Reconfigurable Mobile Device architecture is illustrated in Figure 2-8.

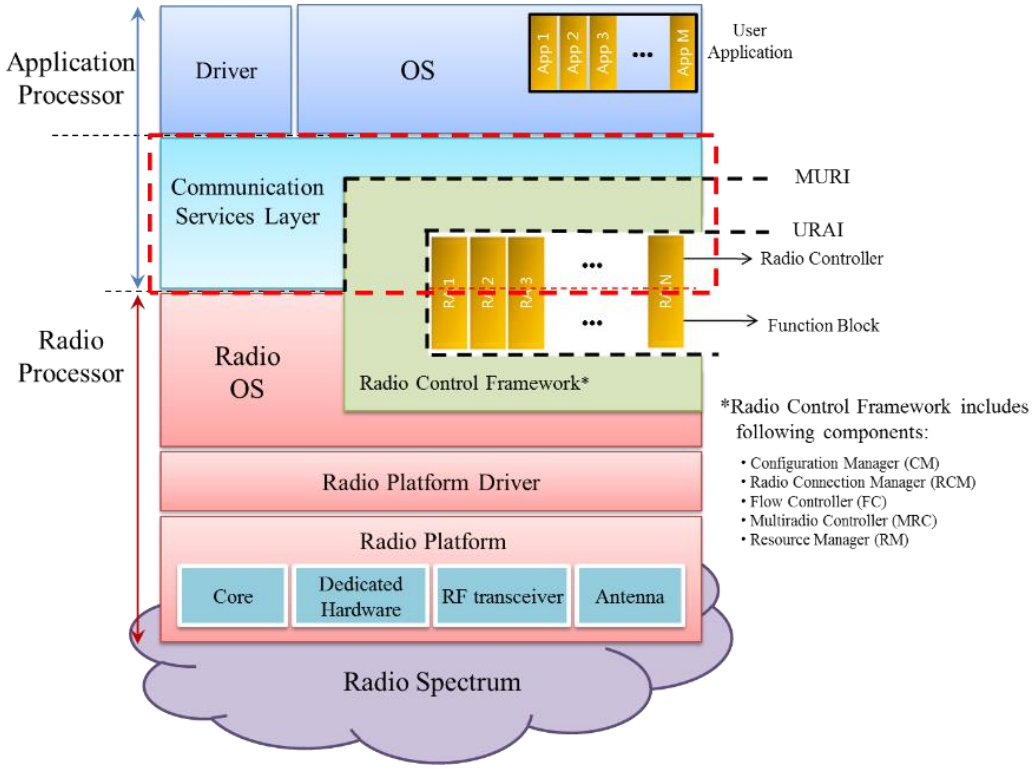

Figure 2-8 Reconfigurable Mobile Device architecture for multi radio applications

A list of the published Technical Reports (TRs) and Technical Specifications (TSs) of ETSI RRS WG2 can be found in Table 4.

Table 4: ETSI RRS WG2 published documents

Document Number	Title	Publication Date	Contents
ETSI TR 102 680	Reconfigurable Radio Systems (RRS); Mobile Device SDR Reference Architecture	March 2009	Reference Architecture for Reconfigurable Mobile Devices (MD)
ETSI TR 102 839	Reconfigurable Radio Systems (RRS);Multiradio Interface for SDR Mobile Device Architecture and Services	April 2011	Normative system requirements, architecture, and interfaces for Reconfigurable MD
ETSI TR 102 944	Reconfigurable Radio Systems (RRS); Use Cases for Baseband Interfaces for Unified Radio Applications of Mobile Device	July 2011	Use Cases of Reconfigurable MD
ETSI TS 102 969	Reconfigurable Radio Systems (RRS); Radio Reconfiguration related Requirements for Mobile Devices	March 2012	Requirements of Reconfigurable MD

ETSI TS 103 095	Reconfigurable Radio Systems (RRS); Radio Reconfiguration related Architecture for Mobile Devices	January 2011	SW/HW Architecture of Reconfigurable MD
ETSI TS 103 146-1	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part1:Multiradio Interface (MURI)	November 2013	Information model and protocol about MURI

2.3.2 CRS-i involvement

CRS-i monitors the activities of ETSI RRS WG2. More specifically, CRS-i attended the recent ETSI RRS WG2 meeting #25, which took place in Mainz, Germany on 24 September 2014. UNIS produced the respective WG2 standardization report, which was circulated to the CREW and SOLDER project(s).

The CRS-i involvement in WG2 lies in the area of spectrum aggregation. During the Mainz meeting, UNIS discussed with the ETSI RRS WG2 chairman, Prof Seungwon Choi, on the potential of considering the support of carrier aggregation functionalities by a reconfigurable device. During this discussion, it was agreed that in the December 2014 meeting in Sophia Antipolis, France, UNIS will present an overview of carrier aggregation functionalities in wireless communication systems, as well as a first draft proposal on system architecture features that need to be considered in order for a reconfigurable terminal to be able to support carrier aggregation functionalities.

2.3.3 Roadmap for the third year

The ETSI RRS WG2 work programme with regards to planned Technical Specifications (TSs) and European Standards (ENs) is shown in Table 5 and Table 6, respectively.

Table 5: Planned ETSI RRS WG2 Technical Specifications

Document Number	Title	Publication Date	Contents
ETSI TS 103 146-2	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 2:Reconfigurable Radio Frequency Interface (RRFI)	June 2015	Information model and protocol about RRFI
ETSI TS 103 146-3	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 3:Unified Radio Application Interface (URAI)	To be done	Information model and protocol about URAI
ETSI TS 103 146-4	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 4: Radio Programming Interface (RPI)	To be done	Information model and protocol about RPI

Table 6: ETSI RRS WG2 planned European Standards (ENs)

Document Number	Title	Status	Contents
ETSI EN 303 969	Reconfigurable Radio Systems (RRS); Radio Reconfiguration related Requirements for Mobile Devices	RRS TC approval	Requirements of Reconfigurable MD
ETSI EN 303 095	Reconfigurable Radio Systems (RRS); Radio Reconfiguration related Architecture for Mobile Devices	Stable draft	SW/HW Architecture of Reconfigurable MD
ETSI EN 303 146-1	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 1:Multiradio Interface (MURI)	Early draft	Information model and protocol about MURI

ETSI EN 303 146-2	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 2:Reconfigurable Radio Frequency Interface (RRFI)	To be done	Information model and protocol about RRFI
ETSI EN 303 146-3	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 3:Unified Radio Application Interface (URAI)	To be done	Information model and protocol about URAI
ETSI EN 303 146-4	Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 4: Radio Programming Interface (RPI)	To be done	Information model and protocol about RPI

2.4 Reference implementation of IETF PAWS

2.4.1 Scope of the standardization work

The Internet Engineering Task Force (IETF) works since June 2011 on the definition of a protocol to access white spaces databases – PAWS ("Protocol for Communication between White Space Device and White Space Database") [7]. The overall goals of this IETF working group are to: standardize a mechanism for discovering a white space database; standardize a method for communicating with a white space database; standardize the data formats to be carried over the defined database communication method; ensure that the discovery mechanism, database access method, and query/response formats have appropriate security levels in place. The integration of PAWS in the white space system is illustrated in Figure 2-9.

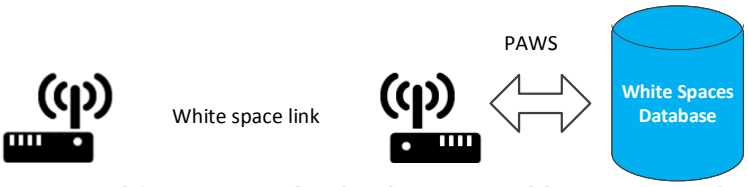

Figure 2-9: PAWS: Protocol for Communication between White Space Device and White Space Database.

2.4.2 COGEU legacy

The IETF draft protocol v0.4 and its data model was chosen and considered flexible enough to be adapted for the COGEU project and its requirements. The COGEU project developed and implemented three basic services of IETF v0.4 draft: Registration, Channel List Request and ID Verification. A web interface was developed to show messages flow between the White Spaces Database and the White Spaces Device as shown in Figure 2-10.

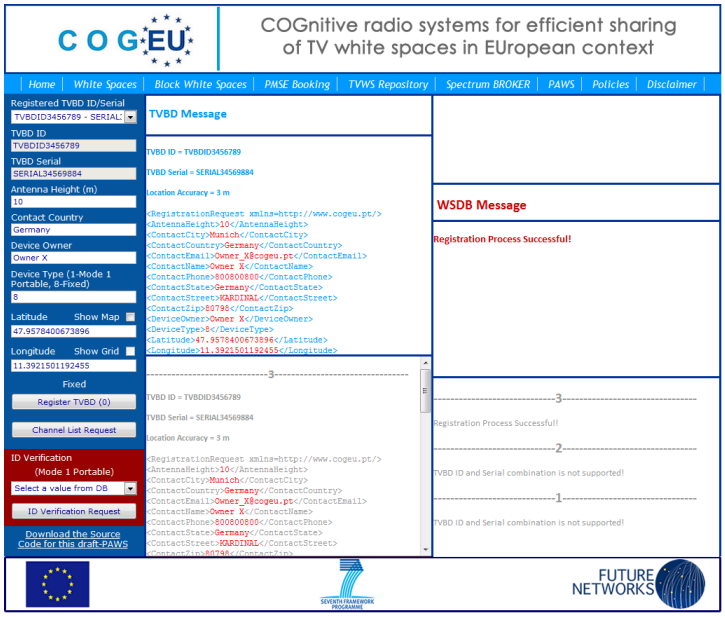

Figure 2-10: GUI presenting the message exchange between a WSD and the White Spaces Database, IETF PAWS v0.4 [14].

2.4.3 CRS-i involvement – Implementation and validation of IETF PAWS

After the end of COGEU (December 2012), the PAWS experienced significant progress being now in v0.12. CRS-i took over the work done in COGEU and implemented v0.12. During the implementation process several bugs and doubts were reported and discussed in the IETF PAWS mailing list that eventually leads to changes in the draft text. Several programming languages, from MySQL, PHP and JavaScript, were used to develop this implementation of PAWS. All languages are open source software. Figure 2-11 presents the GUI developed to present the message exchange between a WSD

and the White Spaces Database, IETF v0.12. The protocol implements the rule set define by the standard ETSI EN 301-598.

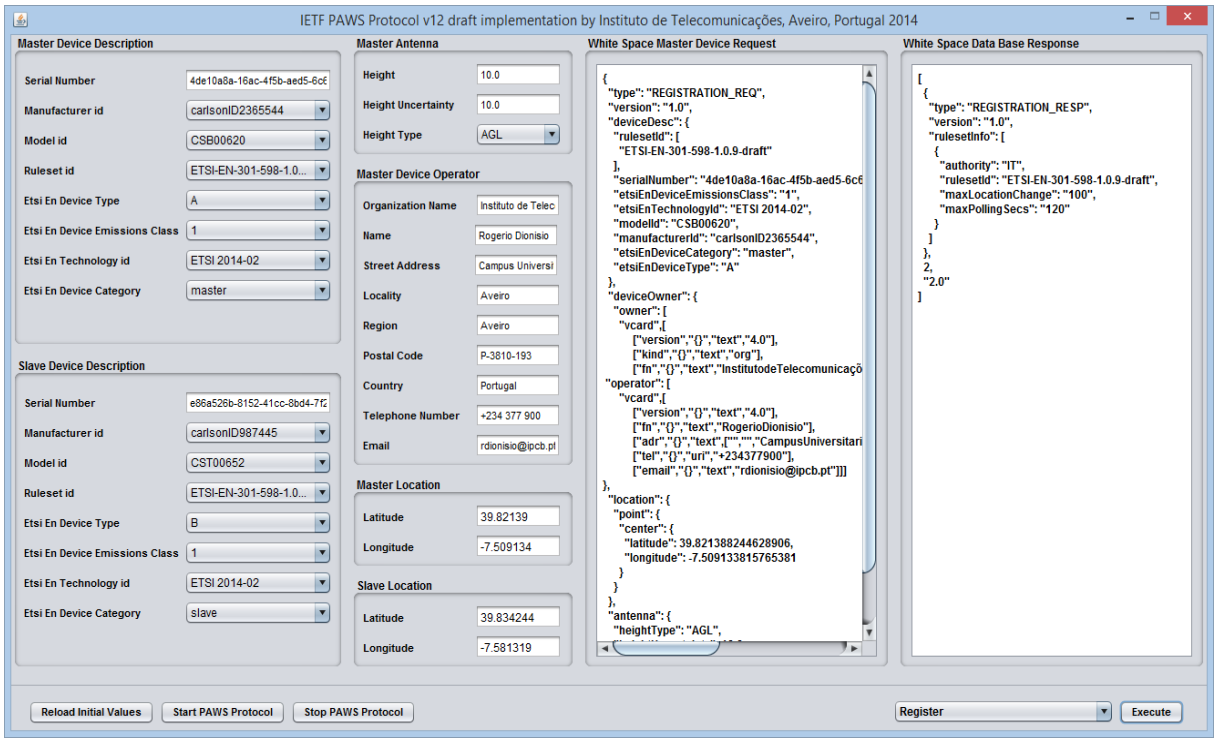

Figure 2-11: GUI presenting the message exchange between a WSD and the White Spaces Database, IETF v0.12. The protocol implements the rule set define by the standard ETSI EN 301-598.

2.4.4 Roadmap for the third year

During the third year of the CRS-i project the plan is to make the IETF PAWS implementation (source code) available for download from the CRS-i portal under an open source license (GNU General Public License). With this protocol, users can connect WSDs to White Spaces geo-location database through a well-defined access method and run trials in geographical areas where white spaces information is available. We believe that making the protocol code open and available will have a significant impact on the IETF and Cognitive Radio communities bring visibility to CRS-i.

2.5 Reference implementation of ECC Report 186 – TV white spaces computation

2.5.1 Scope of the ECC Report 186

The ECC Report 186, developed by the CEPT, gives advice on general principles and basic requirements for WSDs operating under the geo-location database in Europe [8]. The methodology used to compute TVWS maps, i.e., the maximum acceptable transmit power for a given location and TV channel, implements the algorithm proposed in ECC Report 186 (Section 5.2) and summarized in Figure 2-12.

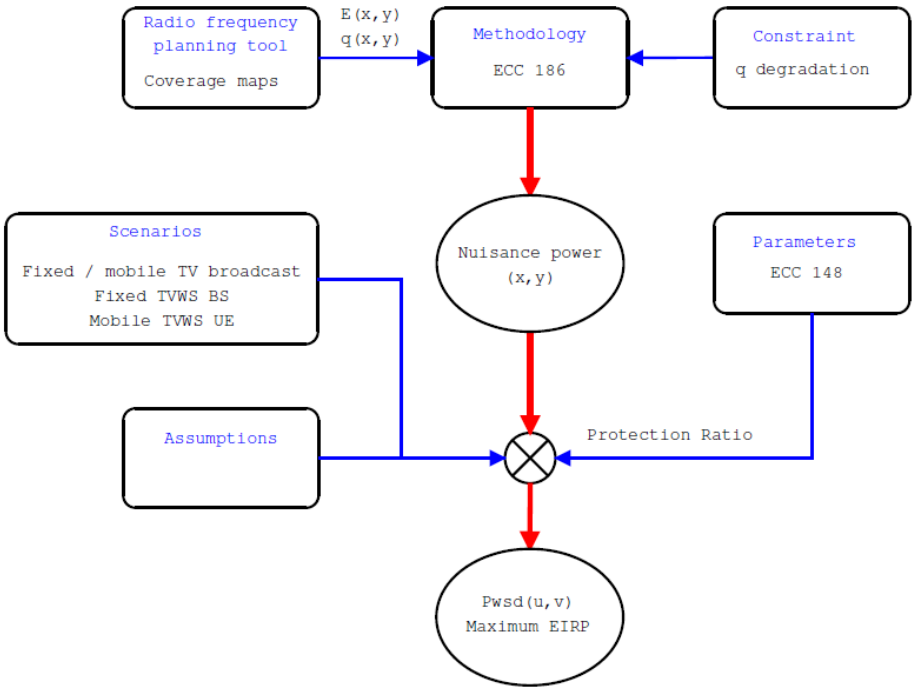

Figure 2-12: TVWS computation methodology.

2.5.2 CRS-i involvement – Reference implementation of TVWS methodology

CRS-i has implemented the methodology proposed by ECC Report 186 (Section 5.2) to calculate the maximum WSD power based on the DTT coverage maps and the DTT protection requirements (acceptable degradation). In order to validate the methodology proposed by ECC Report 186, the partner IT has computed the white spaces maps for a region around the city of Aveiro (Portugal). The results are shown in **Figure 2-14** for Channel 53.

These maps were presented to the Portuguese regulator ANACOM to demonstrate the concept of spectrum database and the related standardization work [13]. Meanwhile ANACOM issued a trial license to test TV White Spaces technologies in the Aveiro area. During the third year of the project the plan is to carry out TVWS pilots using commercial TVWS equipment connected to the geo-location database developed by CRS-i based on CEPT methodology.

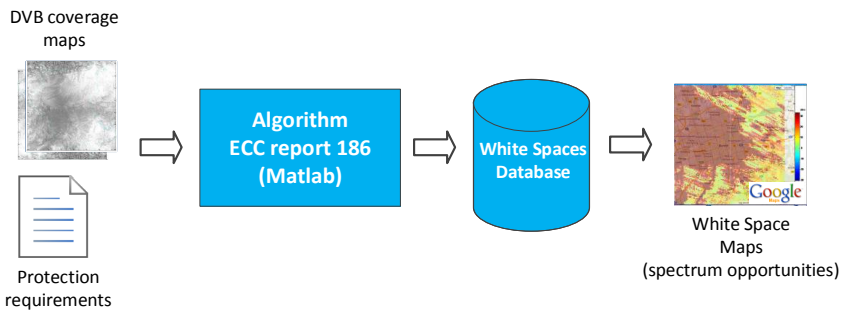

Figure 2-13: Procedure to populate the TVWS geo-location database.

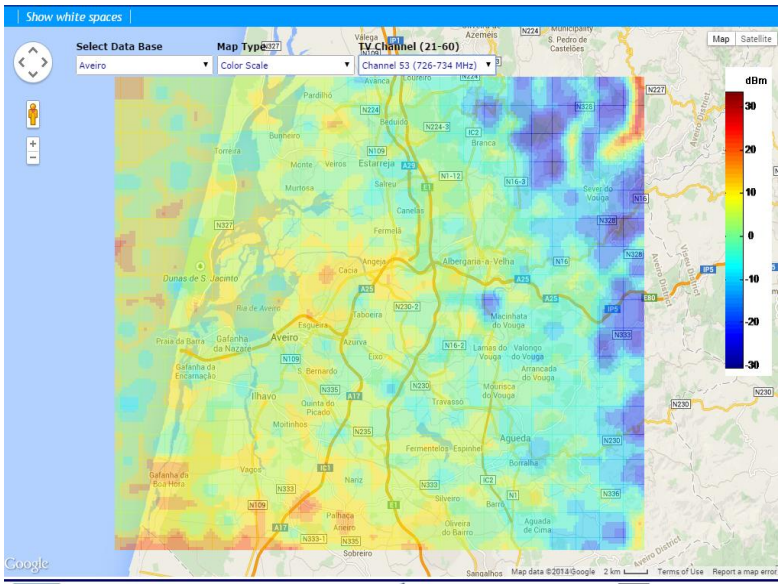

Figure 2-14: TV White Space Maps for the region of Aveiro – Portugal (200 m resolution): maximum power that is possible to transmit in channel 53 without harmful interference in DTT reception.

2.6 CRS-i participation in the Ofcom UK – TV White Spaces pilot

2.6.1 Scope of the Ofcom UK pilot and links with ETSI standards

The UK regulator, Ofcom, has initiated a large-scale Pilot of TV White Spaces technology and devices. The ACROPOLIS Network of Excellence, teaming up with CRS-i, the SOLDER project, the EC-JRC and NICT (Japan), carried out in July-August 2014 an extensive series of trials under this effort (**Figure 2-15**). The purpose of these trials is to test a number of aspects of white space technology, including the white space device and geolocation database interactions, the validity of the channel availability/powers calculations by the database and associated interference effects on primary services under challenging deployment geometries, and the performances of the white spaces devices, among others.

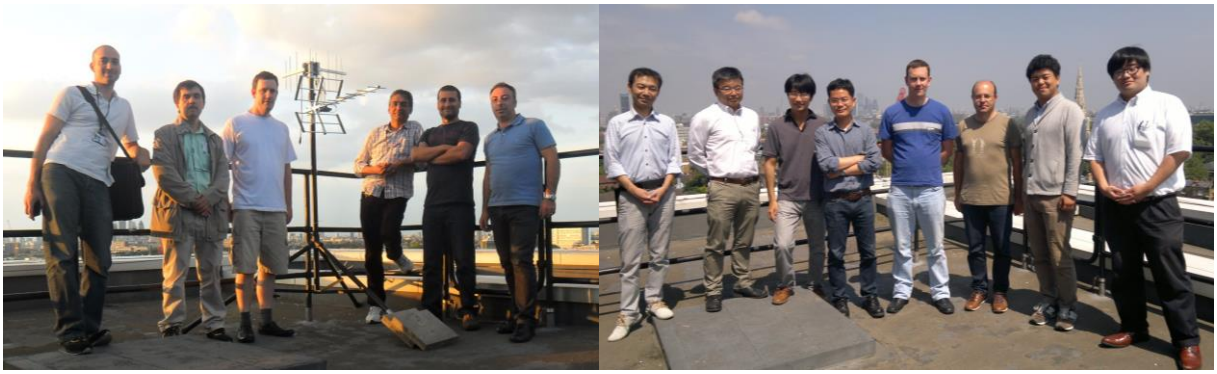

Figure 2-15 : Team from CRS-i, ACROPOLIS, EC-JRC and NICT (Japan) involved in the Ofcom UK pilot in London, August 2014.

All trials within this pilot must be based on Ofcom's prospective rules for WSDs, which are reflected in the ETSI 301 598 harmonized standard for WSD requirements at the European level. The rules for TVWS in the UK/EU are very different from those in the US. In the US, a fixed maximum power (EIRP) is assumed for all WSDs, as authorized to transmit by a geolocation database (GDB). This fixed power has the benefit of providing more certainty on the performance that will be achieved by the WSDs as experienced by the end-user, however, its high (fixed) value vastly increases the number of locations for which unacceptable interference would be caused to the primary service in a given channel. This

constrains the locations in which WSDs are allowed to operate for a given channel, or conversely, the number of channels that can be used at a given location.

The UK/EU rules, on the other hand, allow the GDB to decide on the maximum power (EIRP) that a WSD can use in a given channel and location. The UK/EU rules do this based on information that is inferred about the WSD in its request to operate at the given location, such as on its spectrum mask class of performance (this is inferred by the GDB based on its conveyed model number), elevation, and other characteristics.

The GDB calculates the power that can be used in each channel based on its implied interference to the edge of the primary service area, under the assumption of a given interference limit plus a protection margin for the primary service at that edge of coverage. Under the UK/EU rules, it is therefore likely that WSD will be allowed to operate in far more locations for a given TV channel than would be the case for the US rules, albeit likely at far lower allowed transmission EIRPs in those locations for which devices would otherwise not be allowed to transmit under the US rules. Further, lower quality hence cheaper WSDs with less challenging RF spectrum masks can be used under the UK/EU model, through their allowed transmission power being reduced to take into account adjacent channel interference implications of their lower-quality spectrum mask Class specifications.

Under the UK/EU rules, embodied in the device requirements of ETSI 301 598 [4][1], the Ofcom Pilot aims to serve a number of purposes:

- Provision a proof of concept of the TVWS framework.
- Provision of a step of verification before full-scale TVWS operations start.
- Involvement of the regulator, industry, and end users in the process, such that the interactions between the relevant stakeholders can be verified.

The Ofcom Pilot also aims to test several aspects, such as:

- Device operations.
- Database contract qualification.
- Database operation and calculations.
- Ofcom's provision of the qualifying database listing.
- Ofcom's DTT calculation results and provision of Programme Making and Special Events (PMSE) data.
- Interference management.
- Coexistence.

In August 2014 CRS-i members joined a team from Kings College London (ACROPOLIS and SOLDER project), EC-JRC and NICT (Japan) to carry out a TV White Spaces trial in London under the TVWS Ofcom Pilot programme. CRS-i members were involved in conformance tests, the evaluation of sensing algorithms to detect PMSEs and in a coexistence study between White Spaces Device operation and a PMSE link.

2.6.2 Conformance tests of WSD – compliance with ETSI 301 598

It is a requirement for all trialists participating in the Ofcom TVWS pilot to certify their devices are performing according to ETSI 301 598 [4], both in terms of RF aspects and in terms of logical aspects such as communication with the GDB and appropriate setting of parameters in accordance with responses from the GDB.

In terms of RF performance, Ofcom/ETSI specify 5 performance classes (Table 7, see p. 15 of ETSI 301 598 for more detail) in terms of Adjacent Channel Leakage Ratio (ACLR). These performance classes compare power in the intended channel of width 8 MHz with power outside of the intended channel in 100 kHz chunks, and specify requirements in terms of the intended channel emissions ±1, ±2, and ±3 channels, with limits further out from ±3 channels being equal to those for the ±3 channel.

Table 7: OFCOM/ETSI ACLR requirements in terms of the minimum power reduction ratio in each 100 KHz compared with the power in the 8 MHz intended channel.

Where P_{OOB} falls within the nth adjacent DTT channel (based on 8 MHz wide channels)	ACLR (dB)				
	Class 1	Class 2	Class 3	Class 4	Class 5
n = ±1	74	74	64	54	43
n = ±2	79	74	74	64	53
n ≥ +3 or n ≤ -3	84	74	84	74	64

An observation that has become apparent in the tests using a wide range of WSD equipment, is that the devices typically will easily achieve Class 1 performance at ±2 and ±3 or more from the intended transmission channel, even if they only achieve Class 3 performance at ±1 from the intended channel [10]. In fact, the team has discussed the value of Ofcom/ETSI maintaining the Class 2 specification, which seems to not easily match to any typical WSDs that are currently being developed. One recommendation that our trials therefore have is that the Class 2 specification be adapted to better suit some WSDs and therefore allow the WSDs to take advantage of more spectrum opportunities and/or higher powers through achieving operation at Class 2 instead of Class 3.

2.6.3 Test of sensing algorithms do detect PMSEs

A challenging aspect of TV White Space use in Europe is that TV spectrum is not only occupied by fixed TV broadcasting signals. In addition to the TV broadcasts the spectrum is used by licensed Programme Making Special Event (PMSE) devices, e.g., Wireless Microphones (WM). TV White Space device operation may be permitted if (and only if) it does not interfere with incumbent services such as digital TV and PMSEs.

Current regulation in the UK and US are supporting the solo use of the geo-location database. However it is increasingly recognized that a solution based on exploiting spectral sensing coupled with geo-location databases allows a more effective use of TVWS. This trend is also reflected in the ongoing discussions in ETSI RRS WG1 where CRS-i is contributing. In particular, a geo-location database assisted by a low-cost and densely deployed spectrum monitoring infrastructure is a promising approach to protect dynamic incumbent systems, such as wireless microphones that are not registered in the database. There are two main approaches for spectrum sensing in Cognitive Radio networks: internal sensing and infrastructure sensing. In internal sensing, individual WSDs detect spectrum opportunities before transmitting whereas in infrastructure sensing, an independent and dedicated sensing network provides spectrum occupancy information.

The objective of this trial is to test the performance of different sensing algorithms to detect the presence of WMs, this information is important to discuss the viability of an infrastructure sensing approach in the context of ETSI RRS WG1. At standardization and regulatory level, the trial results will help Ofcom UK to recognize the value of spectrum monitoring as part of the progressive approach to managing spectrum more efficiently.

2.6.3.1 PMSE detection - trial setup

The sensing antenna was placed on the roof of the building Institute of Psychiatry, King's College London, 16 De Crespigny Park (building with 7 floors) as shown in Figure 2-16. The sensing device is based on USRP2 hardware prototyping platform, a GPS receiver and a PC as a host. The WM system is an analogue system HT 450/C operating in FM. The software application was programmed using Labview platform from National Instruments running three sensing algorithms: Energy Detection (ED), Covariance Absolute Value (CAV) and the Maximum Eigenvalue to Trace detection (MET) [11] . The software application automatically computes the Probability of Detection for each sensing algorithm. Note that this software tool was developed in the COGEU project [12], thanks to CRS-i is now used in the context of the Ofcom UK pilot.

Before start the sensing process the sensing device needs to be calibrated. This process includes a threshold calculation for each sensing algorithm. With the WM switch off the system measures the histogram of the background noise and the decision threshold is computed for a probability of false alarm (Pfa) of 10 %. The calibration thresholds results are shown in the table below.

Table 8: Calibration results

Sensing Algorithm	Value
ED	-88.2 dBm
MET	0.19
CAV	2.52
Average Noise level	-103 dBm

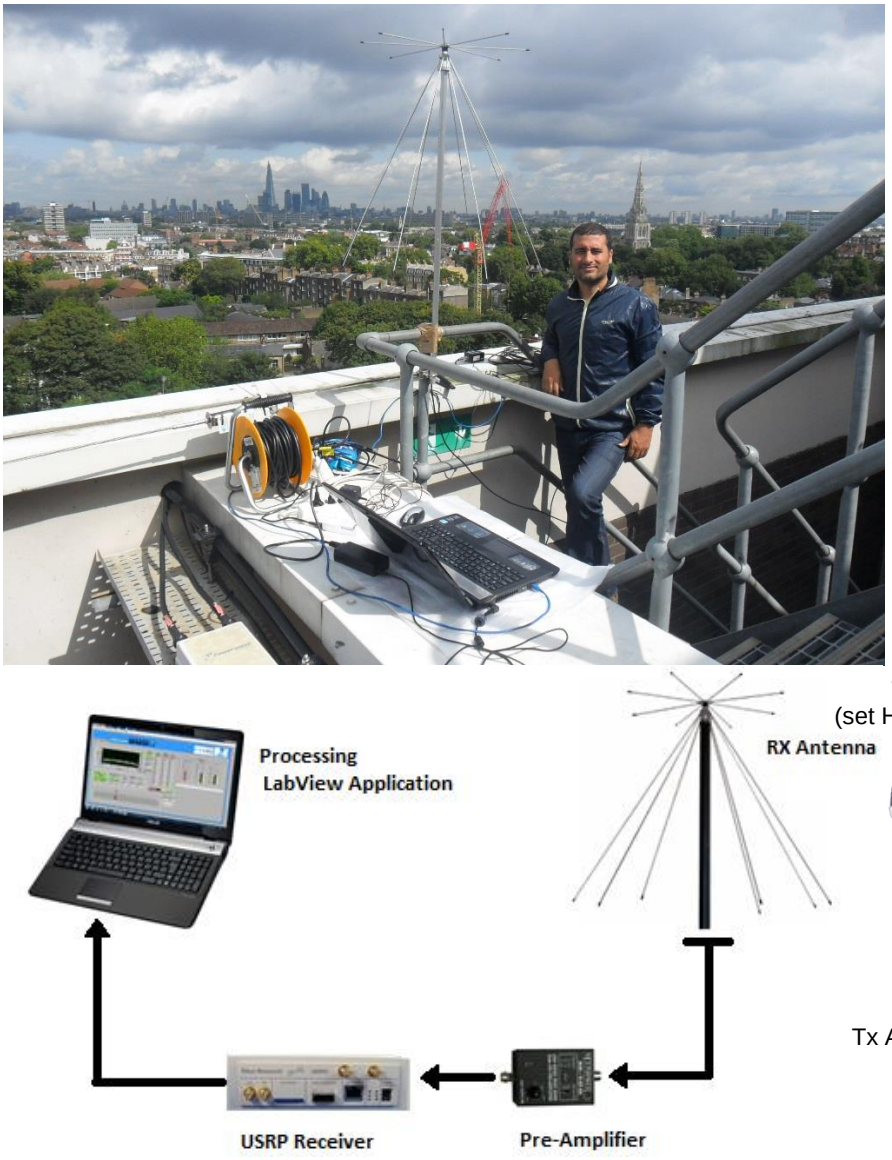

Figure 2-16: Sensing set up in Denmark Hill, London in August 2014.

The wireless microphone was tuned at 703 MHz (TV UHF channel 50: 702-710 MHz), transmitting in analogue FM, with a maximum transmitting power of 10 mW and placed at different locations around the Institute of Psychiatry, King's College London. A PMSE license was obtained from Ofcom through Arqiva allowing the operation of a WM in channel 50 in this area (Licence No: 7/0048412). The sensing antenna is a broadband discone antenna with 0 dBi gain. The parameters used in the sensing algorithms are summarized below.

Algorithms parameter	Value
FFT length, for Energy Detector (ED)	2048 samples
Covariance based algorithms (CAV and MET), Smoothing factor	12
Target Probability of false alarm (Pfa)	10 %
Sensing time for each decision	100 ms
Total sensing time for each site	10 minutes

Figure 2-17 shows the view from the sensing area in Denmark Hill. The green circles mean that at least one of the implemented sensing algorithms is able to detect the presence of the WM at street level with Probability of Detection higher than 95%. The read circles mean that none of the algorithms is able to detect the WM presence with Probability of Detection higher than 95%.

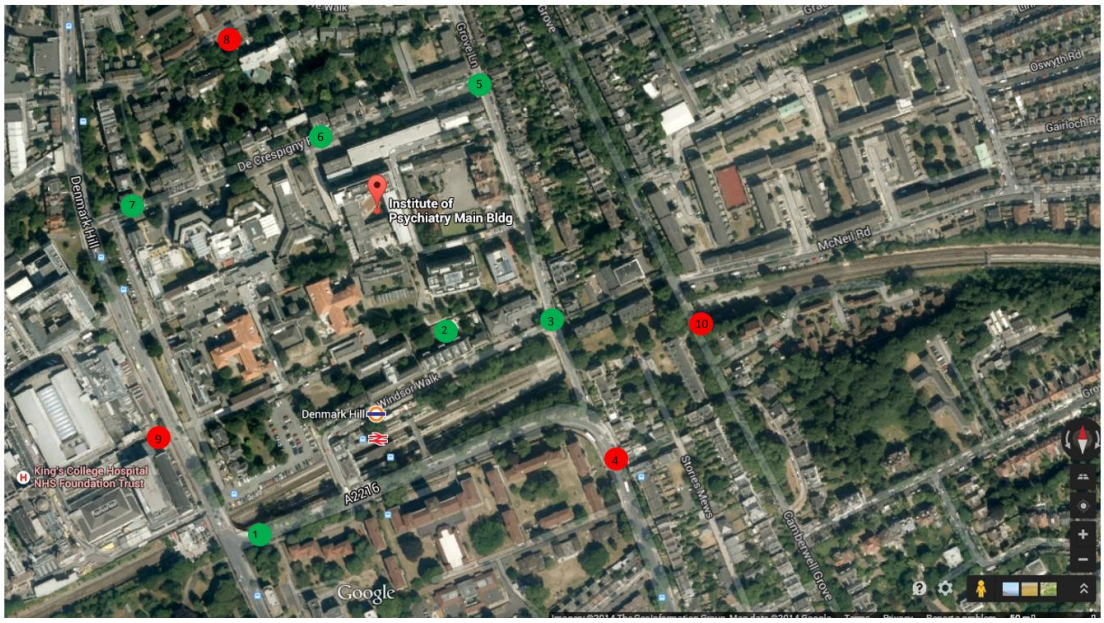

Figure 2-17 : The sensing antenna is located in the roof of the Institute of Psychiatry Main Building. The green circles mean that at least one of the sensing algorithm is able to detect the presence of the WM at street level with Probability of detection higher than 95%.

2.6.4 Results from the PMSE detection trial

As expected the results showed that CAV and MET algorithms perform better than the simple Energy detection (ED) for all locations tested. CAV and MET exploit the orthogonality between the subspace of noise and the subspace of signal and are independent of the noise uncertainty. Note that the Energy detection algorithm is a method highly susceptible to noise variance. CAV and MET showed that is possible to detect the presence of a WM even when the signal is under the noise level as shown in Figure 2-18 (measured when the WM was placed in site 7 in Figure 2-17). This trial in London showed that a network of spectrum sensors needs a minimum density of 300 m in order to ensure a reliable detection of WM. These results will be presented in ETSI RRS WG1 to feed the discussions related with the combination of database access with spectrum sensing.

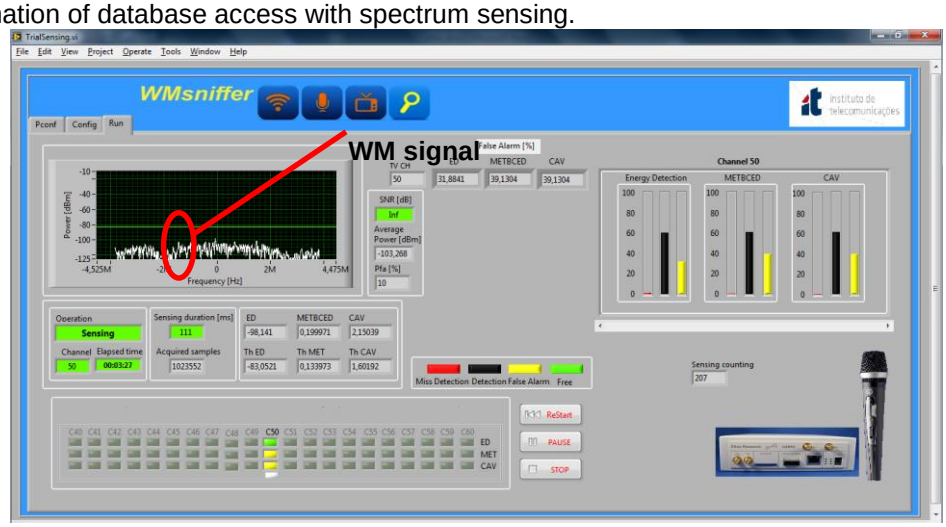

Figure 2-18 : GUI of the sensing application used in the Ofcom UK pilot.

2.6.5 Coexistence study between WSD and PMSE operation

During the trial in London the CRS-i team, in cooperation with the ACROPOLIS and SOLDER projects, carried an experiment to analyze the coexistence between a WSD link and a WM system operating in adjacent TV channels. The set up was based on the PMSE interference scenario proposed by Ofcom and illustrated in Figure 2-19. A professional audio recorder was used to record the signal received by the WM receiver. The objective is to compare the quality of the audio sound received by the WM, with and without the WSD transmitting, this procedure allows the detection of possible interferences that the WSD link may cause in the WM receiver.

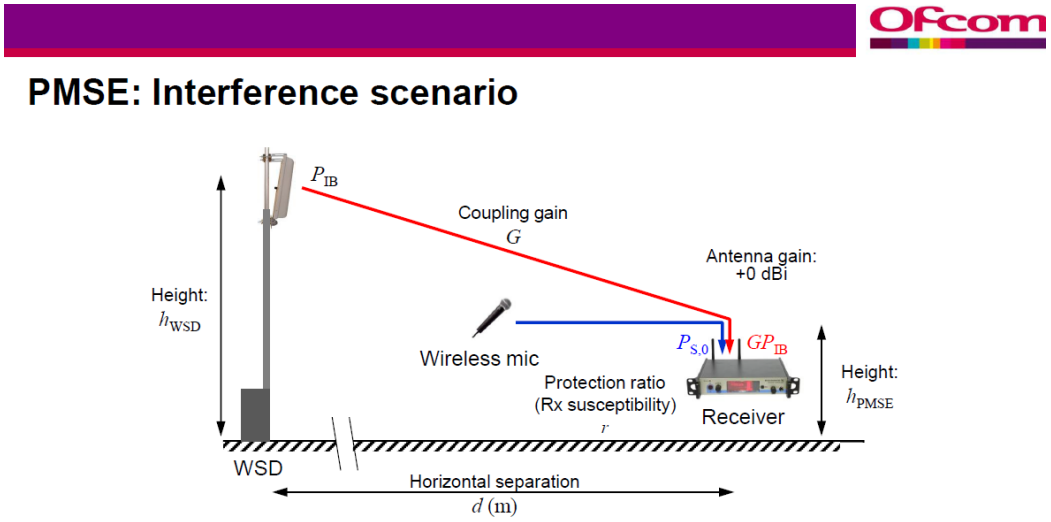

Figure 2-19 : Coexistence scenario proposed by Ofcom and carried out by the CRS-i team.

Set up parameters

- White Space System: Carlson Base Station operating in TV Channel 49 (694-702 MHz)
- hWSD= 2.5 m ; hPMSE=1 m
- Carlson Base Station with Tx power of 23 dBm and continuous traffic
- Carlson Base Station connected to a Yagi antenna indoors with 9 dBi
- 1 dB cable losses
- EIRP=23-1+9=31 dBm
- Distance between the Carlson Base Station and the WM receiver (victim device) = 5 m (LOS)
- WM system: AKG WMS 450 Vocal Set operating in TV channel 50 (703 MHz and 10 dBm Tx power)
- Professional Audio Recorder System: ZOOM Dictafone digital Handy Recorder H4n

The experiment has shown that even in this challenging scenario where the victim device (WM) and the WSD were separated only by 5m, there is no audible interference from the WSD link in the operation of a WM system working in adjacent TV channels. A short video describing the experiment was produced and forwarded to Ofcom UK [15]. A report on these trials was forward to Ofcom UK, we are waiting for feedback and after that the results will be shared with ETSI RRS WG1.

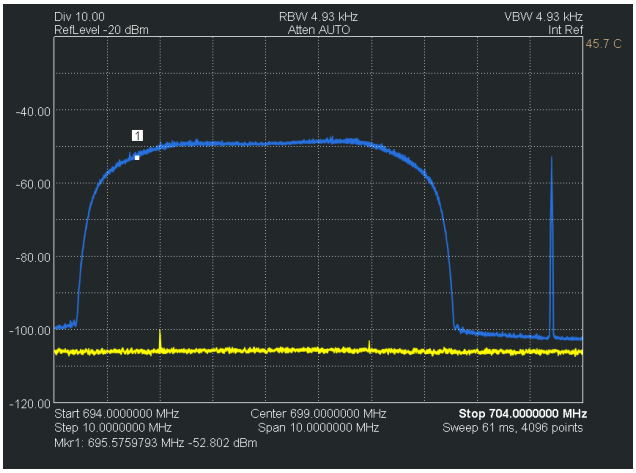

Figure 2-20 : Spectrum view: WSD in TV channel 49 (6 MHz) and a WM operating in TV channel 50 (200 KHz).

3 CRS-i effort towards standardization of device-to-device communications

3.1 Scope of the standardization work

The standardization work on D2D technologies in 3GPP started in 2011 as part of the 3GPP Release 12 (Rel12), which is due to be “frozen” (i.e. no functional change permitted after this date) in June 2014. The work is done under the Work Item “Proximity Services” (or ProSe) and has well progressed, but the volume of required specifications to serve the identified requirements is largely exceeding the capabilities of 3GPP for Rel12 (given also the other topics of Rel12): therefore a procedure for prioritizing the requirements and work in Rel12 has been initiated and has initially been concluded by end of 2013.

The work on D2D technologies in 3GPP is focused on a set of use cases, which were identified to fit the needs of both public safety and commercial mobile networks. Use cases can be defined by various services offered in various situations. The core features identified by ProSe are: direct discovery, direct 1:1 communication and direct 1: many communication. Here "direct" means making use of the direct radio interface between the devices instead of going through the network infrastructure, this use being under the control of the network operator, either on-line control (i.e. by making use of cellular links of the users) or off-line control (e.g. through pre-configuration of users’ equipment’s). The direct discovery feature is designed to support a new service, offering to users to "discover" other users (and associated characteristics) in the vicinity. The direct 1:1 communication feature is designed to support the usual data communication service between 2 users. Finally, the direct 1: many communication feature is designed in order to support a new groupcast data service among a group of users in close locations.

For each of these services, 3GPP will have to consider the managements of QoS, of security and of service continuity: the level of performance targeted for these has not yet been thoroughly discussed. In addition to direct communication features (1:1 and 1: many), 3GPP defines a UE-relaying feature which is used for public safety scenarios, with 2 different variants: UE-to-Network relaying (when a UE is relayed to the network by another UE) and UE-to-UE relaying (when a UE is relayed to another UE through a 3rd one).

The work on ProSe for Rel12 is now completed in SA WG1 (Requirements) where the Technical Specification TS 22.278 has been frozen. The work in SA WG2 (System Architecture) is reaching the end of the feasibility stage: the Technical Report (non-normative document) TR 23.703 has been assembled, compiling all proposed solutions for system architecture, and should be frozen in January 2014 at the latest, before the normative work starts to produce a proper Technical Specification. The work in RAN1 (Radio Layer1) is in the middle of the feasibility stage with compilation of proposal for solutions but also evaluation models (channel, traffic, mobility) in TR 36.843. The work in RAN2 (Radio Layer2 and Layer3-Radio Resource part) is in the first part of the feasibility stage, with discussions on core options for the design of the solution, and will partly have to wait for completion of the RAN1 work. The work in CT1 (Non-Access Stratum protocols) has not yet started and will mostly wait for the completion of the normative work in SA2.

Device-to-Device and 3GPP
In 3GPP, standard specifications for Device-to-Device (or D2D) Discovery and Communication are to be developed by “Proximity Services” (or ProSe) Study and Work Items for 3GPP Release 12.
For 3GPP, the direct over-the-air exchanges between devices can be:

- either based on a new air interface (designed by 3GPP RAN)
- or based on WLAN air interface

Work/Study Items are created on a per-Technical Group (TG) basis and progress is tracked on a per-TG basis. Study Items are for feasibility studies and deliver Technical Reports, which are non-normative documents, used to feed the subsequent (if any) normative phase which deliver Technical Specifications. Working Groups reports and specifications have to go through an approval process by their own Technical Specifications Group. Technical Reports are not maintained. Figure 3-1 presents the 3GPP structure.

Figure 3-1: 3GPP structure.

Reminder of work prioritization in 3GPP Release 12

In September 2013, TSG SA reviewed the Rel-12 progress in different working groups. Due to the important activities in the radio access area, not only due to proximity services, 3GPP TSG RAN proposed to reduce the scope of proximity services in Rel-12. Similarly, experimenting an overload situation, 3GPP WG SA2 proposed to limit Rel-12 to a list of essential features. Based on these information, 3GPP TSG SA decided to limit the proximity features for Rel-12 to discovery and public safety group communication.

Reference documents for ProSe

- SA1:
  - TR 22.803 “Feasibility study for Proximity Services (ProSe)”
  - TS 22.278 “Service requirements for the Evolved Packet System (EPS)”
  - TS 22.115 “Service aspects; Charging and billing”
  - TS 21.905 “Vocabulary for 3GPP Specifications”
- SA2:
  - TR 23.703 “Study on architecture enhancements to support Proximity Services (ProSe)”
  - TS 23.303 “Architecture enhancements to support proximity services (ProSe)” – TS skeleton available in S2-134458
- RAN1 & RAN2:
  - TR 36.843 “Feasibility Study on LTE Device to Device Proximity Services - Radio Aspects”
- CT1:
  - TS 24.333 “Proximity-services Management Object (MO)”
  - TS 24.334 “Proximity-services (Prose) User Equipment (UE) to Proximity-services (ProSe) Function aspects (PC3); Stage 3”

Summary of progress of Work Items across WGs

Release 12

Group Communication System Enablers for LTE (GCSE_LTE)

This work item is inked to Rel-12 FS_ProSe TR 22.803 Study on Proximity-based Services. External requirements are from: NIST, MESA, APCO Global Alliance, TCCA. Aim is to specify 3GPP system enablers to support group communication over LTE for Public Safety

Stages: 1/2/3
Completion: 89%
Last updated: 2014-09-07
Related specifications:

Spec	Title	WG
23.468	Group Communication System Enablers for LTE (GCSE_LTE); Stage 2	S2
23.768	Study on architecture enhancements to support Group Communication System Enablers for LTE (GCSE_LTE)	S2

Proximity-based Services (ProSe)

SP#65 SA3 updated the SA-wide WID SP-140300=>SP-140574 (Moved the TR phase to Rel-13 as a stand-alone Study). Triggered by Rel-12 TR 22.803 Study on Proximity-based Services (FS_ProSe) UID_530044

Stages: 1/2
Completion: 78%
Last updated: 2014-09-15
Related specifications:

Spec	Title	WG
23.401	General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access	S2
22.115	Service aspects; Charging and billing	S1
23.703	Study on architecture enhancements to support Proximity-based Services (ProSe)	S2
22.278	Service requirements for the Evolved Packet System (EPS)	S1
23.303	Proximity-based services (ProSe); Stage 2	S2
33.833	Study on security issues to support Proximity Services	S3
33.303	Proximity-based Services (ProSe); Security aspects	S3

Study on Proximity-based Services (FS_ProSe)

SP#59 completed
Stages: 1/2/3
Completion: 100%
Last updated: 2013-02-19
Related specifications:

Spec	Title	WG
22.803	Feasibility study for Proximity Services (ProSe)	S1

Study on LTE Device-to-Device Proximity Services - Radio Aspects (FS_LTE_D2D_Prox)

RP#63 completed. TR 36.843 for 1-step approval (90% complete). Started normative work. Linked to Rel-12 TR 22.803 Study on Proximity-based Services (FS_ProSe) and Feature ProSe

Completion: 100%
Last updated: 2014-03-14
Related specifications:

Spec	Title	WG
36.843	Study on LTE device to device proximity services; Radio aspects	R1

Release 13

Enhancements to Proximity-based Services (eProSe)

Objectives:
To support stage 2/3 development during Release 13.
To support end-of-release 12 maintenance to review and ensure that Release 13 TS 22.278 and TS 22.115 contain all agreed ProSe Stage 1 requirements. These service requirements are to be copied from Release 12 TS 22.278 and TS 22.115 prior to removal of unfulfilled service requirements from Release 12 as per process for handling WIDs across releases.
The topics likely to be addressed in this process are:

- ProSe E-UTRA Communication between two ProSe-enabled UEs
- Restricted discovery
- Public safety out of coverage discovery
- UE-to-Network & UE-to-UE Relays
- Requesting Discovery Range Class
- Service continuity
- Moving of a user traffic session path
- WLAN QoS consideration
- Some WLAN roaming requirements
- Some third-party application interaction requirements

No new service requirements will be added under this WID.

Stages: 1/2
Completion: 11% (WID)
Last updated: 2014-09-05
Related specifications: none yet

Study on Security for Proximity-based Services (FS_ProSe_Sec)

SP#65 updated WID SP-140300=>SP-140629 (Moved the TR phase to Rel-13 as a stand-alone Study). Completion 09/14=>06/15. SP#64 TR 33.833 v100 for Information

Completion: 95%
Last updated: 2014-09-15
Related specifications:

Spec	Title	WG
33.833	Study on security issues to support Proximity Services	S3

SA2
Progress
The Technical Report 23.703 v1.2.0 has been sent for approval to the SA plenary meeting SA#63: this document is the outcome of the “feasibility study” phase in SA2, it compiles the solutions proposed and evaluated during this phase and will not be maintained. The Technical Specification 23.303 v1.0.0 has been sent for approval to the SA plenary meeting SA#63. The following features have been standardized:

- ProSe Direct 1-to-many communication (in and out of E-UTRAN coverage)
- ProSe Direct discovery

- EPC-assisted WLAN direct discovery and communication
- EPC-level discovery (no D2D exchanges)
- User Equipment (UE) to Network Relay
- ProSe identities for ProSe communication
- ProSe identities for ProSe discovery
- Roaming considerations
- Configuration and Capability Handling
- Charging
- Dynamic configuration/authorization for discovery

System Architecture

An architecture model has been designed and is shown in Figure 3-2. A ProSe Function is introduced in the network and has the following main roles:

- Provisioning (via the Direct Provisioning Function - DPF)
- Direct discovery management (e.g., allocation of ProSe Application code)
- EPC discovery (acting as a location services client)

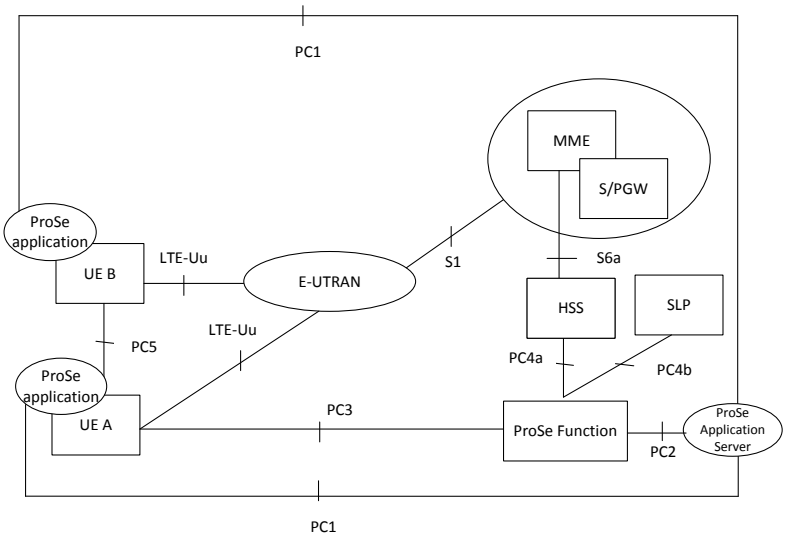

Figure 3-2: System architecture for ProSe.

Protocol stack

Two Protocol stacks have been designed for the device-to-device air interface, one for control-plane and one for user-plane (Figure 3-3). ProSe protocol is to be defined by RAN and CT WGs and Access Stratum stack is to be reviewed and finally decided in RAN WGs.

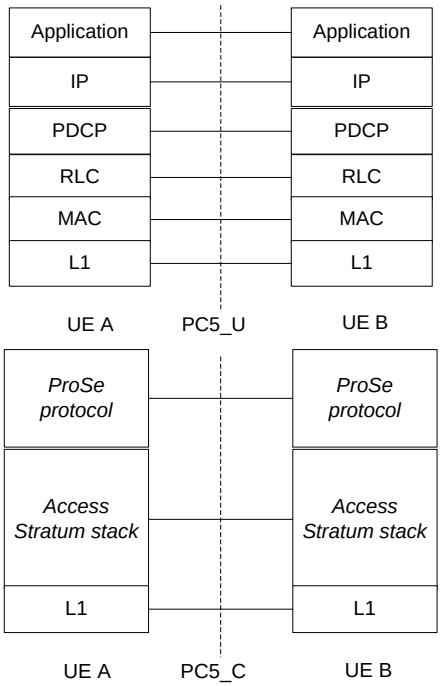

Figure 3-3: Protocol stacks for ProSe.

ProSe Discovery
Two models are supported:

- model A ("I am here"): wanting-to-be-discovered UE announces certain information that could be used by UEs in proximity that have permission to discover.
- model B ("who is there?"/"are you there?"): Discoverer UE send a Request containing information about what it is interested to discover.

UE-to-Network Relay
Relaying is performed at IP level.
Relays create one or more PDN connections dedicated to the relayed traffic.
Both IPv4 and IPv6 are supported. Address allocation is done using DHCPv4 for IPv4 or Stateless Address auto-configuration for IPv6.
Relaying of eMBMS traffic from Uu interface to PC5 is not expected to be supported in this release.

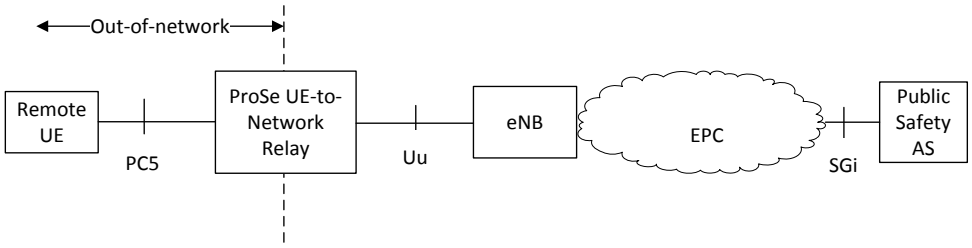

Figure 3-4: UE-to-Network Relay.

ProSe One-to-Many Communication
UEs are configured with Layer 2 Group ID & IP multicast address as described in Figure 3-5.

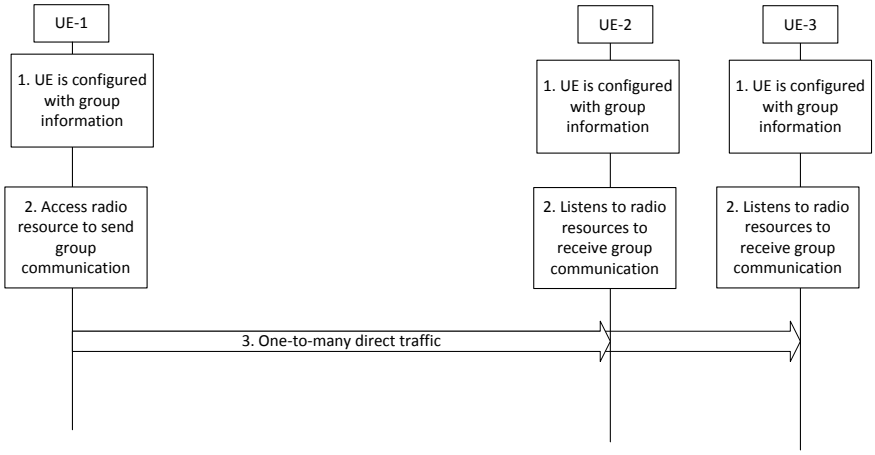

Figure 3-5: ProSe One-to-Many Communication.

ProSe configuration
OMA DM is used as the protocol to authorize and provision the UE. Authorization and provisioning is performed via the PC3 reference point

Outstanding issues

- The completion of Relay discovery procedures in SA2 is dependent on agreements in RAN to standardize the feature.
- The conclusion from SA3 (TR 33.833) may imply further update to the procedures.
- UE Relay requires discovery out of coverage feature, which is unlikely to be covered by RAN in Release 12.
- Even though the TS is considered 90% complete, some significant maintenance work will be needed to reach a stable specification.

RAN2
Resource Allocation
3GPP has defined two Radio Resource Allocation modes for ProSe Discovery and Communication: Autonomous and Scheduled:

- Autonomous Mode or AM (called “Type 1” for Disc and “Mode 2” for Comm) in this mode, a UE willing to perform a D2D transmission autonomously determines which RR to use, based on some multi-access protocol not yet defined by 3GPP. These RR must be chosen (by the UE) in a pool explicitly defined (and advertised) by the eNB.
- Scheduled Mode or SM (called “Type 2B” for Disc and “Mode 1” for Comm): In this mode, the eNB will allocate RR to UE for ProSe in a scheduled way, similar to the one used for cellular Uplink, as a response to request from the UE.

3GPP has defined that the choice of RRA mode for any UE is fully under the control of the operator. When out of coverage, a central entity (“Cluster Head”) may be entitled to play the role of scheduler for a group of UEs.

MAC functionality and header for ProSe Comm

- No Access Stratum signaling is required for group formation and Group ID allocation at access stratum level (Group IDs could e.g. be preconfigured or configured via higher layers).
- No Access Stratum signaling is required for configuring Source and Target IDs in the UE. This information is provided by higher layers. The MAC header comprises a L2 target ID which allows to filter out packets at MAC layer: the L2 target ID may be a broadcast, group cast or unicast address. It is FFS how these are represented in the MAC header. MAC sub header contains LCIDs (to differentiate multiple logical channels).
- The following MAC functions are needed: Multiplexing/demultiplexing, Priority handling and Padding.

Outstanding issues

- D2D Radio link/channel state measurements and reporting;
- New control/data channel structure;
- Inter-cell configuration;
- Detailed signaling.

CT1
In January 2014, CT WGs agreed a new Work Item proposal on CT aspects of Proximity-based Services (ProSe) [C1-140748]. The completion date of the WI is set to September 2014. First contributions to the WI are expected at next meeting (CT1#86bis, Dubrovnik, Croatia).

3.2 Legacy from OneFIT

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.

3.3 CRS-i involvement

CRS-i tracked and analyzed the progress of 3GPP ProSe work and, in particular, the key aspect of work prioritization leading to a tentative split between Rel12 and next release(s). This was reported to interested CRS cluster projects, including the provision of a tentative roadmap for Rel12 and beyond, in order for the CRS projects to check their intentions and schedule against the 3GPP direction.

In April 2014, Nokia Networks (formerly NSN) started to take over the responsibility for D2D aspects within CRS-i. This activity was started with a related presentation (Overview of D2D Proximity Services Standardization in 3GPP LTE) at the EuCNC2014 (European Conference on Networks and Communications) in Bologna, Italy.

Nokia Networks is actively involved in all 3GPP working groups, including the D2D proximity services aspects. Table 9 summarizes CRS-i contributions to D2D Proximity Services in 3GPP RAN.

Table 9: CRS-i contributions to D2D Proximity Services in 3GPP RAN (Nokia Networks, partly co-signed with other companies)

Meeting	Document Number	Document Title
3GPP R1-76b Shenzhen, April 2014	R1-141539	"Issues in D2D Discovery Signal Design"
3GPP R1-76b Shenzhen, April 2014	R1-141540	"Control of ProSe resource use"
3GPP R1-76b Shenzhen, April 2014	R1-141541	"D2D synchronization signal design"
3GPP R1-76b Shenzhen, April 2014	R1-141542	"Discussion on D2D synchronization procedure for communication and discovery
3GPP R1-76b Shenzhen, April 2014	R1-142447	"Scheduling assignment and related data transmissions"
3GPP R1-76b Shenzhen, April 2014	R1-142448	"Timing and resource pools of Type 2B discovery signals"
3GPP R1-76b Shenzhen, April 2014	R1-142449	"Dynamic control of D2D discovery resources"
3GPP R1-76b Shenzhen, April 2014	R1-142450	"Pattern design and resource allocation for discovery Type 2B "

3GPP R1-76b Shenzhen, April 2014	R1-142451	"Relationship between coverage conditions and D2D operation"
3GPP R1-76b Shenzhen, April 2014	R1-142452	"D2D synchronization signal design"
3GPP R1-76b Shenzhen, April 2014	R1-142453	"Synchronization procedure for D2D communication and discovery"
3GPP R1-76b Shenzhen, April 2014	R1-142454	"WAN protection by configurable D2D transmission power control"
3GPP R2-85b Valencia, April 2014	R2-141375	eNodeB control of UE transmission mode for D2D Communication
3GPP R2-85b Valencia, April 2014	R2-141376	RLC release in broadcast based D2D group communication
3GPP R2-86 Seoul, May 2014	R2-142677	Security aspects on D2D related common control information
3GPP R2-86 Seoul, May 2014	R2-142678	Resource allocation for D2D user data transmissions in Mode 2
3GPP R1-78 Dresden, August 2014	R1-143246	"Further discussion on scheduling assignments"
3GPP R1-78 Dresden, August 2014	R1-143247	"Patterns for scheduling assignments", Nokia Corporation
3GPP R1-78 Dresden, August 2014	R1-143248	"Timing and resource pools of Type 2B discovery signals"
3GPP R1-78 Dresden, August 2014	R1-143249	"Dynamic control of D2D discovery resources"
3GPP R1-78 Dresden, August 2014	R1-143250	"Randomization and performance for discovery Type 2B "
3GPP R1-78 Dresden, August 2014	R1-143251	"Pattern design and resource allocation signaling for discovery Type 2B "
3GPP R1-78 Dresden, August 2014	R1-143252	"On remaining details of D2D transmission power control "
3GPP R1-78 Dresden, August 2014	R1-143253	"D2D synchronization signal design"
3GPP R1-78 Dresden, August 2014	R1-143254	"Synchronization procedure for D2D communication and discovery"
3GPP R1-78 Dresden, August 2014	R1-143536	"T-RPT pattern design"
3GPP R1-78 Dresden, August 2014	R1-143537	"WF on Interference Control for Type 1 Discovery", Intel, LGE, Huawei, HiSilicon
3GPP R1-78 Dresden, August 2014	R1-143596	"T-RPT design"
3GPP R1-78 Dresden, August 2014	R1-143656	"SA resource definition and transmit patern design"
3GPP R1-78 Dresden, August 2014	R1-143431	"WF on Triggering Condition(s) of D2DSS Transmission"

3.4 Roadmap for the third year

The original roadmap for D2D in 3GPP is shown in Figure 3-6. However, LTE D2D has a large number of open items. For LTE D2D the finalization of all the intended issues can't be ensured by December 2014 and thus, there is risk of getting postponed to Rel-13.

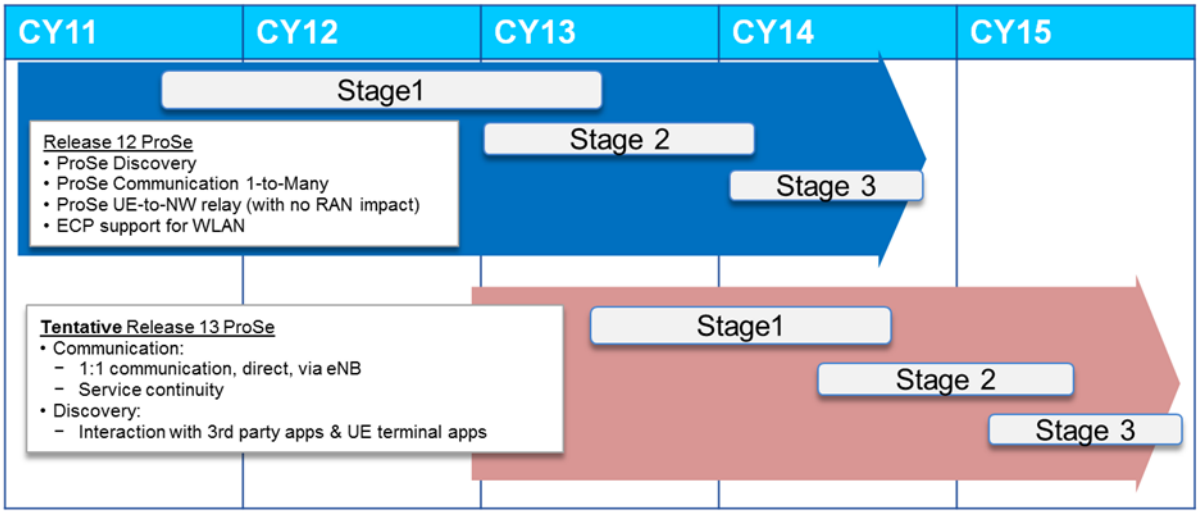

Figure 3-6: 3GPP RAN Roadmap for ProSe.

4 CRS-i effort towards standardization of Licensed Shared Access

4.1 Scope of the standardization work

Following the CEPT definition Licensed Shared Access is a regulatory approach aiming to facilitate the introduction of radiocommunication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under the LSA approach, the additional users are authorised to use the spectrum (or part of the spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorised users, including incumbents, to provide a certain Quality of Service (QoS).

The following three documents are in the scope of ETSI TC RRS. They have been developed or are under development, respectively, by its Working Group 1.

ETSI RRS TS 103 154 "System Reference Document; Mobile broadband services in the 2300 MHz – 2400 MHz frequency band under Licensed Shared Access regime"

Scope of work to be undertaken: This specification provided by this work item describes mobile broadband service in the 2300 – 2400 MHz band under Licensed Shared Access (LSA) regime. This band is allocated to the mobile service and identified for IMT globally in the ITU Radio Regulations. The objective of the LSA regime is to enable access to this band for mobile broadband services in those CEPT countries where access to the band is complex due to the incumbent uses. The LSA regime may require changes in the present regulatory framework for mobile applications regarding either intended or unwanted emissions.

This document has been published in 2013.

ETSI RRS TR 103 113 "System requirements for operation of Mobile Broadband Systems in the 2300 MHz- 2400 MHz band under Licensed Shared Access (LSA) regime"

Scope of work to be undertaken: This Technical Specification defines system requirements for operation of Mobile Broadband Systems in the 2300 – 2400 MHz frequency band under Licensed Shared Access regime. The Technical Specification 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). Therefore, this work is performed in a close liaison with the Joint Task Force ERM RRS (JTFER) related to EC Mandate M/512 and where applicable, additional requirements will also be provided by JTFER.

This document has been approved by ETSI TC RRS WG 1 in October 2014.

ETSI RRS TS 103 235 "System Architecture and High Level Procedures for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band"

Scope of work to be undertaken: This Technical Specification defines the system architecture for the operation of Licensed Shared Access, enabling operation of Mobile Broadband Systems under Licensed Shared Access regime. The architecture builds on the scenarios and applications described in ETSI TR 103 113 "Mobile Broadband Services in the 2 300 MHz - 2 400 MHz Frequency Band under Licensed Shared Access Regime", and the system requirements captured in ETSI TS 103 154 "System requirements for operation of Mobile Broadband Systems in the 2 300 MHz - 2 400 MHz band under Licensed Shared Access (LSA) regime. The scope of the work will be to define the architecture of a system which enables LSA following the requirements developed in TS 103 154. The Technical Specification 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).

This document is still under development. The finalization is expected in the first quarter of 2015.

4.2 Legacy from COGEU

COGEU has developed a framework for sharing the TVWS spectrum, which is very much in line with the 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 [16]. 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.

4.3 CRS-i involvement

Nokia Networks is participating in all meetings of ETSI TC RRS WG1 related with LSA. Nokia Networking is contributing by written contributions and discussion. It is also presenting the actual status in several conferences and publications (EUCNC 2014 and IEEE CCS 2014), as well as directly (by CRS-i guidance) to related European projects.

There have been the following f2f meetings since November 2013:

- 9.-13.12.2013, Mainz, Germany
- 3.-7.3.2014, Paris, France
- 23.-27.6.2014, Montreal, Canada
- 22.-26.9.2014, Mainz, Germany

Table 11 summarizes CRS-i contributions to LSA in ETSI RRS during the reporting period (Nov. 2013-Oct. 2014).

Table 10: CRS-i contributions to LSA in ETSI RRS (Nokia Networks and partly co-signed with other companies).

RRS1-conf call	RRSWG1(13)100157	Further Functional Requirements for TS 103 154
RRS1-conf call	RRSWG1(13)100159r1	Text proposal – Functional System Requirements for LSA – Security
RRS1#25	RRSWG1(13)001013r1	Text proposal – Functional System Requirements for LSA: Resource Grant
RRS1#25	RRSWG1(13)001014r1	Text proposal – Resource Grant Performance Requirements
RRS1#25	RRSWG1(13)001010r1	Further Functional Requirements for TS 103 154
RRS1#25	RRSWG1(13)001009r2	Text proposal for section 6.4 of TS 103 154
RRS1-conf call	RRSWG1(13)000046r2	Draft New Work Item on LSA Architecture
RRS1-conf call	RRSWG1(14)100092r2	LSA Scenarios and Use Cases

RRS1-conf call	**RRSWG1(14)100061**	Comments and proposed changes to updates to TS 103 154
RRS1-conf call	**RRSWG1(14)100073**	Proposed Changes to TS 103 154
RRS1#27	**RRSWG1(14)027015r2**	Proposed Changes to TS 103 154
RRS1#27	**RRSWG1(14)027020**	Phased Standardization Approach for LSA
RRS1-conf call	**RRSWG1(14)100084**	Draft TP on LSA Architecture High Level Functions and Mapping
RRS1-conf call	**RRSWG1(14)100083r4**	Text proposal for the initial sections of TS 103 235

4.4 Roadmap for the third year

The aim was to finalize the LSA requirement specification (stage 1) until September 2014 which has been reached. The next step is the finalization of the architecture specification (stage 2), postponed to the first quarter of 2015. The stage 3 documents (protocols) may, probably at least some of them, be specified by 3GPP working groups. Related liaison statement(s) will be provided probably in December 2014.

In December 2014, there will be an ETSI RRS workshop, co-located with the TC RRS meeting, in Sophia Antipolis, France. At this workshop, Nokia Networks will provide, together with Qualcomm, a tutorial on LSA.

5 CRS-i effort towards standardization of CR for Public Safety

5.1 Scope of the standardization work

In November 2011 the European Commission issued mandate M/512 - "Standardisation Mandate to CEN, CENELEC and ETSI for Reconfigurable Radio Systems" [5]. M/512 includes three main objectives, as depicted in Table 11.

Table 11: The three main objectives from EC M/512.

Objective	Domain	Objective Description
Objective A	Commercial	Targets the deployment and operation of cognitive radio systems (CRSs) including white space devices (WSD) and devices under Licensed Shared Access regime, dependent for their use of radio spectrum on information obtained from geo-location databases (GLDB).
Objective B	Civil Security and Military Applications	Targets the standardization of suitable SDR architecture(s) (SCA-based for the military domain). The ideal situation would be a single architecture fulfilling the requirements of both domains.
Objective C	Commercial, Civil Security and Military Applications	Explores potential areas of synergy among commercial, civil security and military applications

While Objective B is still pending, Objectives A and C have been accepted by ETSI in 2013. CRS-i participation in the ETSI RRS Technical Body has contributed to considerably progress on developing standards in accordance to Objective A of the mandate, as described in Section 4.

The CRS-i effort towards standardization of CR for Public Safety addresses Objective C of EC Mandate M/512 is defined as follows:

Objective C: to explore potential areas of synergy among commercial, civil security and Military applications. These include the following:

- Architectures and interfaces for dynamic use of spectrum resources among commercial, civil security and/or military domains for disaster relief. This objective will require collaboration with spectrum regulatory organizations.
- Reconfigurable mobile device architecture for commercial and civil security applications.
- Other potential synergies to be identified.

As depicted in Table 12, three phases are identified by the Objective C of EC Mandate M/512.

Table 12: The EC M/512 phases, adapted from [4]

C1	Phase 1 - Feasibility study	This phase will explore potential synergies across the commercial, civil security and military domains in the medium/long term (5-15 years in the future) as described in Objective C.
C2	Phase 2 - Proposal of a Work Programme	This phase involves the development of a comprehensive work programme addressing one or more tasks identified in Objective C. This phase may also include the identification of user requirements and a risk analysis.
C3	Phase 3 - Execution of the Work Programme	Depending on the definition of the work programme from Phase 1, this phase will deliver one or more standardization deliverables related to: a) Definition of the network interfaces and architectures for dynamic use of spectrum resources among commercial, civil security and/or military domains for disaster relief. b) Definition of the architecture and interfaces for reconfigurable mobile devices for commercial and civil security applications. c) Other potential synergies to be identified.

5.2 CRS-i involvement

CRS-i was heavily involved in preparing the ETSI Technical Report (ETSI TR 103 217) on Phase 1 – Feasibility Study. Realizing the difficulties on gathering information on the major stakeholders, CRS-i has proposed and contributed to the development of the ETSI RRS WG4 Questionnaire on Exploitation of Inter-Domain Synergies. The questionnaire can be downloaded on the ETSI RRS web page [6].

CRS-i has also invited EMPHATIC[1] and SALUS[2] research projects to contribute to Phase 1. More specifically, EMPHATIC interests are on contributing to PPDR/civil PMR access to spectrum resources of Commercial and/or Military Systems and SALUS contribution mainly targets suitable business models that could potentiate synergies among commercial, civil security and military applications. Current EMPHATIC contribution targets the use of Filter Bank Multi-Carrier (FBMC) structures that will permit to optimize the spectrum efficiency for the deployment of a new PPDR Broadband system in a band already occupied by narrowband PMR systems.

In parallel, CRS-i has participated in the ETSI RRS WG4 meetings, as depicted in Table 13.

Table 13: RRS WG4 meeting attendance

Date	Meeting	Reference	Meeting work item(s)
27-May-2014	RRS4-Phone Call	15459	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies»
24-Jun-2014	RRS4#15	15502	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» • Liaison Statements with stakeholders (possibly FM49, NATO, EDA, Cassidian/Airbus Space and Defense, Rohde&Schwarz, Selex, Thales, UIC, TC TETRA)
29-Jul-2014	RRS4-Conf Call	15748	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» • Analysis of the FM49 document, “On the Future Architecture of Mission Critical Mobile Broadband PPDR Networks” • Discussion on the procedures to collect feedback from stakeholders – Questionnaire is proposed.
15-Sep-2014	RRS4-Conf Call	15749	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» • Questionnaire set-up «Exploitation of Inter-Domain Synergies»
23-Sep-2014	RRS4#16	15557	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» ○ PPDR/civil PMR Access to spectrum resources of Commercial and/or Military Systems – use of Filter Bank Multi-Carrier solution • Questionnaire discussion and approval «Exploitation of Inter-Domain Synergies»

5.3 Roadmap for the third year

[1] FP7 ICT EMPHATIC research project - Enhanced Multicarrier Techniques for Professional Ad-Hoc and Cell-Based Communications, available at: www.ict-emphatic.eu/

[2] FP7 SEC SALUS research project - Security and interoperability in next generation PPDR communication infrastructures, available at: www.sec-salus.eu/

CRS-i will continue to actively participate in ETSI towards finalizing the TR 103 217 document. Following the conclusion of Phase 1, if the study has shown the feasibility for synergies, CRS-i will contribute to the delivery of a work programme (phase 2) addressing the tasks identified in EC M/512 Objective C. This will include continued collaboration with EMPHATIC and SALUS research projects and potentially new projects that may share similar goals.

6 Conclusions

This deliverable reports how the FP7 projects QoSMOS, COGEU, SACRA and OneFIT extended their standardization activities after their lifetime thanks to the support of the coordination action CRS-i. The main achievements during the reporting period are summarized below:

- CRS-i continued to foster FBMC technology into the IEEE P1900.7 draft standard. Today FBMC is considered as one of the options for future 5G PHY. Then, having the first standard implementing this technology is an interesting step forward and QoSMOS, then CRS-i involvement in this regards, need to be acknowledged.
- Regarding the standardization of TVWS technologies done under ETSI RRS WG1, CRS-i supported the setting up of a new Work Item, the EN 303 387-1 "Signaling Protocols and information exchange for coordinated use of TV White Spaces; Part 1: Interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC)".
- CRS-i extended the work done in COGEU towards the implementation and validation of the protocol to access white spaces database (IETF PAWS). A draft implementation of PAWS v0.12 is ready to be demonstrated.
- The Ofcom TVWS pilot represents an important milestone in the realisation of TVWS technology in Europe. CRS-i has been actively involved in the Ofcom pilot through cooperation with the ACROPOLIS and the SOLDER projects and teams from the EC-JRC and NICT (Japan). CRS-i led two trials: sensing of wireless microphones and a coexistence study between WSD and PMSE operating in adjacent channels. The results were forwarded to Ofcom and will feed the ongoing discussion in ETSI RRS WG1.
- The standardization work started in FP7 COGEU on LSA continued in ETSI RRS WG1 where 14 contributions were submitted.
- The standardization work started in FP7 OneFIT on D2D (ProSe) continued in 3GPP RAN where 30 contributions were submitted.
- CRS-i was heavily involved in preparing the ETSI Technical Report (ETSI TR 103 217) on Phase 1 – Feasibility Study. Realizing the difficulties on gathering information on the major stakeholders, CRS-i has proposed and contributed to the development of the ETSI RRS WG4 Questionnaire on Exploitation of Inter-Domain Synergies.

In general the CRS-i participation in the ETSI RRS Technical Body has contributed to considerably progress on developing standards in accordance to the objectives of the EC mandate M/512.

The standardization activities of CRS-i partners will continue in the third year project through the implementation of T3.2: “CRS-i task forces”.

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