CRS-i

FP7 – 318563
Coordination Action

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

D3.5
Assessment of contributions to standards and regulation via CRS-i task forces - final

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Abstract:
This deliverable summarizes the contributions from CRS-i project to standards and regulation related with cognitive radio and dynamic spectrum access.

Keyword list: Standardization, Cognitive radio, Dynamic Spectrum Access, Licensed Shared Access, Proximity Services

Executive Summary

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.

This deliverable summarizes the overall contribution from CRS-i project to standards and regulation related with cognitive radio and dynamic spectrum access. It was shown that the role of CRS-i to monitor and contribute to standardization and regulation bodies was efficiently carried out, as a continuation of the QoSMOS, COGEU, SACRA and OneFit legacy, and later as CRS-i or through collaborations with other projects. CRS-i partners were directly involved in the standardization activities of ETSI RRS WG1, ETSI RRS WG4, IETF PAWS, IEEE DySPAN 1900, 3GPP RAN.

During the lifetime of the CRS-i project, 8 Standards were finalized with strong participation from CRS-i partners:

- **ETSI TS 103 143** “System Architecture for Information Exchange between different Geo-Location Databases (GLDBs) enabling the operation of White Space Devices (WSDs) - Jan. 2015.
- **ETSI TS 103 145** “System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of White Spaces” - Jan. 2015
- **ETSI TR 103 113** “System Reference Document; Mobile broadband services in the 2300 MHz – 2400 MHz frequency band under Licensed Shared Access regime” - July 2013.
- **ETSI TS 103 154** “System requirements for operation of Mobile Broadband Systems in the 2300 MHz- 2400 MHz band under Licensed Shared Access (LSA) regime” - Oct. 2014.
- **ETSI TS 103 235** “System architecture and high level procedures for operation of Licensed Shared Access (LSA) in the 2 300 MHz - 2 400 MHz band” - Oct. 2015
- **IETF PAWS** (“Protocol for Communication between White Space Device and White Space Database”) - May 2015.
- **IEEE 1900.7** “White Space Radio Working Group” – Oct.. 2015.
- **3GPP RAN TR 22.803** “Feasibility study for Proximity Services (ProSe)” - June 2013

The number of standardization activities where CRS-i has contributed and the attention CRS-i experienced from various sides evidence that the Coordination Action achieve its objectives.

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List of Abbreviations

CEPT	Conference of European Postal and Telecommunications Administration
CR	Cognitive Radio
CRS	Cognitive Radio Standardization – cluster projects
D2D	Device-to-Device
DVB-T	Digital Video Broadcast – Terrestrial
DSA	Dynamic Spectrum Access
ECC	Electronic Communications Committee
EU	European Union
ERM	Electromagnetic compatibility and Radio spectrum Matters
ETSI	European Telecommunication Standards Institute
IEEE	Institute of Electrical and Electronics Engineers
ITU	International Telecommunication Union
JTFER	Joint Task Force ERM / RRS
LC	LSA Controller
LR	LSA Repository
LSA	Licensed Shared Access
LSRAI	LSA Spectrum Resource Availability Information
LTE	Long Term Evolution
MFCN	Mobile/Fixed Communications Networks
Ofcom	Office of Communications (UK)
PAR	Project Authorization Request
PHY	Physical layer
RAS	Radio Access and Spectrum – cluster projects
RRS	Reconfigurable Radio systems
SDO	Standards Developing Organization
TVWS	TV White Spaces
WG	Working Group
WSD	White Space Devices
WSDB	White Spaces Data Base

1 Introduction

The CRS-i project has contributed to the transfer of European research results towards standardization and regulation bodies. The actions carried out by the CRS-i standardization task force and the regulation task force was threefold.

First, CRS-i members continued to monitor standardization and regulation activities in the field of cognitive radio. ETSI, IETF, IEEE and 3GPP were the key targets as far as standard bodies are concerned. Those standard bodies are very active in the field and it is important to understand each project’s timeline and standardization expectations for appropriate contribution. Regarding regulation, the activities of the task force were focused on activities in Europe, namely by the CEPT and RSPG and in France as part of the “Mission Spectre” of the French Government.

Second, CRS-i, through its project cluster (CRS) informed European research projects on how, where and when to contribute in order to maximize standardization impact.

Finally, CRS-i contributed, often in conjunction with other projects, to standardization bodies, based on its knowledge of the standard timeline and also on the standardization procedures, which is often depicted as a roadblock by research projects.

This deliverable is an update of D3.2 “D3.2 Assessment of contributions to standards and regulation via CRS-i – initial feedback from CRS cluster projects and measures for improvement” where the outcome of the CRS-i task forces are reported. The core of this deliverable is divided in the following parts. Chapter 2 provides an assessment of CRS-i contributions to standards. The overall number of standardization bodies is significant, and CRS-i decided to focus its contributions in order to guarantee impact. Chapter 3 provides an assessment of CRS-i contributions to regulation bodies. The contribution concerns National Bodies (e.g. ANFR, ARCEP) and transnational bodies (e.g. CEPT, RSPG). Contributions to CEPT are expected from national regulators and it is therefore difficult for a project such as CRS-i to have direct impact. However, monitoring activities in these bodies is vital for CRS-i as a means to understand the requirements that will rule future Cognitive Radio technologies. Chapter 4 provides a list of standardization reports produced by CRS-i in order to inform other EU projects about the status of standardization activities. Chapter 5 provides a list of scientific publications produced by CRS-i. Finally Chapter 6 (Conclusion) provides an overall assessment of CRS-i impact on standards.

2 Assessment of contributions to standards

2.1 Standardization of TV white space access

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.

2.1.1 ETSI Reconfigurable Radio systems (RRS) WG1 – System Aspects

- **TS 103 143** “System Architecture for Information Exchange between different Geo-Location Databases (GLDBs) enabling the operation of White Space Devices (WSDs)

  To develop a European standard for the architecture and procedures for information exchange between different GLDBs enabling the operation of Cognitive Radio System (CRS). The parameters and procedures for such information exchange, including security and reliability aspects.

  CRS-i involvement
  CRS-i has followed and contributed to the specification taking in consideration the European cross-border scenario that shall support automatic interchange of registration information of protected services among GLDB national administrators (e.g. updates on DTT coverage maps in cross-border areas).

  The specification has been published in January 2015.

- **TS 103 145** “System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of White Spaces”

  This technical specification defines the system architecture for the use of spectrum by White Space Devices (WSDs), specifically in the UHF TV Bands. The scope of the work is to define 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). This architecture, illustrated in Figure 2-1: , 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).

  CRS-i involvement
  CRS-i has followed and contributed to the specification taking in consideration the COGEU reference architecture. The proposed architecture for the coordinated use of White Spaces allows the possibility of using infrastructure sensing to complement the information received by the geo-location database (GLDB) which is a requirement of the COGEU project. Trading of TVWS as mechanism of prioritization and guarantee of predictable QoS, as proposed by the COGEU

project, is also possible to implement under the interfaces defined by the current draft of TS 103 145.

The specification has been published in January 2015.

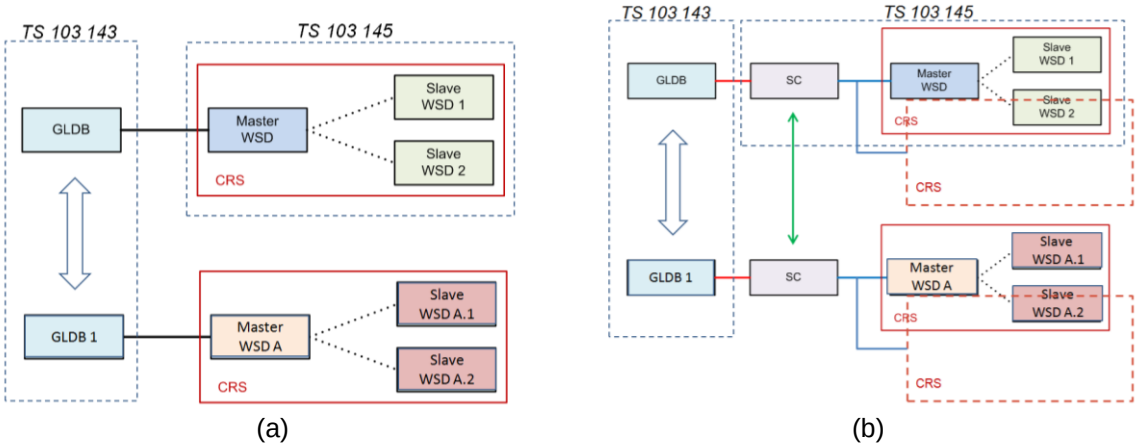

Figure 2-1: a) Architecture for uncoordinated use of White Spaces. (b) Architecture for coordinated use of White Spaces [1].

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). It was ensured 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.

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)

The CRS-i contributions to ETSI RRS WG1 on TVWS are listed in the Table 2-1. The ETSI RRS meeting #29 was hosted by IT in Aveiro (Portugal) from 30 March to 2 April 2015. During this meeting CRS-i assisted projects SOLDER, ADEL and WISHFUL to present research results.

Table 2-1: CRS-i contributions to ETSI RRS WG1 (White Spaces)

Date	Meeting	Meeting work item(s) and CRS-i contributions
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
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
1-5 Dec. 2014	ETSI RRS #28 F2F meeting in Sophie Antipolis, France	Working demo: Combination of TV White Spaces database with infrastructure sensing
30 March – 3 April, 2015	ETSI RRS #29 F2F meeting in Aveiro, Portugal	EN 303 143 (WI proposal at RRS(15)029010): “System architecture for information exchange between different Geo-location Databases (GLDBs) enabling the operation of White Space Devices (WSDs)” EN 303 145 (WI proposal at RRS(15)029009): “System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of TV White Spaces”
1-5 June 2015	ETSI RRS #30 F2F meeting in Seoul, Korea	-Minor modifications have been made in “System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of TV White Spaces” (REN/RRS-0144 / EN 303 145). -Minor modifications have been made in “System architecture for information exchange between different Geo-location Databases (GLDBs) enabling the operation of White Space Devices (WSDs)” (REN/RRS-0145 / EN 303 143)

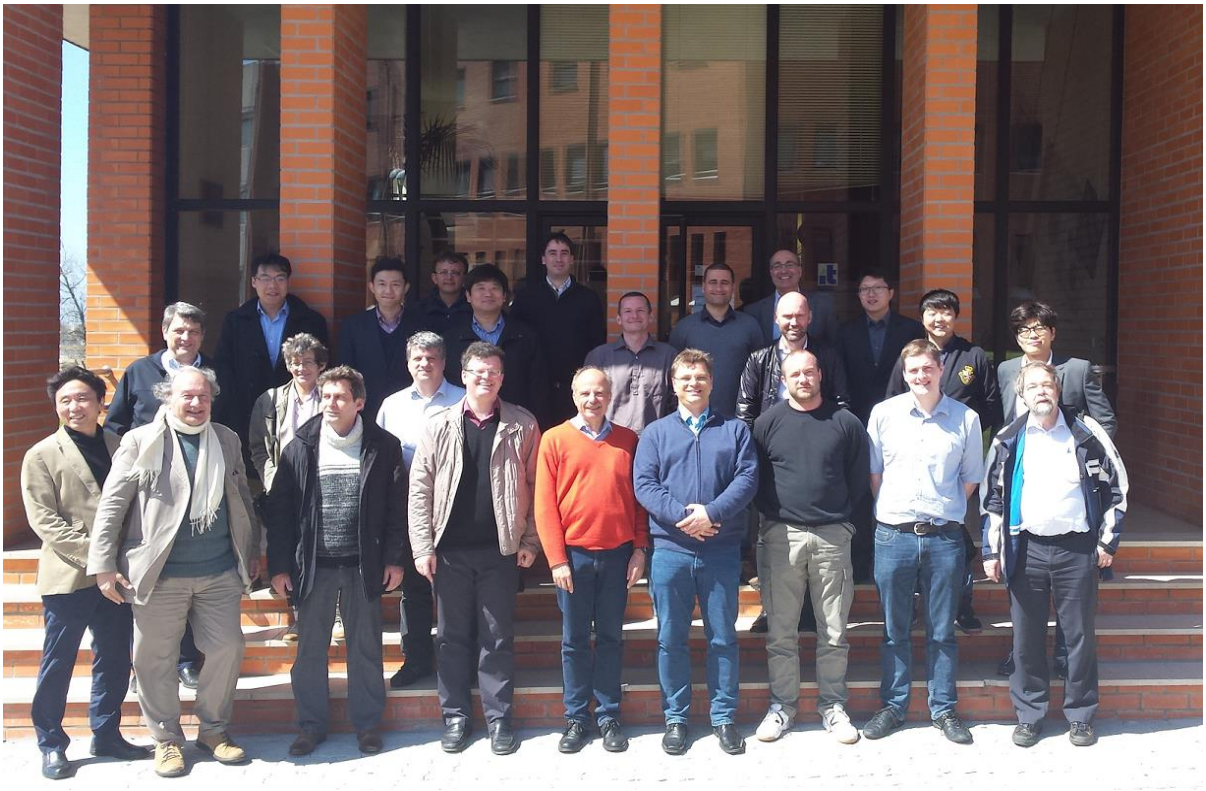

Figure 2-2: CRS-i partner IT hosted the ETSI RRS#29 meeting in Aveiro (Portugal).

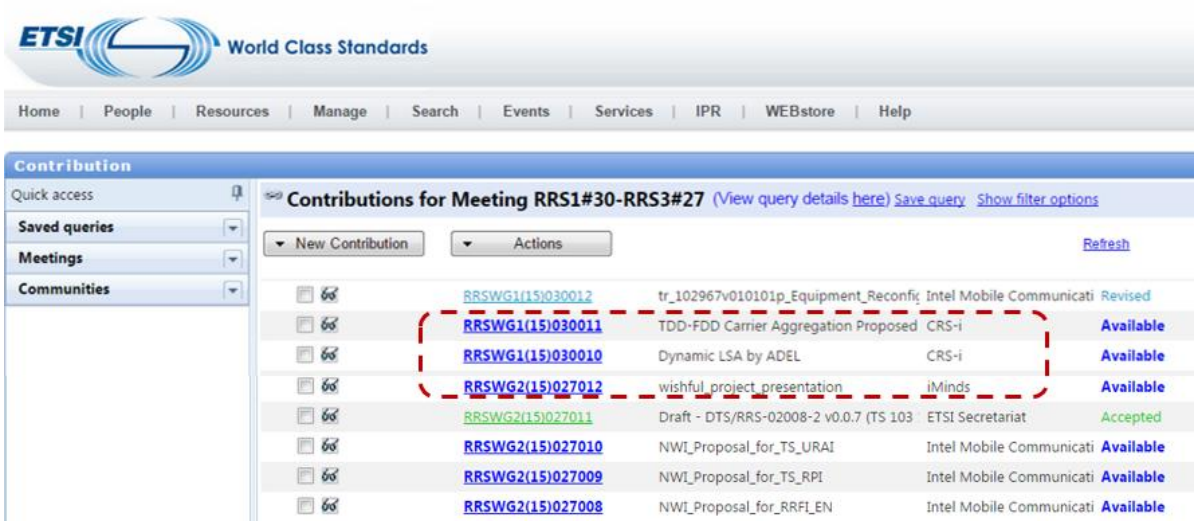

Figure 2-3: CRS-i assisted SOLDER, ADEL and WISHFUL to present results in ETSI RRS#29 meeting

2.1.2 IETF PAWS

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”) [2]. 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 2-4.

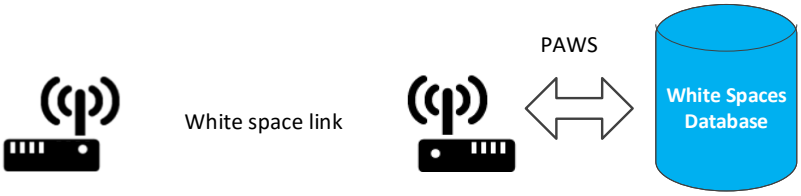

Figure 2-4: PAWS: Protocol for Communication between White Space Device and White Space Database.

CRS-i involvement in IETF PAWS:
After the end of COGEU (December 2012), the PAWS experienced significant progress being finalized in v20. CRS-i took over the work done in COGEU and implemented IETF PAWS. 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. The IETF PAWS WG was closed in May 2015.

The IETF PAWS standard was implemented and tested with the TV White Spaces database developed in the COGEU project. CRS-i produced and disseminated a YouTube video that shows how the protocol works[1].

[1] https://www.youtube.com/watch?v=90ij1d5ejxE

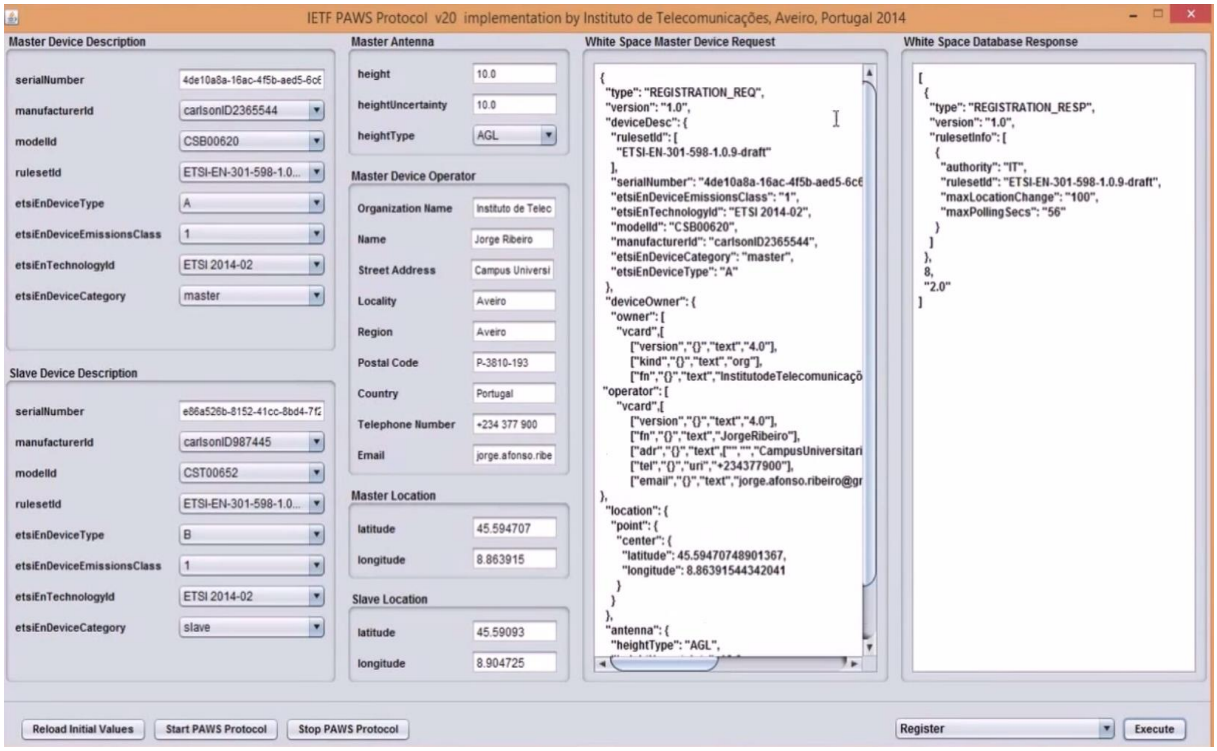

Figure 2-5: GUI presenting the message exchange between a WSD and the White Spaces Database, IETF PAWS.

2.1.3 IEEE DYSPAN-SC (P1900 family)

IEEE 1900.1 Working Group on "Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management"

IEEE 1900.1 aims to standardize terms and definitions in the field of dynamic spectrum access and related technologies. This effort shall provide a common understanding on such technologies among interested stakeholders. The baseline IEEE 1900.1 standard was published on September 26th, 2008 [3]. From February 2011 until December 2012 the 1900.1 Working Group worked on a new amendment project, IEEE 1900.1a, primarily aiming to incorporate updated terms and definitions from other IEEE 1900 Working Groups into the standard. This work, entitled "1900.1a:IEEE Standard Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management Amendment: Addition of New Terms and Associated Definitions" was published in January 2013 [4].
Since January 2013 the IEEE 1900.1 Working Group has been concentrating on preparing a root-and-branch revision of the original baseline standard that was published in 2008. It is intended that this revision will provide an up-to-date viewpoint on the associated fast-moving technology areas. It is also intended that this revision will enhance the informative content detailing the relationship between the various concepts covered by the standard.

CRS-i involvement in IEEE 1900.1:
CRS-i has been asked, besides other projects and individuals, to support this new activity of IEEE P1900.1. Specifically, as a project that aims to coordinate and foster the introduction of new concepts and results of research projects into standardization, CRS-i is asked to co-ordinate the collection of related new concepts and definitions from FP7 projects and to introduce them into the 1900.1 revision.

IEEE 1900.6a: “Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communication Systems Amendment: Procedures, Protocols and Data Archive Enhanced Interfaces”

The IEEE 1900.6-2011 specification was published on April 22nd 2011 [5]. Since June 2011, the 1900.6 Working Group works on a new project, 1900.6a: “Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communication Systems Amendment: Procedures, Protocols and Data Archive Enhanced Interfaces”. This Amendment to the IEEE Std 1900.6TM adds procedures, protocols and message format specifications for the exchange of sensing related data, control data and configuration data between spectrum sensors and their clients.

In addition, it adds specifications for the exchange of sensing related and other relevant data and specifies related interfaces between the data archive and other data sources. It provides specifications to allow integrating 1900.6 based distributed sensing systems into existing and future dynamic spectrum access radio communication systems. It enables existing legacy systems to benefit so as to widen the potential adoption of the IEEE 1900.6 interface as an add-on to these systems and to claim standard conformance for an implementation of the interface. In addition it facilitates sharing of spectrum sensing data and other relevant data among 1900.6 based entities and external data archives. This document has been finalized and went successfully through ballot procedures. The standard was approved on March 27th 2014. It is now available under the reference IEEE 1900.6a-2014.
One new work item has dealt with corrections and modifications of definitions that have been introduced in the base standard, in order to take new results into consideration. It is now available as a corrigendum entitled 1900.6-2011/Cor1. The Corrigendum is under sponsor ballot phase and shall be approved very soon. Publication of the corrigendum is expected in H1 2015.

Finally, 1900.6 WG has worked on a new amendment, namely IEEE P1900.6b “Standard for Spectrum Sensing Interfaces and Data Structures for Dynamic Spectrum Access and other Advanced Radio Communication Systems. Spectrum Database Interfaces Amendment.” The amendment considers a larger range of interfaces and most notably on the topic of the use of spectrum sensing information to support spectrum databases. At the time this report is written the group is refining the reference model.

CRS-i involvement in IEEE 1900.6a
A member of CRS-i is chairing the WG and several members are involved in finalising the draft standard, analysing the comments issued during the sponsor ballot.

IEEE 1900.7: “White Space Radio Working Group”
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 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).”

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.

CRS-i involvement in IEEE 1900.7
CRS-i has helped the FP7 project 5GNOW to efficiently steer its standardization towards timely contributions on PHY in response to a call for contribution issued by the IEEE 1900.7 group on Oct. 9th 2012. These contributions have been presented by CRS-i as joint 5GNOW/CRS-i contributions. These contributions are as follows:

- DCN 7-13-0010r2 “*PHY layer based on FBMC*” N. Cassiau, J-B.Doré, D. Noguet, Feb. 20th 2013, P1900.7 phone conference. This contribution presents some parameters and performance analysis for Filter Bank Multi Carrier (FBMC) physical layer. Bit Error Rate (BER) performance are presented for different modulation and coding schemes."
- DCN 7-13-0016 “*Overview of FBMC PHY*” N. Cassiau, J-B.Doré, D. Noguet, March 13th 2013, P1900.7 phone conference. This contribution presents some fundamentals of Filter Bank Multi Carrier (FBMC) physical layer.

- DCN 7-13-0047 “Adjacent-interference-on-SU-with-FBMC-vs-OFDM” D. Noguet, J-B. Doré, August 08th 2013, P1900.7 meeting, Arlington (VA), USA. This contribution shows that FBMC enables to exploit fragmented spectrum by different users without synchronization requirements.
- DCN 7-13-0067 “Novel backoff strategy for bottleneck remediation” B. Mawlawi, J-B. Doré, D. Noguet Dec. 02nd 2013, P19007 meeting, Tokyo, Japan. "This contribution presents a novel backoff strategy for CSMA/CA technique to improve the saturation throughput and statistical access delay. The aim of this contribution is to distribute users over all the backoff stages in order to solve the bottleneck problem presents in the first backoff stage."
- DCN 7-14-0012 “MAC Description”, B. Mawlawi, J-B. Doré, D. Noguet, April 8th 2014, Grenoble.
- DCN 7-14-0013 “MAC Architecture”, B. Mawlawi, J-B. Doré, D. Noguet, April 8th 2014, Grenoble.
- DCN 7-14-0025 “MAC” J-B. Doré, B. Mawlawi, D. Noguet, August 26th 2014. Draft Standard contribution.
- DCN 7-15-0010-01 “Cognitive Plane”, D. Noguet, J-B. Doré, March 24th 2015.
- DCN 7-15-0011r2 “D4 Channel Map”, D. Noguet, J-B. Doré, March 24th 2015. Draft Standard contribution.
- DCN 7-15-0027-00 “Synchronisation symbol” J-B. Doré, D. Noguet, April 9th 2015. Draft Standard contribution.
- DCN 7-15-0024-00-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0024-01-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0024-02-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0024-03-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0024-04-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0024-05-CMNT “Sponsor ballot comment resolution”, D. Noguet, J-B. Doré. Draft Standard contribution.
- DCN 7-15-0035-00 “MLME-BEACON-NOTIFY.indication primitive”, August 19th 2015. Draft Standard contribution.

At the time this report is written, the draft standard has been sent to IEEE Standardisation Association – Standard Board (SA-SB) for approval. The approval meeting will take place in December 2015 and Standard publication is expected in Q1 2016. **This is a major achievement of CRS-i and an excellent example where CRS-i has enabled to carry out a standardisation activity launched in a prior project – namely QoSMOS – and enabled to follow-up this activity and to support the underlying technology until the approval of the standard.**

Also, CRS-i managed to motivate 5GPPP projects to continue P1900.7 activities. For instance, IEEE P1900.7 is an identified standardisation target of the H2020 5GPPP SPEED-5G project. In the scope of SPEED5G, two proposals for a new PAR have been discussed in a phone conference that took place on October 7th, 2015. SPEED-5G considers IEEE P1900.7 as one of its standardisation target priorities.

Figure 2-6 gives an overview of the IEEE P1900.7 timeline and emphasizes the role of CRS-i in the standard development process. The ad hoc group on communication for white spaces was launched during FP7 QoSMOS where the first FBMC research applied to TVWS was carried out. Then, it was a clear mission of CRS-i to continue this activity and CRS-i indeed was a key enabler for CRS-i partners to contribute to the group. Also, CRS-i managed to attract other EU projects of the CRS-i cluster to be involved in the group. Namely, 5GNOW actively participated through 3 contributions and EMPHATIC expressed interest, though without contributing actively. In the scope of H2020, A significant number of projects will continue to have activities on FBMC in the 5G context (Fantastic5G, SPEED-5G, Flex5GWare, Metis II, mmMagic). As a consequence, the actions of CRS-i to maintain standardisation activities on FBMC will impact the future of WG 1900.7 (Speed-5G already submitted 2 contributions to discuss new topics to open new PARs) and also may impact 3GPP on FBMC technology.

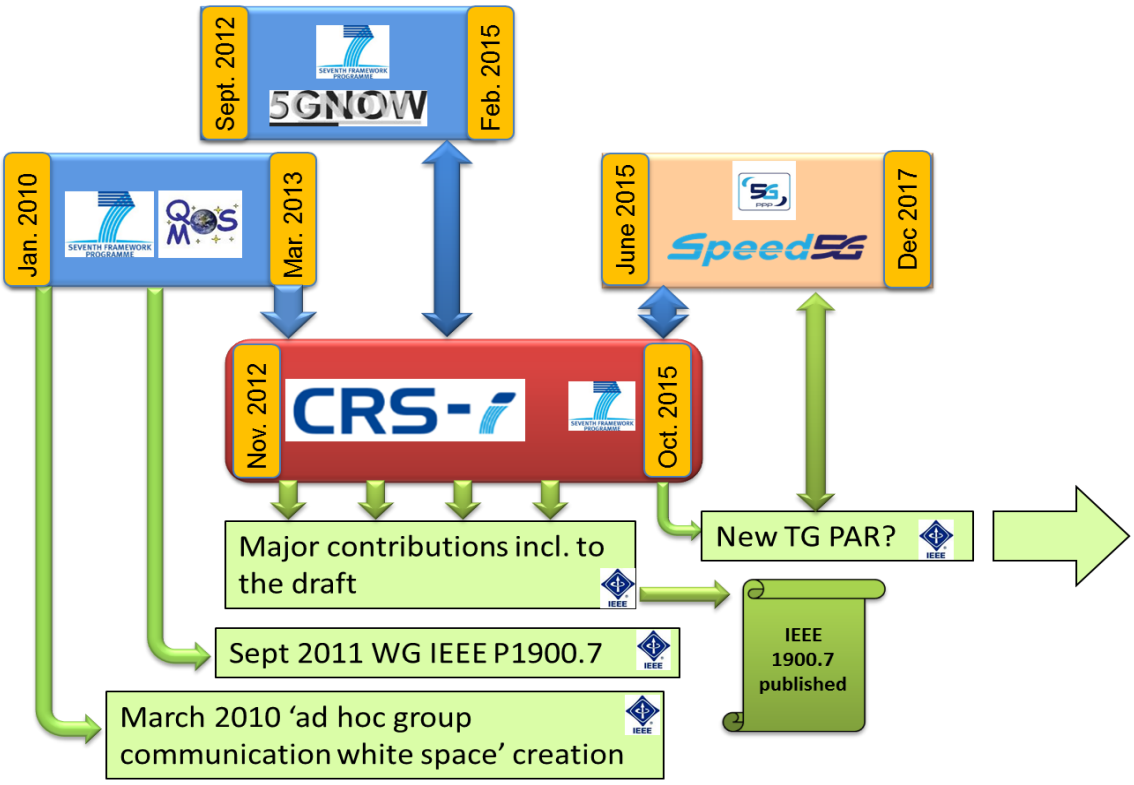

Figure 2-6: IEEE P1900.7 timeline stressing the role of CRS-i

Table 2-2: 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.
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
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
02/12/2014	DYSPAN-SC P1900.7 F2F Singapore	D3 comment resolution (7-14-0039r1)
02/12/2014	DYSPAN-SC P1900.7 F2F San Diego	D3 abbreviations (7-14-0040)
24/03/2015	DYSPAN-SC P1900.7 F2F San Diego	Cognitive Plane (7-15-0010-01)
24/03/2015	P1900.7 PhC	D4 Channel Map (7-15-0011r2)
09/04/2015	P1900.7 PhC	Mapping on physical channel - update to section 7.5
30/07/2015	P1900.7 PhC	Synchronisation symbol (7-15-0027-00)
28/07/2015	P1900.7 PhC	Sponsor ballot comment resolution (7-15-0024-00-CMNT)
29/07/2015	P1900.7 PhC	Sponsor ballot comment resolution (7-15-0024-03-CMNT)
12/08/2015	P1900.7 PhC	Recirculation sponsor ballot comment resolution (7-15-0031-01-CMNT)
19/08/2015	P1900.7 PhC	MLME-BEACON-NOTIFY.indication primitive (7-15-0035-00)

2.2 Standardization of Licensed Shared Access (LSA)

To meet the unprecedented demand for mobile broadband services, LTE-A and 5G networks will take advantage of different types of spectrum bands, namely, exclusively licensed bands, license-exempt bands, and shared bands. In the future, the role of shared bands is likely to increase as the new means to respond to the growing traffic demand in a timely fashion. The new Licensed Shared Access (LSA) regulatory regime offers the potential for Mobile Network Operators (MNOs) to gain access to new spectrum bands under conditions that resemble exclusive licensing while guaranteeing the incumbent spectrum users’ rights. In Europe, the LSA work is currently focused on the 2.3–2.4 GHz band as the first application. The new LSA approach has attracted great interest from industry and is under standardization by ETSI RRS WG1.

The aim of ETSI RRS WG1 was to finalize the LSA requirement specification (stage 1) until September 2014 which has been reached. The next step was the finalization of the architecture specification (stage 2). This specification was finalized in September 2015 and published in October. The stage 3 document, specifying the information elements and the protocols for the interface between LSA Repository (LR) and LSA Controller (LC) has been started by ETSI RRS (the group that was also responsible for the previous documents). The roadmap for LSA standardization and the opportunity is shown in Figure 2-7.

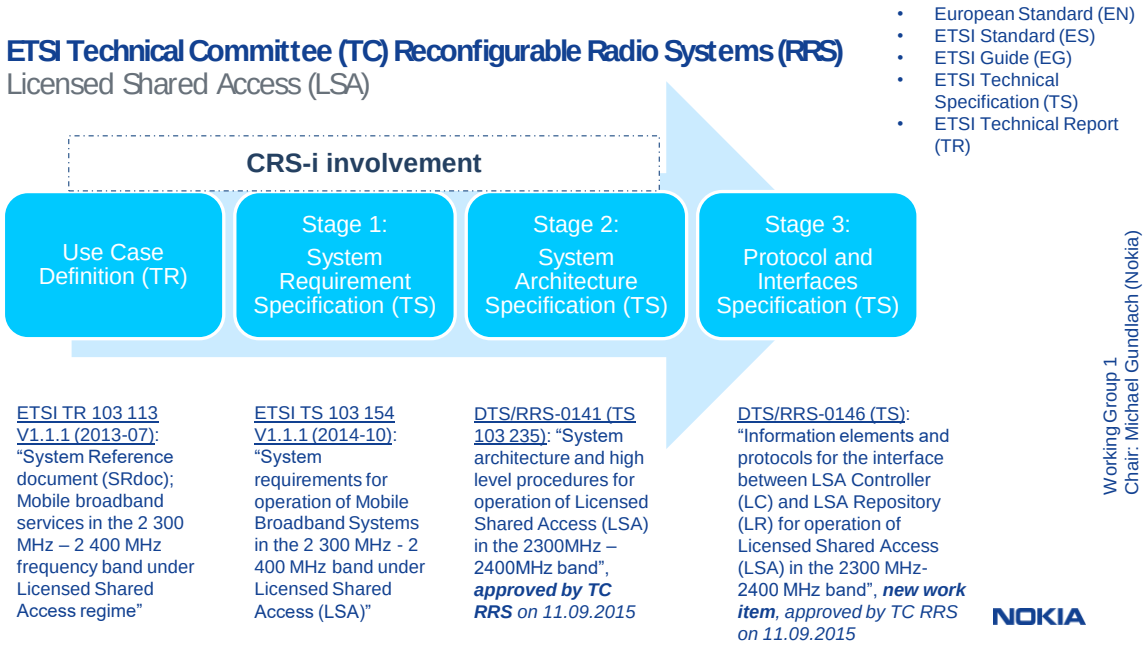

Figure 2-7: LSA specifications of ETSI RRS

An important design principle is that the LSA Controller is fully inside the domain of the MNO’s network. The interface between the LC and the Network Management is considered by 3GPP SA5, supported by Liaison with ETSI RRS as shown in Figure 2-8.

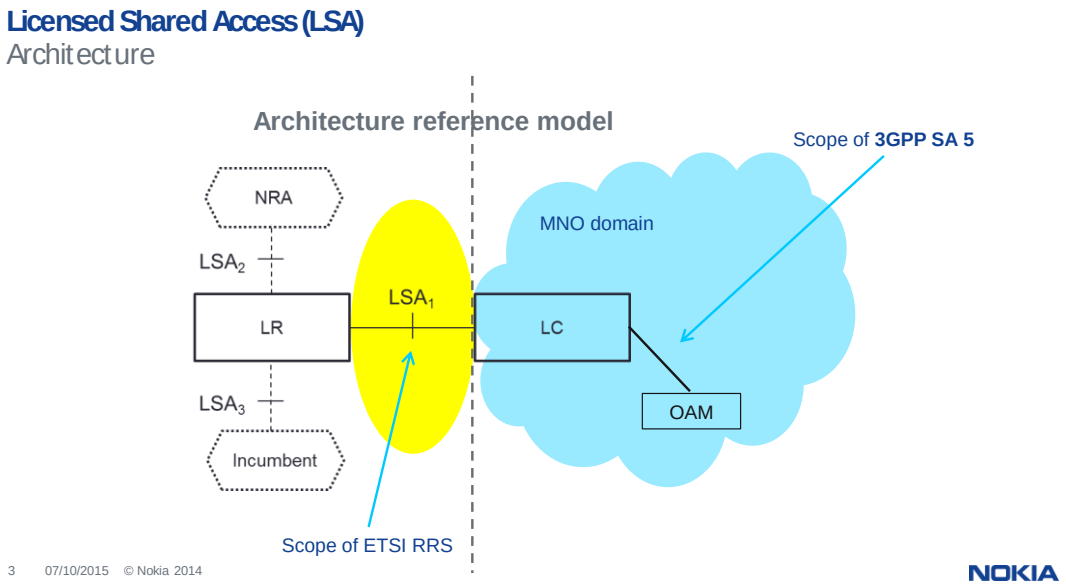

Figure 2-8: Work distribution between ETSI RRS and 3GPP SA 5

ETSI RRS TR 103 113 “System Reference Document; Mobile broadband services in the 2300 MHz – 2400 MHz frequency band under Licensed Shared Access regime”

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.

CRS-i involvement:
The CRS-i partner Nokia (formerly NSN) has been one of the initiators and main contributors of the work items related to LSA (see Table 2-3). Two Nokia delegates participated in all working group meetings, conference calls and e-mail threads related to LSA. Nokia also helped to disseminate the idea of LSA and the results of the related work undertaken by ETSI TC RRS.

The document has been published in July 2013.

ETSI RRS TS 103 154 “System requirements for operation of Mobile Broadband Systems in the 2300 MHz- 2400 MHz band under Licensed Shared Access (LSA) regime”

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 serves 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 have also be provided by JTFER.

CRS-i involvement:
The CRS-i partner Nokia has been one of the initiators and main contributors of the work items related to LSA (see Table 2-3). Two Nokia delegates participated in all working group meetings, conference calls and e-mail threads related to LSA. With the background knowledge from 3GPP activities, from the involvement in IEEE 802 and IEEE DySPAN-SC, and from the participation in FP7 projects, Nokia commented verbally and by written contributions to the drafts. Specifically, Nokia contributed on the requirement organization, LSA agreement rules under permission of the regulator, protection of network information of the incumbent and of the LSA licensee, grant of LSA spectrum resources to LSA licensee, other security requirements, and resource grant performance requirements.

The specification has been published in October 2014.

ETSI RRS TS 103 235 “System architecture and high level procedures for operation of Licensed Shared Access (LSA) in the 2 300 MHz - 2 400 MHz band”

This Technical Specification defines the system architecture and high level procedures for operation of Mobile Broadband Systems in the 2300 – 2400 MHz frequency band under Licensed Shared Access regime, aimed at enabling access for mobile/fixed communication networks (MFCNs) in those CEPT countries where access to the band is foreseen but cannot be provided without restrictions due to Incumbent usage, as documented in ETSI TR 103 113. Application to other bands is not precluded and depends on future regulatory decisions. The documented system architecture includes definition of the logical elements, reference points and functions supported by the architecture, and the definition of the procedures and procedure flows. The present document has been developed following, and in accordance with, the System Requirements for LSA as documented in ETSI TS 103 154 .

CRS-i involvement:
The CRS-i partner Nokia has been one of the initiators and main contributors of the work items related to LSA (see Table 2-3). Two Nokia delegates participated in all working group meetings, conference calls and e-mail threads related to LSA. With the background knowledge from 3GPP activities, from the involvement in IEEE 802 and IEEE DySPAN-SC, and from the participation in FP7 projects, Nokia commented verbally and by written contributions to the draft. Specifically, the mapping of functions to the logical elements and reference points were provided, following the results of CEPT as well as European projects (where applicable).

The specification has been published in October 2015.

ETSI RRS TS 103 379 “Information elements and protocols for the interface between LSA Controller (LC) and LSA Repository (LR) for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band”

This Technical Specification defines the content of the LSA Spectrum Resource Availability Information (LSRAI) and the protocols on the LSA_1 interface, between LSA Controller (LC) and LSA Repository (LR), and is based on the System Requirements defined in ETSI TS 103 154 and the System Architecture and High Level Procedures defined in ETSI TS 103 235. The specification supports the operation of mobile broadband service in the 2300 – 2400 MHz band under Licensed Shared Access (LSA), aimed at enabling access for mobile/fixed communication networks (MFCNs) in those CEPT countries where access to the band is foreseen but cannot be provided without restrictions due to Incumbent usage, as documented in ETSI TR 103 113. Application to other bands is not precluded and depends on future regulatory decisions. This new work item has been approved at the ETSI RRS meeting in September 2015.

CRS-i involvement:
The CRS-i partner Nokia has proposed this new work item, following discussions with European projects, with CEPT, with 3GPP, and with the colleagues in ETSI RRS.

The specification shall be finalized in September 2016.

Table 2-3 – CRS-i contributions to LSA in ETSI RRS.

Contributions as part of CRS-i (NSN/Nokia and partly co-signed with other companies) (always only the latest revision within a meeting is mentioned)		
Meeting	**Reference**	**Title**
RRS1#19	RRSWG1(12)100021r4	NWI: SRDoc on LSA for 2.3GHz (New Work Item to develop a System Reference Document for mobile broadband services in the 2300 – 2400 MHz band under Licensed Shared Access regime)
RRS1#21	RRSWG1(12)100124	Text proposal for Section 7.5 of SRdoc TR 103 113
RRS1#23	**RRSWG1(13)100065**	Draft New Work Item on LSA System Requirements
RRS1#23	**RRSWG1(13)100066**	Combined Comments on draft TR 103 1
RRS1-Conf call	**RRSWG1(13)100100**	Additional Definitions in Draft TS 103 154
RRS1#24	**RRSWG1(13)100117r1**	Text proposal – Additional Working Assumptions
RRS1#24	**RRSWG1(13)100116r2**	Text proposal – Functional System Requirements for LSA

RRS1#24	RRSWG1(13)100111	Text proposal – Requirement Organization
RRS1-Conf call	RRSWG1(13)100127r1	Text proposal – Working Assumptions for LSA
RRS1-Conf call	RRSWG1(13)100130	Text proposal – Functional System Requirements for LSA: Resource Grant
RRS1-Conf call	RRSWG1(13)100128	Text proposal – Resource grant performance Requirement
RRS1-Conf call	RRSWG1(13)100112r2	Text proposal – Functional Requirements on Security for LSA
RRS1-Conf call	RRSWG1(13)100110r2	Text proposal – Additional Definitions for LSA
RRS1#25	RRSWG1(13)100157r1	Further Functional Requirements for TS 103 154
RRS1#25	RRSWG1(13)001014r1	Text proposal – Resource Grant Performance Requirement
RRS1#25	RRSWG1(13)001013r1	Text proposal – Functional System Requirements for LSA: Resource Grant
RRS1#25	RRSWG1(13)001013r1	Text proposal – Functional System Requirements for LSA: Resource Grant
RRS1#25	RRSWG1(13)001012	Text proposal – Resource Grant Performance Requirements
RRS1#25	RRSWG1(13)001010r1	Text proposal for section 5.3 of TS 103 154
RRS1#25	RRSWG1(13)001009r2	Text proposal for section 6.4 of TS 103 154
RRS1#25	RRSWG1(13)001009	Text proposal for section 6.4 of TS 103 154
RRS1#25	RRSWG1(13)001006r1	Introduction of LSA Roles
RRS1#25	RRSWG1(13)000046r2	Draft New Work Item on LSA Architecture for operation in the 2 300 MHz – 2 400 MHz band
RRS1#26	RRSWG1(14)100037	Discussion on System Architecture for LSA
RRS1-Conf call	RRSWG1(14)100073	Proposed Changes to TS 103 154
RRS1#27	RRSWG1(14)027020	Phased Standardization Approach for LSA
RRS1#27	RRSWG1(14)027015r2	Proposed Changes to TS 103 154
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
RRS1-Conf call	RRSWG1(14)100093	LSA Architecture - High Level Functions and Mapping
RRS1#28	RRSWG1(14)028021r2	LSA System Operation in case of Changes to Sharing Arrangement or Sharing Framework
RRS1#28	RRSWG1(14)028021r2	LSA System Operation in case of Changes to Sharing Arrangement or Sharing Framework
RRS1#28	RRSWG1(14)028020	TP on Deployment Scenarios for LSA in TS 103 235
RRS1-Conf call	RRSWG1(14)000019	Discussion on LSA Licensee Access
RRS1-Conf call	RRSWG1(14)000018	Annex A on LSA Scenarios and Use Cases
RRS1#29	RRSWG1(14)029015	Discussion on Fault Management for LSA
RRS1#29	RRSWG1(14)029011r1	TP on Deployment Scenarios for LSA in TS 103 235
RRS1#29	RRSWG1(14)000020r2	Discussion on LSA Interfaces
RRS1-Conf call	RRSWG1(15)000010r1	TP on Deployment Scenarios for LSA in TS 103 235
RRS1-Conf call	RRSWG1(15)000009	Fault Management for LSA
RRS1-Conf call	RRSWG1(15)000026r1	Text Proposal for Section 5.4 on Failure Management and Deployment
RRS1#30	RRSWG1(15)030008r1	Improving Robustness of the LSA Confirmation Procedure
RRS1-Conf call	RRSWG1(15)000041	Improving the Registration Procedure for LSA
RRS1#31	RRSWG1(15)031019r2	Further text proposal to section 5.3 (Synchronisation)
RRS1#31	RRSWG1(15)031012	Further discussion on LSA protocol issues
RRS1-Conf call	RRSWG1(15)031036	Modification of LSRAI Request Procedure
RRS1-Conf call	RRSWG1(15)031035	Additions to Section 5.2 on LSA Failure Management

RRS1-Conf call	RRSWG1(15)031040r2	Changes to High Level Procedures and Procedure Flows
RRS1#32	RRSWG1(15)032010r1	Information Elements and Protocols for the LSA1 interface
RRS1#32	RRSWG1(15)032008	LSRAI and LSA1 protocol related work
RRS1#32	RRSWG1(15)032003r2	New Work Item on "Protocols for the Interface between LSA Controller (LC) and LSA

2.3 Standardization of Device-to-Device communications in 3GPP

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.

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). Data Paths for Proximity Based Service Communication are shown in Figure 2-9.

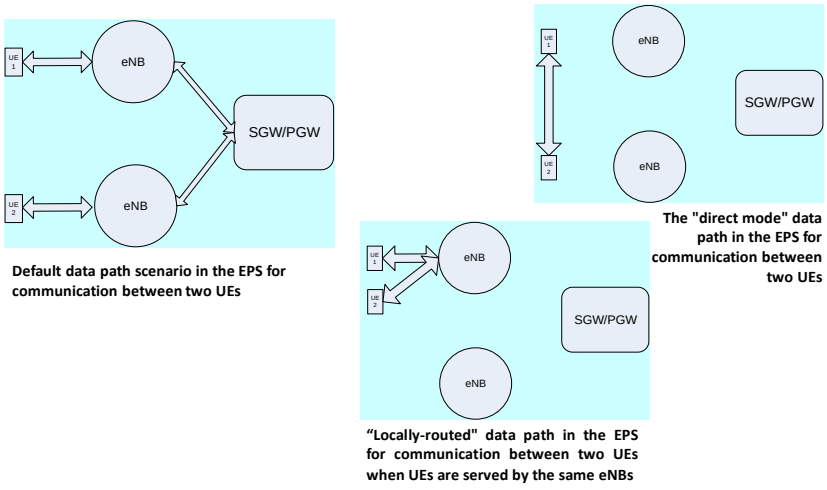

Figure 2-9: Data Paths for Proximity Based Service Communication [Source: 3GPP TR 22.803]

The work on ProSe for Rel12 is now completed (apart from remaining work in RAN on performance). For 3GPP Release 13, enhancements are being specified to support more advanced proximity services for Public Safety (PS) and Consumer use cases. Part of the work is to support the requirements being identified by the System groups as necessary for Mission Critical Push-To-Talk (MCPTT), which is the ongoing project to complete support of PS services in the 3GPP platform based on the requirements coming from various administrations and industry stakeholders.

Most relevant work with respect to D2D is currently done in 3GPP RAN. Enhanced LTE D2D ProSe for Release 13 has started with significant push from companies. Planned completion date for the core part is December 2015, and June 2016 for the performance part.

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 addition, CRS-i, tracked contributions to 3GPP from CRS cluster projects, in order to feed the search for potential synergies (see CRS-i D2.3). As result of this consultancy activity the FP7 ABSOLUTE project submitted one contribution to RAN1 and the FP7 CONCERTO project, which is only dealing with UE-relaying feature, submitted six contributions to SA2. CRS-i directly contributed to 3GPP as a follow-up of the work done in FP7 OneFIT, as listed in Table 2-4.

Table 2-4 – CRS-i contributions to D2D Proximity Services in 3GPP RAN

Meeting	Document Number	Document Title
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 pattern design"
3GPP R1-78 Dresden, August 2014	R1-143431	"WF on Triggering Condition(s) of D2DSS Transmission"
RAN2#83	R2-132776	Expected aspects for work on LTE ProSe Discovery
RAN2#83bis	R2-133464	General aspects on Centralized Allocation approach
RAN2#84	R2-134305	Comparison of resource allocation approaches for D2D communications
RAN2#84	R2-134306	Centralized resource allocation flow chart
RAN2#84	R2-134308	On Layer2 identity for D2D one to many communications

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

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.

ETSI TC RRS has been working on the feasibility study and made some efforts to involve major stakeholders (commercial, public safety and military). Up to last year, there seems to be no interest from the military stakeholders, very limited interest from the commercial stakeholders and limited interest from the public safety stakeholders. Apparently, it can be considered the topic to be premature whilst waiting for the spectrum allocation decisions to be taken in the upcoming ITU World Radiocommunication Conference 2015 (WRC15) - to be held on November 2015. As such, ETSI has informed the EC that a feasibility study reflecting mature views of the stakeholders on the topic could be delivered not before Q1 2016.

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.

Despite the current frozen state of ETSI RRS WG4, CRS-i submitted a contribution (RRS(15)030014) during ETSI RRS#30 on possible opportunities for Reconfigurable Radio Systems and Licensed Shared Access in the Public Protection and Disaster Relief (PPDR) market, taking in consideration Civil Security and Inter-Domain Synergies and the current discussions on the allocation of additional spectrum for Mobile Networks, to be discussed in WRC15.

Table 2-5: RRS WG4 meeting attendance and contributions

Date	Meeting	Meeting work item(s)
27-May-2014	RRS4-Phone Call	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies»
24-Jun-2014	RRS4#15	• 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	• 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	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» • Questionnaire set-up «Exploitation of Inter-Domain Synergies»
23-Sep-2014	RRS4#16	• Contributions on DTR/RRS-04010 (TR 103 217): «Inter-domains synergies» o 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»
3-June-2015	ETSI RRS#30	• Contribution on «Opportunities for Reconfigurable Radio Systems and Licensed Shared Access in the Public Protection and Disaster Relief (PPDR) »

3 Assessment of contributions to regulation

3.1 CEPT ECC FM52 on 2300-2400 MHz band

The Project Team FM 52, developed an ECC Decision, aimed at harmonising implementation measures for Mobile/Fixed Communications Networks (MFCN), including broadband wireless access systems, 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;

It shall ensure the possibility for administrations to allow an alternative radio frequency (RF) power level of the MFCN transmitter in order to satisfy diverse national circumstances.

This has been done by taking all related work outside the group into account. This includes liaisons with other WGs, PTs and FGs within ECC, and also (as authorised by WGFM) with ETSI and other relevant external organisations. Specifically relevant within ETSI are TC RRS and TC ERM including the Joint Task Force ERM RRS for the production of Harmonised Standards under article 3.2 of the R&TTE Directive related to Reconfigurable Radio Systems [9].

3.2 CEPT WG FM53

The Project Team FM 53 on Reconfigurable Radio Systems (RRS) and Licensed Shared Access (LSA) contributed to the ECC Report on “Licensed Shared Access (LSA)”. In order to do this, the PT analysed the procedures for the assignment of LSA individual rights of use, in conformity with the EU Framework and Authorisation Directives. It developed an ECC Report on general conditions, including possible sharing arrangements and band-specific conditions for the implementation of the LSA that could be used as guidelines for CEPT administrations. It established relevant interaction with ETSI in order to translate relevant sharing requirements into harmonised standards including those in relation with the implementation of the LSA framework. FM53 was also liaising with the relevant groups as mentioned for FM52. The term of FM53 was planned until September 2015.

Input to the two groups FM52 and FM53, in all matters related to RRS, TVWS, and LSA, has been done through ETSI RRS as the most appropriate technical standardization body. The activities of FM52 and FM53 were monitored and influenced through participation of Nokia in ETSI TC RRS.

3.3 European Commission's Radio Spectrum Committee

CRS-i, in cooperation with the RAS cluster produced a White Paper on “*Broadcasting-Broadband convergence: a contribution to the forthcoming European Commission study on the convergence between broadcasting and mobile broadband in the UHF band*”. This white paper is a reply to the call launched by the European Commission in the Radio Access and Spectrum (RAS) cluster meeting, 27th Feb. 2013 in Brussels. The white paper was forwarded to the European Commission (DG CONNECT Spectrum Unit, Radio Spectrum Committee) and got a very good feedback.

3.4 Relations with national regulators

CRS-i participated in a consultation on dynamic spectrum management in France. CEA-LETI was invited by the French regulator (ANFR) by the commission established by the Ministre déléguée en chargée des Petites et moyennes entreprises, de l'Innovation et de l'Économie numérique (Mrs Fleur Pellerin), in answer to this consultation.

The commission was established to identify the organisation, institution, legal and regulatory levers that could enable a more open spectrum policy, liable to foster innovation and growth. The report from the commission [12] establishes some guidelines and advices on flexible and dynamic spectrum management.

In the framework of CRS-i, the need for a more dynamic access of the spectrum was promoted. The report mentions 3 factors to highlight the relevance of a more flexible management of the spectrum:

- The spectrum management administrative model was created when receivers had no intelligence, whereas current radios are far more flexible.
- There are business cases where a best effort service approach is sufficient and such systems would not require exclusive usage of spectrum, as implemented in licensed based spectrum.
- Unlicensed spectrum usage fosters innovation from small companies that could not afford bidding for auctioned spectrum.

The report highlights that unlicensed spectrum can coexist with licensed models (as per today’s situation), and also stresses the role of sharing with LSA as a compromise between the two models.

In particular, CRS-i highlighted the role of unlicensed systems through examples such as WiFi. WiFi is collecting a huge amount on traffic and provides citizens with very useful services. Nowadays, it is a very pervasive technology, although often underestimated in spectrum management debates. Today, it is estimated that WiFi conveys 85% of wireless traffic in homes. Similar services could be deployed at a larger scale if secondary usage of spectrum would be enforced like it is the case in the TVWS in the USA, in the UK, and other countries. CRS-i presented activities related to low channel leakage air interface (e.g. FBMC) as a good means to facilitate coexistence in secondary usage scenarios such as TVWS.

Also, CRS-i emphasized the role of the IoT where long range radio systems shall be deployed whereas current unlicensed spectrum considerations are restricted to Short Range Devices (SRD). The recent boom of narrow band long range systems (e.g. Sigfox, Semtech) testifies that there are clear expectations for systems that would operate in an unlicensed fashion over long ranges.

Finally, CRS-i presented an overview of cognitive radio strategies involving a centralized approach with databased, or decentralized based on sensing, or mixed. These methods are referenced in the report. The centralized approach is favoured by the commission, which is consistent to FCC, OFCOM and CEPT approaches. The report highlights these inputs as being in line with similar studies at the European level (ECC, RSPG, CEPT, ETSI).

Among other items, the commission stresses the following points in line with CRS-i inputs:

- Benefits of dynamic spectrum access implementation in the TVWS.
- DSA implementations of LSA approaches in the 2.3-2.4 GHz band, shared with military forces and 4G.
- Future evolution of PMR will require more spectrum and new spectrum management or sharing mechanisms.
- Foster standardized approaches to avoid harmful interference.

These items are developed into 8 concrete propositions to establish new dynamic spectrum management conditions.

As a follow-up on the conclusions of this commission, the French regulator ARCEP launched a consultation on Short Range Devices (SRD). Yet, unlicensed usage is understood as SDR in most regulatory rules. CRS-i answered with similar inputs as raised above, stressing that unlicensed spectrum usage shall be understood as more power operation rather that short range. This appellation is indeed confusing in the context of narrow band systems where very high sensitivity are obtained at the RX (e.g. -110dBm) enabling long range IoT communication in the unlicensed sub-GHz band. The result of the consultation is available at [13].

4 Standardization reports

In order to efficiently assist the cluster projects towards their standardization efforts and familiarize their members with the European and global standardization activities in their areas of interest, the CRS-i members produce Standardization Reports, which aim at summarizing the scope and latest activities of each group, as well as their baseline documents. Table 4-1 provides more information on the twelve Standardization Reports issued by CRS-i during the project’s lifetime.

Table 4-1: Standardization Reports issued by CRS-i.

	Reporter	Issue date	Target CRS projects
IEEE P1900.7	CEA-LETI	16 May 2014 8 Sep. 2014	EMPHATIC; 5GNOW
ETSI RRS WG1 (LSA)	NSN	11 April 2014 14 August 2014 30 Oct. 2014	ADEL
ETSI RRS WG1 (TVWS and Data Bases)	IT	12 May 2014	CREW, SOLDER CORASAT
ETSI RRS WG2	IT	12 May 2014	CREW, SOLDER
ETSI RRS WG4 (Public Safety)	IT	12 May 2014	CREW, SOLDER EMPHATIC; ABSOLUTE, SALUS
3GPP LTE D2D	NTUK, NSN	31 March 2014 30 Oct. 2014	ABSOLUTE SALUS
IEEE P1900.6b ; P1900.7	CEA-LETI	20 May 2015	EMPHATIC; 5GNOW
3GPP TSG RAN	NOKIA	29 May 2015	ABSOLUTE
ETSI RRS WG1	NOKIA	17 April 2015	ADEL, SOLDER, WISHFUL
ETSI RRS WG1, WG2, WG4	IT	18 June 2015	ADEL, SOLDER, SALUS
ETSI RRS WG1	NOKIA	25 Sep. 2015	ADEL, SOLDER, WISHFUL
3GPP TSG RAN	NOKIA	22 Oct. 2015	ABSOLUTE

5 CRS-i scientific publications

Apart from contributing to the standardization process, CRS-i partners also aims to disseminate standardization opportunities on international conferences and scientific events as listed below.

Conference and workshop papers:

- Michael Gundlach, “*Authorized dynamic spectrum access from the viewpoint of a network Manufacturer”,* ETSI workshop on reconfigurable radio systems, 12 Dec. 2012, Sophia Antipolis, France.
- P. Marques, J. Rodriguez, S. Delaere, P. Delahaye, B. Lécroart, M. Gundlach, D. Triantafyllopoulou, K. Moessner, D. Noguet, "*Shared use of radio spectrum in the EU: from research projects to standards*", IEEE ICC'2013 Workshop on Telecommunication Standards: From Research to Standards, Budapest, Hungary, June 2013.
- Michael Gundlach, “*CRS-i and IEEE DySPAN-SC 1900 overview*”, Wireless Innovation Forum, 13 June 2013, Munich, Germany.
- Paulo Marques, J. Rodriguez, S. Delaere, P. Delahaye, B. Lécroart, M. Gundlach, D. Triantafyllopoulou, K. Moessner, D. Noguet, “*Spectrum Sharing in the EU and the Path Towards Standardization*”, Future Networks and Mobile Summit, 3 - 5 July 2013, Lisbon, Portugal.
- Rogério Dionísio, Jorge Ribeiro, Paulo Marques and Jonathan Rodriguez, “*Implementation of a Communication Protocol between a Geo-location Database and TV White Space Devices*”, The 4th Workshop of COST Action IC0902 , Cognitive Radio and Networking for Cooperative Coexistence of Heterogeneous Wireless Networks October 9–11, 2013 Rome, Italy.
- Dominique Noguet, Michael Gundlach, “Pre-conference tutorial, an introduction to TVWS”, White Space Summit 2013, Paris, France, 10-12 December 2013.
- Michael Gundlach, “Licensed Shared Access (LSA), An Innovative Approach of Spectrum Sharing”, White Space Summit 2013, Paris, France, 10-12 December 2013.
- Paulo Marques, “Exploiting TV White Space in Europe: Results from the FP7 COGEU Project”, White Space Summit 2013, Paris, France, 10-12 December 2013.
- Dominique Noguet, “Flexible TVWS Usage with FBMC”, White Space Summit 2013, Paris, France, 10-12 December 2013.
- Paul Suton, Paulo Marques et al, “The FP7 CogEU TV White Space Radio Transceiver”, SDR WInnComm, Illinois, USA, March 2014.
- Dorin Panaitopol, Christian Mouton, Benoit Lecroart, Yannick Lair and Philippe Delahaye, “Recent Advances in 3GPP Rel-12 Standardization related to D2D and Public Safety Communications”, Workshop on Device-to-Device and Public Safety Communications (WDPC), IEEE Wireless Communications & Networking Conference (WCNC) April 2014.
- Michael Gundlach, Jürgen Hofmann, Christian Markwart, Eiman Mohyeldin, “Recent Advances on LSA in Standardization, Regulation, Research and Architecture Design”, 1st IEEE International Workshop on Cognitive Cellular Systems, Rhine River, Germany, September 2-4, 2014.
- O. Holland, P. Marques, et al. “A Series of Trials in the UK as Part of the Ofcom TV White Spaces Pilot”, IEEE International Workshop on Cognitive Cellular Communications, Rhine River, Germany, Sep. 2014.
- Shahid Mumtaz, Kazi Mohammed Saidul Huq, and Jonathan Rodriguez, “Direct mobile-to-mobile communication: paradigm for 5G”, IEEE Wireless Communications, Oct. 2014
- Paulo Marques, “A civilian perspective of military spectrum use - overview of the ETSI RRS activities on civil-public safety and military synergies”, Workshop on Civilian Use of Military Spectrum, March 2015, Maynooth, IrelandPaulo Marques, “Dynamic TV White Spaces database: practical implementation and trial results“, WInnComm-Europe, Nov. 2014, Rome, Italy.
- Michael Gundlach, Luis Lopes, “Licensed Shared Access: Status and System Design”, ETSI workshop on Reconfigurable Radio Systems, Sophia Antipolis, France, 3 – 4 December 2014.

- Simon Delaere, Vânia Gonçalves and Paulo Marques, “Coordinating Standardization in Dynamic Spectrum Access”, IEEE Globecom Workshop op Telecommunication Standards, Austin (TX, USA), 8 December 2014.
- Rogério Dionísio, Jorge Ribeiro, Paulo Marques, Jonathan Rodriguez, “Combination of a geolocation database access with infrastructure sensing in TV bands” EURASIP Journal on Wireless Communications and Networking Dec. 2014.
- Oliver Holland, Paulo Marques et al, “Some Initial Results and Observations from a Series of Trials within the Ofcom TV White Spaces Pilot”, IEEE VTC 2015, May 2015.
- Michael Gundlach, “Recent Results and New Approaches of Cognitive Radio Architectures Towards 5G – Activities in ETSI RRS WG 1 and in European Research Projects”, 2015 Smart Radio Symposium (International Workshop on Smart Radio with Emphasis on 5G Applications), Seoul, 3rd June 2015.
- Michael Gundlach, “Interest and effort in research and standardization of DSA and related technologies (using the example of LSA/SAS)”, IEEE DySPAN 2015 (International Symposium on Dynamic Spectrum Access Networks), Panel on Global standardization of DSA and the link between research and standards, Stockholm, 2nd October 2015.
- Stanislav Filin, Dominique Noguet, Jean-Baptiste Doré, Baher Mawlawi, Oliver Holland, Muhammad Zeeshan Shakir, Hiroshi Harada, Fumihide Kojima, IEEE 1900.7 Standard for White Space Dynamic Spectrum Access Radio Systems, IEEE Conference on Standards for Communications and Networking (CSCN), Kyoto, Japan, October 2015.
- Paulo Marques, “Lessons learned from TVWS implementation in Europe and the road towards standardization”, Workshop EU-India, IIT Mumbai, India, May 25th, 2015
- D. Noguet, J-B. Doré, B. Miscopein, “Preliminary performance evaluation of the FBMC based future IEEE 1900.7 Standard”, Global Wireless Summit, Hyderabad, Dec 2015 (accepted).

Book chapters:

- Markus Mueck, Naotaka Sato, Chen Sun, Martino Freda, Pekka Ojanen, Dong Zhou, Junfeng Xiao, Rogério Dionisio, Paulo Marques, “ ETSI opportunistic spectrum sharing technology for (TV) white spaces”, book chapter in “Opportunistic Spectrum Sharing and White Space Access – The practical reality”, Wiley, April 2015

- Rogério Dionísio, José Ribeiro, Jorge Ribeiro, Paulo Marques, and Jonathan Rodriguez, “TV White Spaces with Geo-Location Database Access: Practical Considerations and Trials in Europe”, book chapter in “Opportunistic Spectrum Sharing and White Space Access – The practical reality”, Wiley, April 2015

- Olivier Rits, Simon Delaere, and Pieter Ballon, “Spectrum as a Platform: a Critical Assessment of the Value Promise of Spectrum Sharing”, book chapter in “Opportunistic Spectrum Sharing and White Space Access – The practical reality”, Wiley, April 2015

- Oliver Holland, Hiroshi Harada, Ha-Nguyen Tran, Bernd Bochow, Ki Won Sung, Masayuki Ariyoshi, Matthew Sherman, Michael Gundlach, Stanislav Filin, Adrian Kliks, “The IEEE Dynamic Spectrum Access Networks Standards Committee (DYSPAN-SC) and IEEE 1900 Working Groups”, book chapter in “Opportunistic Spectrum Sharing and White Space Access – The practical reality”, Wiley, April 2015

- Paulo Marques, Jonathan Rodriguez, Tim Forde, Linda Doyle, Ki Won Sung, Jürgen Lauterjung, “Towards a unified 5G Broadcast-Broadband architecture”, book chapter in Fundamentals of 5G Mobile Networks, Wiley, June 2015.

6 Conclusions

This deliverable reports on the CRS-i contributions to standardization and regulatory bodies. It was shown that the role of CRS-i to monitor and contribute to standardization and regulation bodies was efficiently carried out, as a continuation of the QoSMOS, COGEU, SACRA and OneFit legacy, and later as CRS-i or through collaborations with other projects. Examples where contributions to standards by CRS-i and CRS cluster members jointly submitted contributions were given, and the role of CRS-i was highlighted as a key catalyser for these actions. Moreover CRS-i partners were directly involved in the standardization activities of ETSI RRS WG1, ETSI RRS WG4, IETF PAWS, IEEE DySPAN 1900, 3GPP RAN submitting several contributions:

- 18 contributions to IEEE P1900.7 (and more than100 draft comment resolutions solved);
- 9 contributions to ETSI RRS WG1 on White Spaces;
- 51 contributions to ETSI RRS WG1 on LSA;
- 5 contributions to ETSI RRS WP4 on Public Safety;
- 20 contribution to 3GPP (RAN1 and RAN).

During the lifetime of the CRS-i project, 8 Standards were finalized with strong participation from CRS-i partners:

- **ETSI TS 103 143** “System Architecture for Information Exchange between different Geo-Location Databases (GLDBs) enabling the operation of White Space Devices (WSDs) - Jan. 2015.
- **ETSI TS 103 145** “System Architecture and High Level Procedures for Coordinated and Uncoordinated Use of White Spaces” - Jan. 2015
- **ETSI TR 103 113** “System Reference Document; Mobile broadband services in the 2300 MHz – 2400 MHz frequency band under Licensed Shared Access regime” - July 2013.
- **ETSI TS 103 154** “System requirements for operation of Mobile Broadband Systems in the 2300 MHz- 2400 MHz band under Licensed Shared Access (LSA) regime” - Oct. 2014.
- **ETSI TS 103 235** “System architecture and high level procedures for operation of Licensed Shared Access (LSA) in the 2 300 MHz - 2 400 MHz band” - Oct. 2015
- **IETF PAWS** (“Protocol for Communication between White Space Device and White Space Database”) - May 2015.
- **IEEE 1900.7** “White Space Radio Working Group” – Oct. 2015.
- **3GPP RAN TR 22.803** “Feasibility study for Proximity Services (ProSe)” - June 2013

Moreover twelve Standardization Reports were issued by CRS-i during the project’s lifetime.

The deliverable also reports contributions and participation in regulatory discussions, and finally provides a list of CRS-i publications:

- 24 contributions to conference and journal papers;
- 5 contributions to book chapters.

The number of standardization activities where the project has contributed and the attention CRS-i experienced from various sides evidence that the Coordination Action achieve its objectives.

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