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Specific Targeted Research Projects

SOLDER

Spectrum OverLay through aggregation
of heterogeneous DispERsed bands

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WP5 – Exploitation and dissemination

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Abstract: The objective of this deliverable is to produce, capture the dissemination status and the exploitation plans accomplished within the scope of WP5 during the first year of the SOLDER project. These activities include scientific presentations, general presentations and demonstrations in conferences, meetings, etc. as well as the standardization efforts.

Keywords: SOLDER, communication, dissemination, presentations, publications, demonstrations, exploitation, carrier aggregation, cognitive radio

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Executive Summary

This deliverable produces, captures the dissemination status and the exploitation plans accomplished within the scope of Work Package (WP) 5 "Exploitation and dissemination" during the first year of the SOLDER project. These activities include scientific presentations, general presentations and demonstrations in conferences, meetings, etc. as well as the standardization efforts.

1. Introduction

The objective of this deliverable is to produce, capture the dissemination status and the exploitation plans accomplished within the scope of WP5 "Exploitation and dissemination" during the first year of the SOLDER project. These activities include scientific presentations, general presentations, demonstrations and organization of workshops in conferences, meetings, etc. as well as the standardization efforts. Among them:

1) A SOLDER workshop was organized at the 26-29/08/14 IEEE ISWCS 2014, Barcelona, Spain, reporting and disseminating the potential application scenarios. Experts who are working in the same field, both from industry and academia, were invited to give talks.
2) SOLDER is included and participates to the Radio Access and Spectrum (RAS) cluster (http://www.ict-ras.eu). The SOLDER potential contribution to ETSI RRS was presented in the 23-27/06/14 Montreal, Canada meeting by Dr. Paulo Marques as part of CRS-*i*.

In this document compiling all the publications and dissemination activities that were undertaken by the members of the SOLDER consortium, the scientific publications are mostly linked to a presentation, a poster or a demonstration. These linked activities are mentioned only once under the “publication” category. Where applicable, it is indicated whether a presentation or a demonstration was linked to this publication. The dissemination activities that are related to standardization or regulation are also included in this deliverable.
The deliverable D5.3 is a public deliverable, primarily targeting the European Commission staff as a report of the external activities towards dissemination and the external reaching of the SOLDER project. It helps in measuring the impact of the project on the scientific community. Moreover, it provides good insights on the SOLDER major outstanding contents to anyone interested in the project. This deliverable will be followed by the deliverables D5.4 and D5.6 for the second and the third year, respectively.

2. Scientific publications

[1] F. Kaltenberger, F. Foukalas, O. D. Holland, S. Pietrzyk, S. Thao, and G. Vivier, “Spectrum overlay through aggregation of heterogeneous dispersed bands,” in European Conference on Networks and Communications (EuCNC 2014), Bologna, Italy, Jun. 2014.

[2] O. D. Holland, N. Sastry, S. Ping, P. Chawdhry, J.-M. Chareau, J. Bishop, M. Bavaro, E. Anguili, R. Knopp, F. Kaltenberger, D. Nussbaum, Y. Gao, J. Hallio, M. Jakobsson, J. Auranen, R. Ekman, J. Paavola, A. Kivinen, R. Dionisio, P. Marques, H.-N. Tran, K. Ishizu, H. Harada, H. Kokkinen, and O. Luukkonen, “A series of trials in the UK as part of the ofcom TV white spaces pilot,” in 2014 1st IEEE International Workshop on Cognitive Cellular Systems (IEEE CCS 2014), River Rhine, Germany, Sep. 2014.

[3] A. Medeisis, J. Sydor, L. C. Cremene, O. D. Holland, A. Anskaitis, D. Wiecek, Y. Haddad, T. Cuzanauskas, “ISM-Advanced: Improved Access Rules for Unlicensed Spectrum,” IEEE DySPAN 2014, McLean, VA, USA, April 2014

[4] N. Dimitriou, A. Zalonis, A. Polydoros, A. Kliks, O. Holland, “Context-Aware Radio Resource Management in HetNets,” IEEE WCNC 2014 Workshops, Istanbul, Turkey, April 2014

[5] J. Acevedo Flores, F. J. Velez, O. Cabral, D. Robalo, O. Holland, A. H. Aghvami, et al., “Cost/Revenue Performance in an IMT-Advanced Scenario with Spectrum Aggregation over Non-Contiguous Frequency Bands,” ICT 2014, Lisbon, Portugal, May 2014

[6] O. Holland, H. Bogucka, A. Medeisis, “Introduction,” book chapter accepted to appear in the book: O. Holland, H. Bogucka, A. Medeisis, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality, Wiley, February 2015

[7] O. Holland, H. Bogucka, A. Medeisis, “Conclusions and Future Work,” book chapter accepted to appear in the book: O. Holland, H. Bogucka, A. Medeisis, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality, Wiley, February 2015

[8] O. Holland et al., “The IEEE Dynamic Spectrum Access Networks Standards Committee (DySPAN-SC) and IEEE 1900 Working Groups,” book chapter accepted to appear in the book: O. Holland, H. Bogucka, A. Medeisis, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality, Wiley, February 2015

[9] O. Holland, A. Basaure, W. Yamada, “Novel Licensing Schemes,” book chapter accepted to appear in the book: O. Holland, H. Bogucka, A. Medeisis, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality, Wiley, February 2015

[10] O. Holland, H. Bogucka, A. Medeisis, *Opportunistic Spectrum Sharing and White Space Access: The Practical Reality*, Wiley, to be published in February 2015

[11] A. Kliks, N. Dimitriou, A. Zalonis, O. Holland, “Traffic Offloading Scenarios for Heterogeneous Networks,” book chapter appearing in the book A. Anpalagan, M. Bennis, R. Vannitham, *Design and Deployment of Small Cell Networks*, Cambridge Univesity Press, 2014

[12] B. Zayen, F. Kaltenberger, and R. Knopp, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality. Wiley, 2015, ch. OpenAirInterface and ExpressMIMO2 for spectrally agile communication.

[13] F. Kaltenberger, T. A. Tsiftsis, F. Foukalas, S. Ping, and O. Holland, Opportunistic Spectrum Sharing and White Space Access: The Practical Reality. Wiley, 2015, ch. Aggregation of spectrum opportunities.

[14] F. Kaltenberger, A. Byiringiro, G. Arvanitakis, R. Ghaddab, D. Nussbaum, R. Knopp, M. Berbineau, Y. Cocheril, H. Philippe, and E. P. Simon, “Broadband wireless channel measurements for high speed trains,” in IEEE ICC 2015 - Wireless Communications Symposium (ICC'15 (02) WC), London, United Kingdom, Jun. 2015, submitted.

[15] S. Ping, A. Aijaz, O. Holland, H. Aghvami, “A Spectrum Aggregation based Cooperative Routing Protocol for Cognitive Radio Ad-Hoc Networks,” IEEE ICC 2015, London, UK, submitted

[16] S. Ping, A. Aijaz, O. Holland, H. Aghvami, “SACRP: A Spectrum Aggregation based Cooperative Routing Protocol for Cognitive Radio Ad-Hoc Networks,” submitted to IEEE Transactions on Communications.

[17] A. Mpoulogeorgos, G.Ntouni, D. Karas, T. Tsiftsis, F. Foukalas and G. Karagiannidis, “Carrier Aggregation in LTE-A Heterogeneous Networks with MIMO Link Adaptation” in IEEE ICC 2015 - Wireless Communications Symposium (ICC'15 (02) WC), London, United Kingdom, Jun. 2015, submitted.

[18] G. D. Ntouni, A.-A. A. Boulogeorgos, D. S. Karas, T. A. Tsiftsis, F. Foukalas, V. M. Kapinas, G. K. Karagiannidis, "Inter-band Carrier Aggregation in Heterogeneous Networks: Design and Assessment," ISWCS 2014, Aug. 2014, Barcelona, Spain.

3. Contributions to standardization fora

The three following **standardisation bodies** are targeted in the scope of the SOLDER project: European Telecommunications Standard Institute (ETSI) Reconfigurable Radio Systems (RRS), 3GPP and IEEE DySPAN-SC and IEEE 1900 Working Groups (WGs).
SOLDER is included and participates to the RAS cluster (http://www.ict-ras.eu) such as the participation to the RAS workshop at the 23-26/06/14 EuCNC, Bologna, Italy, chapter 6.
The SOLDER potential contribution to ETSI RRS has been presented in the 23-27/06/14 Montreal, Canada meeting by Dr. Paulo Marques as part of CRS-*i*.

3.1 ETSI RRS

3.1.1 Participation and interaction with ETSI RRS Meetings

SOLDER team provided feedback to CRS-i CSA project of FP7 that facilitate the standardization contribution of each FP7 project related to cognitive radio. In particular, we provided 3 slides with our potential plans for contribution to ETSI. The presentation is described below:

"SOLDER", ETSI Reconfigurable Radio System meeting, 23-27 June 2014, Montreal, Canada.

We described briefly the key aspects and objectives of SOLDER and next, we clarified the following information about SOLDER relation to ETSI RRS:

- **ETSI RRS WG1:**

There is no Work Item that deals with the Carrier Aggregation and to start a new one will not be practical due to the lifetime of the project.

The System Requirements of the document TS 103 154 were just published on May 2014 and it’s possible to start a discussion on Carrier Aggregation between TDD/FDD systems (i.e., LSA TDD and licensed band FDD systems) and provide corresponding requirements.

Interest on the early draft document EN 303 387 (Signaling Protocols and information exchange etc.). It would be a worthwhile contribution to ensure that the systems that are going to use TVWS in a coordinated way, and the associated coordination protocol and mechanisms consider the potential for aggregation of resources by each of those systems.

Interest in the exchange of information among GLDBs (EN 303 144) that will support better resource coordination decisions in view of aggregation of resources by different systems using different GLDBs. Such contributions on aggregation involving TVWS are possible future inputs from KCL as well as possibly others.

- **ETSI RRS WG2:**

Contribution related to Software Defined Radio equipment using for example OpenAirInterface of Eurecom. Potential contribution to early draft document EN 103 146-1: Mobility Device Information Models and Protocols: Multiradio Interface.

The partner AthenaRC could also contribute to this document from equipment point of view based on their own platform, mainly build by SOLDER. They could also provide contribution to any multi-RAT aspect of the proposal.

- General comment:

In order to provide something efficiently, we have to have very good knowledge of the ETSI documents, i.e. TS, TR etc., to where and how could we contribute.

CRS-i will provide consultancy to SOLDER.

3.1.2 Participation to phone calls of ETSI RRS WGs

- **ETSI RRS WG1:**

SOLDER team members had the chance to follow up the progress within ETSI RRS WG1 about the LSA topic. Initially, we had been informed by the chair Dr. Markus Mueck about the following documents:
- TS 103 235: system architecture for LSA (in draft stage);
- TS 103 154: System requirements for operation of Mobile Broadband Systems in the 2300 MHz - 2400 MHz band under Licensed Shared Access (LSA) (approved for publication);
Although, in those documents, WG1 does not address CA directly, but clearly, there is an interesting use case of applying a combination of FDD operation (existing licensed LTE bands) with TDD operation (LSA bands).

In addition to that, SOLDER members joined a phone call related to LSA topic within WG1. Michael Gundlach from NSN moderated the discussion and Dionysia Triantafyllopoulou organised the session. The call held on 14th of October and the agenda is described as follows:

Agenda

1. LSA in ETSI RRS
2. Updates on Stages of LSA evolution
3. Future trends and plans for LSA within 3GPP

Details on the discussion

SOLDER members, Fotis Foukalas and Oliver Holland participated to the call and one member of ADEL FP7 project. The discussion and decision relevant to the SOLDER project was taken place as follows:

- KCL asked about the coordination among the systems opportunistically using spectrum as part of an LSA concept, highlighting that a contribution regarding the consideration of aggregation in the sharing coordination among such opportunistic spectrum users would be useful. Such a situation is similar to the secondary-

coexistence issue experienced in TV white space. NSN concurred, but mentioned that the group would perhaps consider such issues from phase 2 of the ETSI-RRS LSA work onwards. NSN therefore suggested that a SOLDER contribution to the March 2015 ETSI-RRS meeting addressing such issues would be beneficial.

- ISI asked about the possibility of FDD former LSA bands and TDD new LSA bands combination in a type of aggregation. NSN explained that they are working on this topic and it's a matter of decision in the next ETSI RRS meeting in Sophia Antipolis in 4th of December 2014. In this sense, SOLDER could contribute to this within the second year developments in WP3. Nevertheless, the final decision will be made based on the decision within the ETSI RRS about any possible incorporation of TDD/FDD combination.

- **ETSI RRS WG2:**

SOLDER members participated to a CRS-i phone conference on SDR architectures in ETSI RRS WG2 that was moderated by the chairman of the WG2 Prof. Seungwon Choi. Florian Kaltenberger (EURECOM, SOLDER), Oliver Holland (KCL, SOLDER) and Fotis Foukalas (ISI, SOLDER) had attended that phone call. The agenda of the call was mentioned below:

Agenda:

4. ETSI RRS WG2 terms of reference
5. Overview of the Baseline documents – key assumptions, scenarios and architectures
6. Overview of the ongoing Work Items in ETSI RRS WG2
7. Roadmap, practical aspects on how to contribute to the ongoing standards.

Details on the discussion:

The main interest of ETSI RRS WG2 lies in the area of Requirements, Architecture and Interfaces for Reconfigurable Mobile Devices (MDs). Prof. Choi listed the use cases, requirements and reference architecture docs published by ETSI RRS WG2, these are the baseline docs already published, but can be revisited if justified. The work on SDR architectures done by ETSI RRS WG2 only considers architectures and interfaces for reconfigurable mobile devices. Interfaces within base stations tend to be 'hidden' avoiding exposure through standardization. The work on Multiradio Interface (MURI) is finalized (ETSI TS 103 146-1). The work on Reconfigurable Radio Frequency Interface (RRFI) just started (ETSI TS 103 146-2). Prof. Choi mentioned the need to incorporate appropriate references; the first approach is to consider the work done under the Wireless Innovation Forum, but other sources are also needed.

Regarding the carrier aggregation topic, although Carrier Aggregation is not explicitly mentioned in the reference architecture, the multi radio / heterogeneous interfaces concept is presented in the four documents: ETSI TS 103 146-(1, 2, 3 and 4). KCL pointed out that it is important to take into account the potential to aggregate resources. In the case of the Unified Radio Application Interface (URAI), the ability to map upper layer requirements to aggregate resources should be addressed by providing the appropriate information structures in the interfaces.

The straightforward next step is to attend ETSI RRS WG2 phone conferences. Initial contributions can be done as format of paper/report/presentation from the project to be discussed within the WG. Later part of the work / project vision can be accommodated in a specific section of the standard text, after agreement within the WG. Any ETSI member can contribute, ETSI RRS portal generates a template where written contributions can be

submitted, usually 3 days before the meeting: http://portal.etsi.org/tb.aspx?tbid=713&SubTB=713,718,719,720,721. An example of an issue that triggers discussions is the level of granularity of the technical specification.

SOLDER expressed interest to join the next WG2 telco but also other WGs phone calls. CRS-i organized a telco in September on WG1 and will invite SOLDER. Prof. Choi commented that the ultimate goal of the work on Radio Programming Interface (RPI) is a software modem to be able to be deployed by any device. The work focuses on defining functional blocks as standard APIs. ERC mentioned that the EURECOM LTE software modem, which is open-source, could be a candidate for the RPI. It was noted that research projects cannot expect a perfect match between project results and the standard, an effort to adapt to the actually standard needs is required. Prof. Choi expressed his availability for bilateral email discussions with the participants on specific issues.

The next ETSI RRS WG2 F2F meeting are

- 24 September, in Mainz, Germany.
- 1-2 December in Sophia-Antipolis France.

SOLDER is planning to participate at the meeting in Sophia Antipolis, 1-2 December 2014. This event is also followed by a workshop Reconfigurable Radio Systems, where SOLDER is going to demonstrate the OpenAirInterface platform.

Table 1: Updates to the ETSI RRS WGs related to SOLDER.

ETSI RRS WG	Specification
WG1	**TS 103 145:** System architecture and High Level Procedures for Coordinated and Uncoordinated Use of TV White Spaces. (Stable draft) **TS 103 143:** System architecture for information exchange between different Geo-location Databases (GLDBs) enabling the operation of White Space Devices. (Stable draft) **EN 303 144:** Parameters and procedures for information exchange between different GLDBs. (Early draft) **EN 303 387-1:** Signalling Protocols and information exchange for coordinated use of TV White Spaces; Part 1: Interface between Cognitive Radio System (CRS) and Spectrum Coordinator (SC). (Work just started) **TS 103 235:** System Architecture and High Level Procedures for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band. **TS 103 154 (v1.1.1):** System requirements for operation of Mobile Broadband Systems in the 2300 MHz - 2400 MHz band under Licensed Shared Access (LSA)

ETSI RRS WG	Specification
	(approved for publication, find latest version in the attachment)
WG2	**TS 103 146 (2013-11):** Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 1: Multiradio Interface (MURI).

3.2 3GPP

3GPP is the body in charge of standardization of LTE, LTE-Advanced and its evolution. As such, it is important for the SOLDER project to stay informed of the evolution of the standardization to steer the technical work aligned with the main stream.
Carrier Aggregation (CA) was introduced in LTE with the release 10. The introduction of CA impacted the following core specifications:

- 36.101, 36.104, 36.133, 36.141, 36.211, 36.212, 36.213, 36.300, 36.302, 36.306, 36.321, 36.331, 36.413, 36.423, 37.104, 37.141.

From a test perspective, the following specifications were updated:

- 36.508, 36.521-1, 36.521-2, 36.521-3, 36.523-1, 36.523-2, 36.523-3, 37.571-1, 37.571-3, 37.571-5

At that time (Release 10), few scenarios were defined, and most of them did not correspond to a practical operator scenario.

Then, more and more scenarios were added and pushed by operators willing to see their own use case considered by the standard. They were introduced within the framework of Rel. 11, Rel. 12, etc. but as they mostly impact only RF related aspects, they were mostly handled as non-release specific items.
In July 2014, more than 130 different scenarios were defined and treated by 3GPP. The SOLDER project is trying to continuously monitor the progress of the CA related work, but cannot reasonably follow step by step all these work items.
These individual scenario investigations generate reports and in addition, the activity related to carrier aggregation in the standard could also produce standalone technical reports or specifications that could be of interest to the project. The following table lists reports related to carrier aggregation in 3GPP,

TR 36.808	Evolved Universal Terrestrial Radio Access (E-UTRA); Carrier Aggregation; Base Station (BS) radio transmission and reception
TR 36.823	Evolved Universal Terrestrial Radio Access (E-UTRA); Carrier aggregation enhancements; User Equipment (UE) and Base Station (BS) radio transmission and reception
TR 36.833 series	Covering intra scenarios, per band
TR 36.847	Study on LTE Time Division Duplex (TDD) - Frequency Division Duplex (FDD) joint operation including Carrier Aggregation (CA)
TR 36.850, 36.851	Inter-band carrier aggregation
TR 36.853	Technical Report for 3 Band Carrier Aggregation with Single Uplink
TR 36.860	LTE-Advanced dual uplink inter-band Carrier Aggregation (CA)

Although carrier aggregation is a feature introduced in release 10, it is still enhanced with introduction of new functionality. For instance, the possibility to aggregate a TDD carrier and

a FDD one is a recent introduction, still work in progress. Definitely, SOLDER is monitoring such activity.
In order to track the development of the 3GPP activity, we are monitoring at least on a quarterly basis the progress in the RAN (RAN plenary, RAN1, RAN2, RAN4) with sometimes direct attendance to the meeting.

Beyond carrier aggregation, other topics investigated in 3GPP are relevant to the SOLDER project. We could mention dual connectivity, WiFi offload and more recently LTE-U (also called LTE-LA), which corresponds to the use of LTE in unlicensed spectrum (or Licensed Assisted LTE).
In 2013, the project attended to two workshops on the topic, one in January 21st and the second on June 13th. These workshop were reported in the WP2 framework, as input for context to the technical work.

At last, It should be however noted that due to the pace of 3GPP and the size of the SOLDER consortium, it is almost impossible for the project to effectively contribute to this standardisation body.

3.3 IEEE DySPAN-SC and IEEE 1900 Working Groups

SOLDER has been extremely active in IEEE DySPAN-SC and IEEE 1900 working groups. It has maintained a number of leadership roles, including Treasurer and Leadership Member of IEEE DySPAN-SC, Chair of IEEE 1900.1, Chair of IEEE 1900.6, and Vice-Chair of IEEE 1900.7. It has ensured through these roles that the importance of Spectrum Aggregation solutions is captured, to an appropriate level, within the IEEE DySPAN-SC and IEEE 1900 work.

Within IEEE 1900.1, SOLDER has attempted to ensure that terms/definitions related to spectrum aggregation in Dynamic Spectrum Access (DSA) and Opportunistic Spectrum Access (OSA) scenarios, as well the placing of spectrum aggregation *per se* in such scenarios pertaining to its importance and the relationship between the various involved technologies in DSA/OSA, is captured. It has done this through one contribution thus far to IEEE 1900.1 which will be expanded on with further contributions in the future, and through discussion in its leadership roles and also more generally through its active participation in IEEE 1900.1.

Within IEEE 1900.6, SOLDER begun the work of ensuring that spectrum aggregation is appropriately served through the spectrum sensing solutions that IEEE 1900.6 considers, most recently related to the new project that IEEE 1900.6 has initiated on spectrum sensing supporting spectrum databases (e.g., the geolocation databases as are a current hot topic in TV White Space, the FCC's 3.5GHz small cells spectrum sharing scenario, and in Licensed Shared Access deployment examples). It has done this through one contribution thus far, and through active discussion in the IEEE 1900.6 meetings.

Within IEEE 1900.7, SOLDER intends to ensure that spectrum aggregation is captured appropriately in the spectrum access decisions that the IEEE 1900.7 radio interface makes. This is most likely be done through additions to the "Cognitive Plane" capabilities of the developing IEEE 1900.7 radio interfaces, although could also be done through enhancements to the FBMC physical layer option that IEEE 1900.7 has adopted. It is uncertain as yet whether such contributions will materialise in the first reporting year of SOLDER or the second reporting year, or whether the contributions will be able to materialize.

The specific contributions that SOLDER has thus far brought forward to IEEE DySPAN-SC and the IEEE 1900 working groups are as follows:

[1] O. Holland, “Terms and Definitions Relating to Aggregation of Resources Obtained by, or Involving, Dynamic Spectrum Access,” IEEE 1900.1 Meeting, Grenoble, France, April 2014

[2] O. Holland, “Support for Spectrum Database and Cognitive Engine Assisted Channel Aggregation,” IEEE 1900.6 Meeting, Piscataway, NJ, USA, August 2014

[3] A very large number (in excess of 30) presentations and other contributions related to leadership roles in DySPAN-SC and IEEE 1900, that can’t acknowledge SOLDER due to their leadership nature.

4. Other presentations

Some of the presentations below are presentations on invitation, not linked to any peer-reviewed publication. Nevertheless, these presentations contributed to the dissemination of the SOLDER project and are therefore important to list. These presentations are also often used to promote the SOLDER workshop.
Still other presentations below are a result of a peer-reviewed extended abstract (without “official” publication).

[1] F. Kaltenberger, A. Byiringiro, G. Arvanitakis, R. Ghaddab, D. Nussbaum, R. Knopp, M. Bernineau, Y. Cocheril, and H. Philippe, “Broadband wireless channel measurements for high speed trains,” COST IC1004, Krakov, PL, Tech. Rep. TD(14)11017, 9 2014.

[2] O. Holland, ”New Approaches to Licensing,” COST IC0905 Workshop on Cognitive Radio Policy and Regulation, Vilnius, Lithuania, April 2014.

[3] O. Holland *et al.*, “Trials Led by the ICT-ACROPOLIS Network of Excellence,” Ofcom TV White Spaces Pilot Stakeholders Event, London, UK, June 2014.

[4] O. Holland *et al.*, “Standardisation Plans; Ofcom TV White Spaces Pilot Activities and Associated Standardisation Aspects,” RAS Workshop, EuCNC, Bologna, Italy, June 2014.

5. Demonstrations and posters

The "scientific publication" chapter of this document already indicated that several demonstrations were given as a result of the acceptance of a peer-reviewed publication. In this chapter, the additional SOLDER posters and demonstrations –those that are not attached to peer-reviewed publications– are listed.

[1] F. Kaltenberger, R. Knopp, N. Nikaein, "OpenAirInterface 4G: an open LTE network in a PC", ETSI workshop on Reconfigurable Radio Systems - Status and novel Standards, 3-4 December, Sophia Antipolis, France.

Abstract: LTE 4G cellular networks are gradually being adopted by all major operators in the world and are expected to rule the cellular landscape at least for the current decade. They will also form the starting point for further progress beyond the current generation of mobile cellular networks to chalk a path towards fifth generation mobile networks. The lack of open cellular ecosystem has limited applied research in this field within the boundaries of vendor and operator R&D groups. Furthermore, several new approaches and technologies are being considered as potential elements making up such a future mobile network, including cloudification of radio network, radio network programmability and APIs following SDN principles, native support of machine-type communication, and massive MIMO. Research on these technologies requires realistic and flexible experimentation platforms that offer a wide range of experimentation modes from real-world experimentation to controlled and scalable evaluations while at the same time retaining backward compatibility with current generation systems. In this work, we present OpenAirInterface (OAI) as a suitably flexible platform towards open LTE ecosystem and playground. We will demonstrate an example of the use of OAI to deploy a low-cost open LTE network using commodity hardware with standard LTE-compatible devices. We also show the reconfigurability features of the platform.

Video: http://youtu.be/wh9XNYpqffM

[2] O. Holland *et al.*, "TV White Spaces Trials in the UK Led by the ICT-ACROPOLIS Network of Excellence," weM2M, London, UK, April 2014

[3] **Video:** P. Marques, J. Ribiero, R. Dionysio, O. Holland, P. Chawdhry, P. Viaud, "Experimental analysis of the coexistence between a white space link and a wireless microphone system operating in adjacent TV channels—King's College London Denmark Hill Campus," September 2014. Privately available within the SOLDER, CRS-i and ACROPOLIS projects. May be more publically disseminated in the near future.

6. Workshops and tutorials

SOLDER team members have proposed a Workshop to the ISWCS 2014 specialized on the topics of SOLDER like heterogeneous networks, carrier aggregation etc. and it had been accepted at the time of call for interests. In particular, chairs of SOLDER project were: Fotis Foukalas (Athena RC, Industrial Systems Institute Greece), Florian Kaltenberger, (Eurecom-France), Guillaume Vivier (Sequans Communication, France), Somsaï Thao (Thales Communications & Security SAS France), Slawomir Pietrzyk (IS-Wireless, Poland).
The abstract of the SOLDER workshop was described as follows:

> **Abstract:** 4G mobile communication systems achieve high data rates, which might be comparable with those achieved by landline communication systems. Several key technologies play significant roles towards this end, among them Carrier Aggregation (CA). Carrier Aggregation has been introduced in LTE since Release 10 (LTE-Advance) and is also used in recent WLAN system, sometimes referred as Channel or Carrier Bundling.
> Carrier Aggregation consists in combining several carriers available within the communication system to enhance the data rate for the end-user. This could enable access to a very large bandwidth, and has the supplementary benefit of facilitating the use of fragmented spectrum for wireless operators. As a result, Carrier Aggregation has become a hot topic, both from the research perspective and from the commercial deployment standpoint.
> This proposed workshop aims to discuss the applications and the challenges of Carrier Aggregation as deployed nowadays, with reflections on experience from prototyping, field trials or commercial deployments. Moreover, the workshop will explore the evolution of Carrier Aggregation by addressing all kinds of aggregation, as pragmatic steps toward full flexible spectrum usage. In particular, the workshop will address the aggregation of heterogeneous radio access technologies and the use of LTE in license-exempt spectrum.

The final date of the Workshop that co-organized with CRAFT Workshop of ISWCS 2014 was Tuesday 26th of August. In order to have industrial feedback on the topics of SOLDER, we organized a panel discussion for cognitive radio application in 5G wireless communication system. The following panelists, as experts from industry who are working in the same field, gave a presentation and a talk:

1) Markus Mueck, Intel Mobile (Keynote speech for Spectrum Sharing and Inherent challenges for Carrier Aggregation) ;
2) Christophe Gruet, Airbus Defence & Space (former Cassidian), CA for typical public safety: Use cases;
3) Nathalie Haziza, Thales Communications & Security S.A.S., on behalf of FP7 ICT Call 11 ADEL, Licensed Shared Access with Aggregation Capabilities ;
4) Guillaume Vivier, Sequans, on behalf of FP7 ICT Call 11 SOLDER: Practical aspects of Carrier Aggregation implementation.

The panel discussion was very stimulating among the industrial experts the researchers of both CRAFT and SOLDER Workshops and the attendees. The most important outcome of the SOLDER panel discussion was the identification of cognitive-wise communications in 5G wireless communication systems. Mainly but not exclusively, carrier aggregation and licensed shared access are the most promising technologies to this direction. However, it is indeed recognized that both technologies require dynamic approaches making decision for the channel selections. In other words, cognitive engineering approaches is going to be addressed especially for the deployment in heterogeneous spectrum environments identically to the SOLDER objectives.

Finally, SOLDER members had the chance to present their works in the SOLDER workshop like ISI's paper with title: Inter-band Carrier Aggregation in Heterogeneous Networks: Design and Assessment, and KCL to present their exploitation of ACROPOLIS to the SOLDER project.

7. Exploitation plans

The initial exploitation plans are reviewed, updated, refined at the end of the first year in view of the project's results and changed context.

SEQUANS (SEQ)
Short term, **SEQ** will benefit from Solder outcome to support the enrichment of its product portfolio by introducing the support of carrier aggregation. In a longer term perspective the investigation related to improvement or generalisation of carrier aggregation is of interest to Sequans as they could become enabler for product differentiation. For instance, we could mention the traction we see with respect to LTE-U, the use of LTE in unlicensed spectrum.
The collaboration with SOLDER partners will be also likely exploited on various ways. First, we established during this first year trusted relationship that could be transformed into future collaboration Second, the project was an opportunity to know better solution inherited from partner's contribution in the project, such as the OpenAirInterface provided by Eurecom or IS-Wireless suite of solutions. Both could become tools to support Sequans R&D if relevant in the future.

IS-Wireless (ISW)
ISW, will enhance its product portfolio by improving existing and creating new products with the knowledge gathered in SOLDER. Especially tools for modelling complex radio networks (system-level simulators) are important to ISW. Here, the impact is in implementation of CA features within ISW' modelling tool. Another area for application of SOLDER's findings are recently introduced LTE/LTE-A protocol stacks, where the issue of Carrier Aggregation and Heterogeneous Networking is of high importance due to marketing target at small cells. Here we envision benefiting from the SOLDER's findings on the algorithm level. Finally, the knowledge gathered within SOLDER can be implemented, utilized and disseminated through commercial technical courses that ISW is providing to telecom professionals globally. We aim at developing new courses or modules within existing course addressing CA feature.

Thales Communications & Security S.A.S. (TCS)
TCS exploitation plan as described in the Description of Work (DoW) is confirmed. TCS will exploit the SOLDER results in the domain related to Professional Mobile Radio (PMR) market, and its evolutions towards broadband networks. Research in this domain is currently oriented towards LTE and beyond, since this radio access seems very promising to provide the required capacities for communications in public safety operations. In particular, the objective of SOLDER is perfectly in line with the expectations of a public safety operation where communication needs are with usage of a scarce resource: the radio spectrum. In the PMR market, TCS already proposes a product range of TETRA networks, called Digicom25. TETRA is the European standard for PMR narrowband and wideband digital radio for professional usages, from public safety to railway networks. The SOLDER results will allow the extension of the Digicom25 offer to include Cognitive Radio and Spectrum Aggregation capabilities in order to provide adaptive rapid deployment of the small-scale base stations (µBTS) on-board vehicles in unknown and harsh radio environments. The new PMR systems are expected to allow classical PMR communication services like voice, as well as more advanced applications like video streaming requiring higher data rates. Finally, significant

outcomes are also expected in terms of technology, in particular related to its WP3 "Aggregation of heterogeneous dispersed spectrum bands in HetNets and h-RATs" activities on transmitter optimisation techniques. The SOLDER project will ideally complement the ABSOLUTE project that addresses specifically the PMR market and in which TCS is the coordinator.

King's College London (KCL)
KCL notes the productive, rapid start to the SOLDER project. It aims to use the work done in SOLDER to underpin some of its key research interests in areas of opportunistic spectrum access, cognitive radio and spectrum sharing technology in general. This will be done through the use of spectrum aggregation solutions developed in SOLDER to enhance the practicality of spectrum sharing and opportunistic access, such that a required baseline in user performance can be maintained. Further, KCL plans to use the work done in SOLDER to enhance the education of its students on topics related to spectrum aggregation, through ensuring that such technologies and the learned experience in SOLDER are appropriately captured in its curricula. KCL also plans to use some of the impacts of the project to build on its technical capabilities, e.g., the work on implementation of aggregation solutions in TV white space will feed its prototyping and demonstration strengths particularly, and allow it to build on its reputation in such areas. It will further aim to use the project to underpin its dynamic in pushing relevant, practical solutions to standards. Finally, KCL also aims to use the work done in SOLDER to build on its knowledge base and enhance its core of researchers, academics and research students that have a particularly strong profile in spectrum sharing related research.

Industrial Systems Institute (ISI)
ISI plans to develop a hardware platform with LTE-Advanced functionality relying on simulation results of the SOLDER in the topic of CA in heterogeneous networks and systems. This will improve the visibility of our group in Athena RIC for future funding opportunities from Europe and nationally. Furthermore, using the funding of SOLDER, ISI supports PhD students partially from two major Universities in Greece, in particular Aristotle University of Thessaloniki and University of Thessaly. In this way, high quality publications will be guaranteed for the benefit of the project and the research community in general. Finally, ISI/Athena_RC aims to contribute to ETSI RRS standardization body that is more practical than other bodies, for example 3GPP.

Eurecom (ERC)
OpenAirInterface (OAI) currently provides a standard-compliant implementation under a GNU GPLv3 license of a subset of Release 10 LTE for UE, eNB, MME, HSS, SGw and PGw on standard Linux-based computing equipment (Intel x86 PC architectures). It can be used in conjunction with standard RF laboratory equipment available in many labs (i.e. National Instruments/Ettus USRP and PXIe platforms) in addition to custom RF hardware provided by EURECOM to implement these functions to a sufficient degree to allow for real-time interoperation with commercial devices. Some industrial users have working OpenAirInterface-based systems integrated with commercially-deployable remote radio-head equipment and have provided demonstrations at major industrial tradeshows (Mobile World Congress Asia 2014, Mobile World Congress Barcelona in 2013, IMIC 2013). The current major industrial users of OpenAirInterface for collaborative projects are Agilent, China Mobile, IBM, Alcatel-Lucent, Thales, National Instruments and Orange. The primary future objective is to provide an open-source reference implementation which follows the 3GPP standardization process starting from Rel-12 and the evolutionary path towards 5G and that is freely-available for experimentation on commodity laboratory equipment.

OAI is currently hosted and maintained by EURECOM. It will become a foundation (French Association) in the fall of 2014 and will seek funding from members, in the spirit of foundations offering support for open-source software such as OpenStack, APACHE and ANDROID. The output of the SOLDER project will help extend OpenAirInterface to towards the definition of 5G systems. In particular the open-source policy will hopefully help to drive innovation in 5G by following the standard as it is being drafted and to leverage the crowdsourcing effect both from industrial and academic users. The resulting development can be used in both publicly-funded collaborative projects as well as industry-driven initiatives aiming to demonstrate 5G features at the earliest possible stage. Moreover, the results can be replicated in several locations independently through the combination of open-source and commodity hardware. This then becomes a truly distributed experimental facility with a very large number of potential contributors.

8. Conclusion

The dissemination status and the exploitation plans accomplished within the scope of WP5 "Exploitation and dissemination" during the first year of the SOLDER project has been produced, captured. These activities include scientific presentations, general presentations, demonstrations and organization of a workshop in conferences, meetings, etc. as well as the standardization efforts. It will be continued in the deliverables D5.4 and D5.6 for the second and the third year, respectively.
All the publications and dissemination activities that were undertaken by the members of the SOLDER consortium have been compiled. The dissemination activities that are related to standardization or regulation have been also included in this deliverable. Among them:

1) The SOLDER workshop at the 26-29/08/14 IEEE ISWCS 2014, Barcelona, Spain, reporting and disseminating the potential application scenarios, was launched in a sufficiently early stage. Experts who are working in the same field, both from industry and academia, were invited to give talks.
2) SOLDER is included and participates to the RAS cluster (http://www.ict-ras.eu) such as the participation to the RAS workshop at the 23-26/06/14 EuCNC, Bologna, Italy.
3) The SOLDER potential contribution to ETSI RRS has been presented in the 23-27/06/14 Montreal, Canada meeting by Dr. Paulo Marques as part of CRS-*i*.
4) The website has been updated with the SOLDER public deliverables so as to reflect the actual state of the SOLDER project.

From the list of events and publications above, it can be seen that SOLDER has been very active in its dissemination activities during the first year.
The deliverable D5.3 is a public deliverable, primarily targeting the European Commission staff as a report of the external activities towards dissemination and the external reaching of the SOLDER project. It has helped in measuring the impact of the project on the scientific community. Moreover, it has provided good insights on the SOLDER major outstanding contents to anyone interested in the project.

List of Acronyms

Acronym	Meaning
3GPP	3rd Generation Partnership Project.
ADEL	Advanced Dynamic spectrum 5G mobile networks Employing Licensed shared access.
CA	Carrier Aggregation.
CFP	Call For Papers.
CR	Cognitive Radio.
CRS	Cognitive Radio System.
DoW	Description of Work.
DSA	Dynamic Spectrum Access.
DySPAN-SC	Dynamic SPectrum Access Networks Standards Committee.
EC	European Commission.
ETSI	European Telecommunications Standard Institute.
EuCNC	European Conference on Networks and Communications.
EuMW	European Microwave Week.
GLDB	Geo-Location DataBase.
ICC	International Conference on Communications.
ISWCS	International Symposium on Wireless Communication Systems.
LSA	Licensed Shared Access.
LTE	Long-Term Evolution.
NEM	Network & Electronic Media.
OSS	Open Source Software.
PIMRC	Personal, Indoor and Mobile Radio Communications.
PMR	Professional Mobile Radiocommunications.
RAS	Radio Access and Spectrum.
RAT	Radio Access Technology.
RCM	Radio Connection Manager.
Rel.	Release.
REM	Radio Environment Map.
RF	Radio Frequency.
RRS	Reconfigurable Radio Systems.
SDR	Software Defined Radio.
SOLDER	Spectrum OverLay through aggregation of heterogeneous DispERsed bands.
TC	Technical Committee.
TCOM	Transactions on Communications.
TMTT	Transactions on Microwave Theory and Techniques.
TWC	Transactions on Wireless Communications.
VTC	Vehicular Technology Conference.
WCNC	Wireless Communication and Networks Conference.
WG	Working Group.
WP	Work Package.
WSD	White Space Device.

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