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NEWSLETTER

Cooperative Radio Communications for Green Smart Environments

Number 10, February 2015

Newsletter Editor: Alain Sibille, Telecom ParisTech, France

COST IC1004 Chairman: Narcis Cardona, Univ. Politecnica Valencia, Spain

Editorial

Dear colleagues,

In this last but one issue of the IC1004 newsletter I would like once more to highlight a few of our recent achievements and the insertion of the Action efforts into the broader context of European research in wireless communications. A new step is being taken with the recent launch of the 5G PPP, which is a major joint effort between industry and the European commission to place our continent at the forefront of future networks, with a strong impact on our economies. The 1st call of the 5G PPP call in November resulted in about 80 proposals, which demonstrates the extremely vivid character of this topic and the motivation of both academia and industry. IC1004 has recently been invited to formalize a liaison to 5G PPP, which is a valuable proof of the relevance and reputation of our scientific contributions to future wireless networks. Maybe the 5000 downloads of the white paper on Scientific Challenges towards 5G Mobile Communications issued from IC1004 helped in this respect ! In addition, IC1004 sent at the end of February a response to the OFCOM consultation on "Spectrum Above 6GHz", which is a hot topic now on account of the greedy throughput needs for 5G and the abundant potential availability of spectrum at very high frequencies such as 60 GHz and beyond. This response was based on a joint work with contributions from about 20 Academia and Industry participants in IC1004.

In this newsletter, aside from the highlights coming from the various WGs and the selection of 4 TDs presented at the last Dublin meeting, you can read an interview of Rafael Cepeda (InterDigital), who describes some of the challenges and R&D developments in IoT and wireless sensors for smart cities and vehicles. Both these challenges and the promised bright future of these devices are well known, and it turns out that again 5G will be part of the game in facilitating the networking for many applications.

Happy reading !

Alain Sibille

Chairman's Address

Dear reader,

COST IC1004 is officially to close on May 7 in Valencia. We can proudly say that scientific objectives have been accomplished, even surpassed, since our expertise is evolving very quickly from concepts and predictions at the start of the Action, to the current views on what future Radio Access Technologies have to be in the years to come.

IC1004 participants have innovated in ideas and contributions at every meeting, and the relevance of documents discussed made the action more and more attractive for European and non-European industries as well as FP7 projects and other Actions, as demonstrated by the continuous addition of new participants and the references to COST IC1004 in many fora. The strong participation of young researchers - above 50% - who have provided high quality technical contributions, supported by whatever possible from the scarce Action budget through training schools and STSMs. Hopefully they also found rewarding the networking effect of COST, getting in contact to senior researchers and industries during the Action meetings.

The last year of IC1004 was extremely active with plenty of publications, special sessions and issues, white papers, joint events, FP7 clusters, H2020 discussion groups and standardisation activities. Two last open challenges are ahead: write a final book compiling the huge amount of scientific material produced in the 12 meetings and find a way to keep the group together in the COST framework.

Let me launch a final question to COST and H2020 managers, asked many times in meetings: **will this excellent networking effect just be dissolved after closing IC1004?** Hopefully it won't.

Thank you so much, dear IC1004 colleagues, for 4 years of excellent networking !

Narcis Cardona

Highlights

As the second last meeting of COST IC1004, it was both encouraging and fitting to see the good progress made by many regular SWG1.1 contributors in their research topics through the TDs presented. These include switched beam antenna design for vehicles, HF RFID tag design and electrical balance duplexer for full duplex implementation. The subgroup also welcomed a new participant from RWTH Aachen University, who presented an interesting concept of beamforming using a compact dual-antenna design (See this issue's selected TD, TD(15)12025, for details).

In TWG-I, 11 papers have been presented in three dedicated session. These contributions, in line with previous activities of this group, comprised papers on indoor localization, mm-Wave propagation, and (UWB) indoor channel modelling. Among the addressed topics were reverberation models and the influence of humans, furniture, and frequency, a reduced point-cloud model for mm-Wave channel prediction, and a multipath-based simultaneous localization and mapping technique.

WGs 2 and 2.1 organised a session to discuss physical layer challenges and future development for wireless systems, with particular reference to 5G (and beyond), and to a successor Action to IC1004. The discussion focussed around two 'triangles' - the first of these being of "Challenges", "Theoretical Foundations" and "Technologies". "Challenges" include the well-known issues raised by 5G applications, including high data rate, low latency, low energy and high reliability, but also large numbers of very small packets. A number of these issues should cause us to go back to the fundamental theory, to determine whether traditional 'optimised' approaches to network design are still optimal. Some technologies mentioned include massive and distributed MIMO, physical layers for mm-wave and terahertz, relaying and PNC, the 'open physical layer' and coding by the network. Another triangle was provided by the proposed division of the network into 'the cloud', 'the fog' (of wireless personal devices and low energy nodes) and 'the things', again providing a locus for innovative technologies.

On the topic of "Over The Air" (OTA) testing, COST IC1004 submitted a Liaison Statement at the 3GPP RAN plenary meeting in December, which was instrumental to enable the approval of new Working Item Description on MIMO OTA harmonization, guiding 3GPP in the direction of technical correctness.

The Task Working Group on Body Environment (TWGB) has been working on the development of a comprehensive channel model for Body Area Networks (BANs). Contributions from different institutes have addressed different BAN communications (in-body, on-body, off-body and body-to-body). The model focusing on the dynamic aspects related to human movement is under completion and expected to be one of the main outcomes of the working group within the IC1004 action.

WG3 is organizing the 8th Training School with the topic "From HetNets to Cloud Radio Access Networks" with the participation of industry, operators and university speakers. Contents include detailed analysis of technical challenges and architecture of C-RAN, optical transport networks, Virtual Networks, Testbeds, Operator view of C-RAN, SON in HetNets, SDR and Joint Signal Processing. The School is organized by Symeon Chatzinotas, Lucio Ferreira and Sílvia Ruiz and will be held at the University of Luxembourg from 21st to 23rd of April. Grants will be given to the first 20 attendees as in previous Training Schools. Detailed information can be found at http://www.ic1004.org/index.php?page=8th-training-school.

Since COST IC1004 is ending in May 2015, a proposal of future COST Action, based on the work and momentum achieved in this Action and the previous ones is being prepared by a small team of volunteers. The submission deadline is March 28.

The 7th IC1004 Training School on Methods and performance metrics for assessing Vehicular Communication Systems was organized on January 26-28, 2015 in Dublin City University, Ireland by Erik Ström &Levent Ekiz . It was quite successful with more than 30 attendees, and involved a highly expert set of lecturers from academia and industry.

Left: A happy Chairman and happy newcomers at the 12th MCM gala dinner in Dublin, January 2015

Right: audience at The 7th IC1004 Training School in Dublin City University

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Interview: Rafael Cepeda, Member of Technical Staff at InterDigital Europe Ltd. United Kingdom

[IC1004]: InterDigital has a strong focus on wireless solutions. In comparison with the boom of smartphones less than a decade ago, would you say the adoption of other connected devices would be as fast, slower, much slower? Would you quote technical or economical/societal aspects be the main hindrance?

[Rafael Cepeda]: …Smartphones are very generic devices that are evolving as personal hubs for data aggregation, remote connectivity, visualization and analysis. Other connected devices will certainly interact very closely with smartphones to enable innovative solutions, but still the main evolving hindrance is technology, and specially energy harvesting / consumption. Once this is solved, the vast variety of applications and possibilities, combined with a low aggregated cost, will enable a much faster technology adoption compared to the one for smartphones, which was very limited initially.

[IC1004]: actually many years ago there was domotics, which never really came out. Smart homes is a renewed attempt, with the benefit of wireless. Do you think that the enormous progress in wireless networking achieved for 2 decades will be a major ingredient of success? If so, should all these devices be operated in the way of a cellular network? What about 4G/5G there?

[Rafael Cepeda]: Wireless networking is certainly a success driver. Domotics was considered as a “luxury-market” solution due to its associated costs. Nowadays, we are seeing cost-effective applications that can actually reduce costs for institutions while enabling new business models. A common example is the remote monitoring of elderly and disabled citizens. Wireless networking is playing an important role in this sphere since its reliability and energy efficiency are increasing. 4G/5G are becoming also a key driver and we might expect a large number of sensors and actuators enjoying the reliability and mobility from cellular networks. But that’s not the end of the story, innovative solutions are emerging from SMEs and startups, which target very “niche” problems and use either bespoke or standardized wireless solutions like WiFi or ZigBee. Consequently, future wireless ecosystems in Smart Homes will need to manage resources from different networks seamlessly.

[IC1004]: one of the problems, especially for smart cities, is how to cope with the massive amount of devices that need to be connected wirelessly. Is the anticipated available spectral resource sufficient? Are sophisticated techniques such as cognitive radio indispensable to manage interference?

[Rafael Cepeda]: Spectral resources will not be enough if not used wisely. So, Cognitive Radio and Dynamic Spectrum Management will become essential in future Smart Cities to sustain wireless connectivity of city furniture, cars and people. Dynamic ecosystems, devices and platforms will, hence, be fundamental to sustain an always-connected high Quality of Experience for citizens.

[IC1004]: since such devices are reputed to have quite little energy available, what about their ability to communicate at enough distance, through thick walls...? Obviously we shouldn't change batteries every other day!

[Rafael Cepeda]: This is perhaps the main reason why there is not a single answer to: what is the best wireless technology to use? For some applications, like a citywide flood-alert network, a mix of overlapping wireless technologies are required to ensure close-to-100% reliability. Hence, relaying devices and networks would play an important role as aggregators of information and wireless-technology translators. Here, we can see the manifestation of dynamic ecosystems from the angle of multiple devices with different degrees of capabilities and responsibilities.

[IC1004]: among the benefits of smart sensors there is the instantaneous information they can provide in the event of dramatic situations (earthquakes, industrial catastrophes...), but how to deal with the rare burst of communication for a system designed for day to day operation? I mean in an economical way, not wasting resources nearly never used.

[Rafael Cepeda]: We can see this from a practical point of view. If we have large numbers of sensors embedded in the membrane of buildings, we don’t really want to allocate resources to all of them at all times. However, if there is structural damage in the building, emergency services need to have a clear and fast understanding of what is going on, and this is when the problem begins! A way to target this issue is, again, to have a dynamic use of resources. A possible solution is to have the capability of segmenting a network into sub-networks as a way to control resources. This dynamic process would require allocation of resources depending on data flows, which might come from cloud and fog processing / storage power.

[IC1004]: another problem is the fast evolvement of technologies, while buildings have durations of at least several decades. What confidence can an organization have into the far term value of an investment in today's wireless technology?

[Rafael Cepeda]: The key point is to demonstrate remote access and upgrade capabilities. Then, solid business models must demonstrate that technology can pay for itself either in a direct or indirect way.

[IC1004]: Thank you!

Dr Rafael Cepeda, *MBA CEng FIET SMIEEE*, is leading the Societal Challenges and M2M/IoT activities for the InterDigital’s European office in London. Rafael holds an MBA and an MSc in Financial Management from the Rotterdam School of Management (RSM), and a PhD degree in Electrical Engineering and an MSc in Communication Systems & Signal Processing, both from The University of Bristol. He joined InterDigital from BSkyB, where he led research on future wireless technologies. Before this position, he was a Principal Research Engineer at Toshiba Research Europe Ltd. His more than 14 years of research activities have conducted to several peer-reviewed publications, public talks and granted patents mainly related to wireless comms.

Selected scientific topic: "Emulation of Ray Tracing Models in Multi-probe Anechoic Chamber Setups", by Inés Cartón Llorente, Wei Fan and Gert F. Pedersen (TD(15)12054)

MIMO OTA performance testing requires devices to be tested under realistic channel conditions. Standard channel models such as SCME or WINNER aim at emulating generic environments that represent certain channel conditions, e.g. urban, suburban, or indoor environments. Alternatively, replaying field measurements or using ray tracing models would result into more realistic models since they are based on site specific information. This contribution discusses the use of ray tracing simulations on channel emulation for Multi-Probe Anechoic Chamber (MPAC) setups. The goal in the MPAC technique is to transmit specific signals from spatially separated antennas so that the spatial, temporal, delay and polarimetric characteristics of the channel are accurately emulated within the test area where the Device Under Test (DUT) is placed.

Ray tracing simulations are used to obtain the rays that would arrive to the DUT position (See Fig. 1). These rays can be seen as plane waves impinging the DUT from a certain angle, with their corresponding complex field, delay, and polarization; which can be emulated in MPAC setups using Plane Wave Synthesis (PWS). The emulation of the total field for a single DUT position is evaluated via simulations, and the results are given in terms of the Error Vector Magnitude (EVM) in Fig. 2. If ray tracing simulations are performed for a number of DUT positions forming a trajectory along the scenario, temporal and fading characteristics of the channel model could be emulated as well, assuming that the channel is constant for small time periods.

Future work includes 3D emulation and measurements verification in a real MPAC setup.

For more details please contact: icl@es.aau.dk

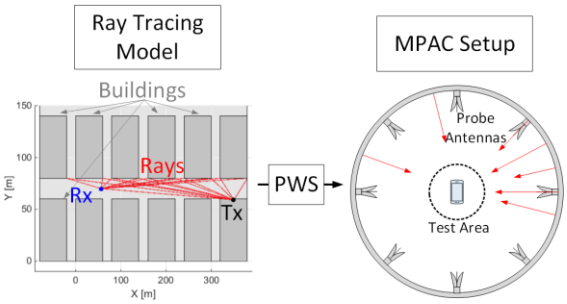


Fig. 1: Ray tracing simulations provide spatial, polarimetric, and delay characteristics of the ray tracing model. The simulated rays can be emulated in the Multi-Probe Anechoic Chamber (MPAC) by using Plane Wave Synthesis (PWS), which emulates plane waves impinging the test area from a certain angle.

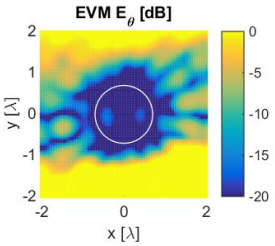


Fig. 2: Error Vector Magnitude (absolute difference between the target and emulated field) of the vertical component of the total field for one DUT position. Test area of diameter 1.4λ at 2655MHz is enclosed by a white circle.

Selected scientific topic: "Compact reconfigurable antennas for MIMO", by Adam Narbudowicz, Dirk Heberling and Max Ammann (TD(15)12025)

Reconfigurable beamsteering is an important property for modern communication systems, as flexible spatial multiplexing can offer a significant increase in data throughput. Currently, most often used are two approaches: a multiple antenna array or a reconfigurable antenna with integrated switches. Each has its pros and cons: antenna arrays offer high flexibility, but occupy large volume; reconfigurable antennas are compact, but the switches necessitate using the same beam for all frequency channels – a strong limitation for mobile or WLAN applications.

The proposed antennas are intended to combine the best of the two worlds: they offer the flexibility of an array, while occupying the volume of a single antenna. They consist of a low-cost PCB-based resonant structure, which can be excited from two inputs. By varying the phase and amplitude between those inputs, one can control beamsteering with the linear dependency between phase and beam direction: $\Phi = \frac{1}{2}\,\Delta_{ph}$. This is illustrated in Fig. 1 for four different phase configurations.

One of the key advantages of the proposed antennas is that the beam direction can be controlled directly by the transceiver baseband circuitry. Fig. 2 demonstrates this with an exemplary modulation of 4-QAM. Each antenna input is connected to a separate transceiver. Both transceivers use the same modulation constellation, but shifted by an angle D_{ph}. If both transceivers are synchronized and code the same information, the change of D_{ph} will also change the physical direction in which this information is transmitted.

For more details please contact: adam.narbudowicz@dit.ie

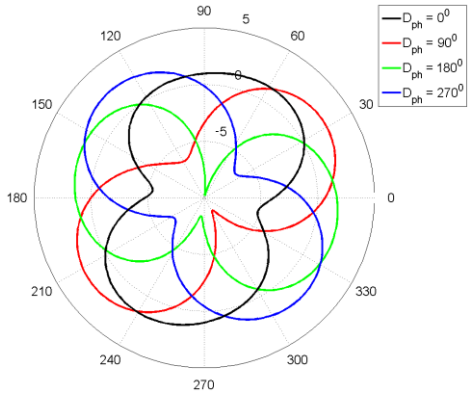


Fig. 1: Radiation patterns for the proposed antenna for different phase shifts D_{ph} (horizontal plane at 2.4 GHz).

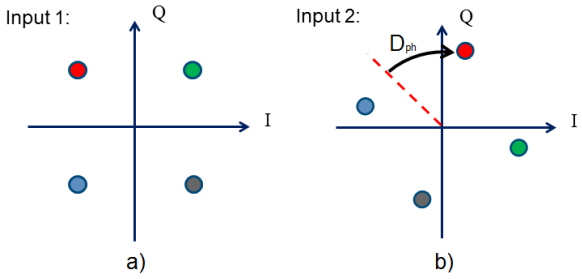


Fig. 2: Example of a 4-QAM modulation constellation, able to steer the beam of the proposed antenna when the two transceivers are synchronized and code the same information.

Selected scientific topic: "The Effect of Channel Quality on Virtual Radio Resource Management", by Sina Khatibi and Luis M. Correia (TD(15)12034)

The goal in the virtualisation of radio resources is to serve multiple Virtual Network Operators (VNOs) over the same physical infrastructure, while offering isolation and flexibility in addition to network element abstraction and multi-RAT (Radio Access Technology) support. Instead of splitting the available radio resources among VNOs, they are aggregated and jointly managed by a higher level entity. VNOs request wireless capacity from a set of physical network providers to serve their subscribers, thus, not having to deal with the physical infrastructure, but rather only with the required capacity. This approach offers pay-as-you-go Connectivity-as-a-Service to VNOs, while enabling new business models for network operators and infrastructure providers. As illustrated in Fig. 1, the key concept of Virtual RAN (VRAN) corresponds to the one of Virtual Machines (VMs) in computing. In RAN virtualisation, in contrast to RAN sharing, the physical infrastructure is not transparent to the clients. By means of isolation, services with different protocols, algorithms, and requirements for quality of service can be offered over the same physical infrastructure.

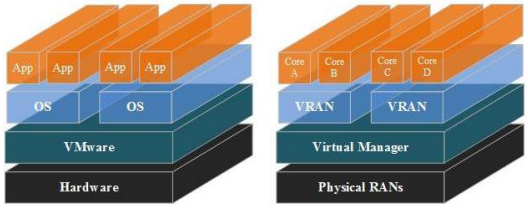


Fig. 1. Comparison between Virtual Machine and Virtual RAN

This paper proposes a model for the management of virtual radio resources, considering different assumptions on terminals' Signal-to-Interference-plus-Noise Ratio. The model has two main components: estimation and allocation of the available resources. In the former, a technique for obtaining probability functions of the network throughput based on the available radio resources is introduced, while in the latter, a portion of the estimated network capacity is allocated to each of the services of VNOs. Meeting the Service Level Agreements (SLAs) in addition to increasing the efficiency of resource usage are the key objectives in resource allocation. The cellular network capacity can vary from 0.9 Gbps in a pessimistic approach (PE) up to 5.5 Gbps in an optimistic one (OP), the general (G) and realistic ones (RE) being in between. The effect of this capacity variation on the allocation of the virtual radio resources to the services of the VNOs with guaranteed bitrate (GB) is shown in Fig. 2.

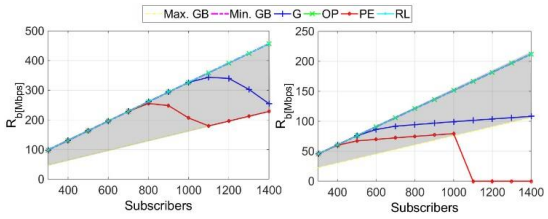


Fig. 2. The allocated data rate to service classes of VNO GB

For more details please contact: sina.khatibi@inov.pt

Selected scientific topic: "Impacts of Room Structure Models on the Accuracy of 60 GHz Indoor Radio Propagation Prediction", by Jan Järveläinen, Matti Kurkela and Katsuyuki Haneda (TD(15)12011)

For investigating the feasibility of future millimeter-wave systems for 5G, channel models are essential. In order to acquire large amounts of channel data for the model to be statistically valid, deterministic field prediction can be used to generate channel realizations in addition to measurements. However, deterministic field prediction always requires structural data of the environment, but such 3D maps describing indoor scenarios are rare. Furthermore, the structural data should include complex structures of the furniture and fixtures. By laser scanning we can obtain this detailed structural data in the form of a point cloud (Fig. 1). Since conventional field prediction tools are not applicable to the point cloud data format, we predict the electromagnetic scattering by using a diffuse scattering model which can be used directly with the point cloud.

In this TD we study how the density of the point cloud affects the prediction accuracy at 60 GHz by predicting delay and angular spreads for five point clouds with different densities. Since the number of points is proportional to the computational time, finding the sufficient point cloud density is vital. The results show that the measured and predicted power delay profiles (PDPs) agree well even with the sparsest point cloud, as presented in Fig. 2. Good agreement can also be found in angular domain as showed by the azimuth and elevation power angular spectra (PASs) in Fig. 3. It is found that the most accurate point cloud with 676 000 points is redundant for some details and that even a reduction to 1000 points has no major effect on predicted delay and angular spreads in the considered environment.

For more details please contact: jan.jarvelainen@aalto.fi

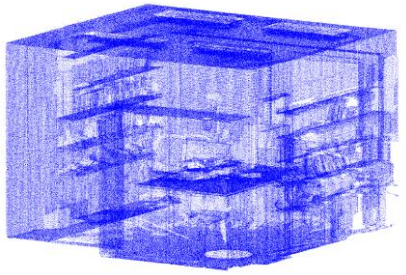


Fig. 1: Laser scanned point cloud of office with 676 000 points.

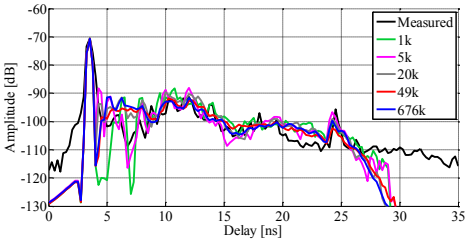


Fig. 2: Measured and predicted PDPs (5 different densities).

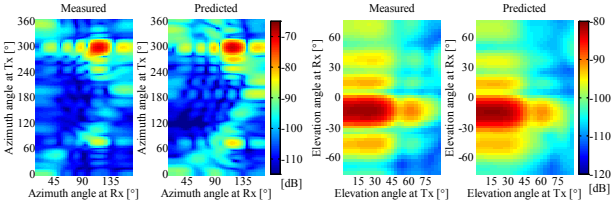


Fig. 3: Measured and predicted PASs.

Next Management Committee meeting

The 13th and final MC meeting will take place in Valencia, Spain, May 5-7, 2015.

Local Organiser: Narcis cardona (Polytechnic University of Valencia, IC1004 Chair)

Format:

05/05/2015 Workshop(s)

- Radio Channel models for higher frequency bands
- Evolution of Radio Access Network Technologies towards 5G

06/05/2015 Presentation of regular TDs

07/05/2015 Technical Plenary track, selected topics from WGs + invited talks

Training school: "From HetNets to Cloud Radio Access Networks":

Luxemburg, April 21-23 (2 ½ days), prior to the 12th MCM.

Organizers: Symeon Chazinotas
Silvia Ruiz

Objective: to explore the pros and cons of different options for assessing performance of V2X communication, with emphasis on antenna systems

Cloud computing technology has emerged as a promising solution for providing high energy efficiency together with gigabit data rates across software defined wireless communication networks, in which the virtualization of communication hardware and software elements place stress on communication networks and protocols.

Future Networks architectures are evolving to become to ever more flexible, developing towards the Cloud RAN concept, based on technologies such as distributed antenna systems, and evolving beyond it towards what can be called "ultra-flexible RANs". C-RAN means a centralized processing, collaborative radio, real-time cloud computing and clean RAN systems. C-RAN brings to RAN the advantages of the cloud: resource-sharing, elasticity, on demand and pay-as-you-go.

Cloud RAN concept is expanded to include also EPC (Evolved Packet Core) functionalities, in what could be called Network Virtualisation, which refers to the capability of partitioning and/or pooling underlying physical resources or logical elements in a network, usually associated with the concepts of software-defined networking (SDN) and cloud services.

Grants will be given to the first 20 attendees (registered members of IC1004), as in previous Training Schools.

See the TS web site.

ISSSE 2015 and AT-RASC

The ISSSE (International Symposium on Signals, Systems and Electronics) has been held every three years and has been organized under the sponsorship of URSI Commission C (Radiocommunication Systems and Signal Processing) and D (Electronics and Photonics) and has included aspects of URSI Commission B (Fields and Waves). In 2015 ISSSE will be held as part of the AT-RASC Conference. The newly established triennial URSI Atlantic Radio Science Conference (URSI AT-RASC) is the 3rd URSI flagship conference in addition to the triennial URSI General Assembly and Scientific Symposium and the triennial AP-RASC conference (AsiaPacific Radio Science Conference). AT-RASC 2015 will be held 18 (Monday) - 22 (Friday) May 2015 at the ExpoMeloneras Convention Centre, in Gran Canaria, Spain.

ISSSE sessions will be held 19 (Tuesday) - 21 (Thursday) May 2015 unless the number of submitted papers necessitates some rescheduling to Monday or Friday. Papers will be welcomed on a wide range of subject areas (see below). Paper submission will be through the AT-RASC portal and will adhere to the AT-RASC deadlines and rules and benefits (eg the student paper competition).

ISSSE delegates are being offered a reduced three day registration price.

.A special session issued from IC1004 will take place on the topic "Smart and efficient wireless networks and technologies towards 5G and beyond"

Organizers: Sana salous (Durham university, UK) and Alain Sibille (Telecom ParisTech, France)

See updated information here

About 50 conferences/courses/events are organized with COST IC1004 involved in in the committees ; they are announced at: http://www.ic1004.org/index.php?page=announcements

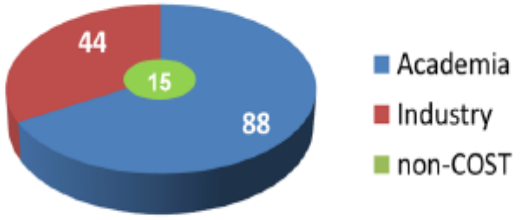
About COST IC1004

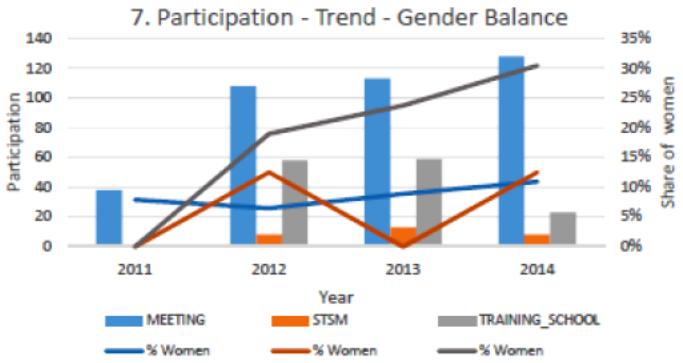
COST IC1004 is the Action on **"Cooperative Radio Communications for Green Smart Environments"**, belonging to the ICT Domain of the COST framework (see www.cost.eu). This Action addresses research issues in the field of cooperative radio communications to make our society cleaner, safer and more energy efficient. It started on January 2011 and will end on May 2015. Among many activities, 3 meetings and at least one training school are organized per year.

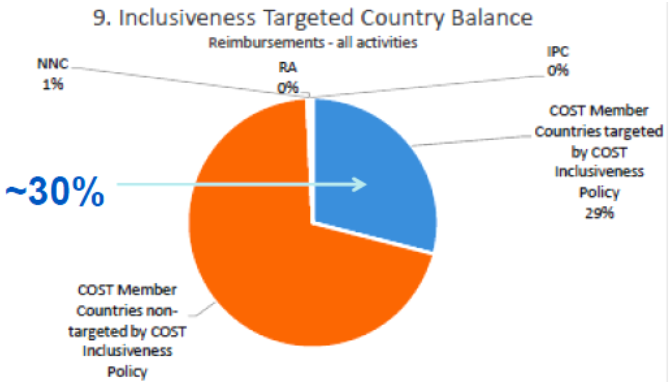
The Action goals are:

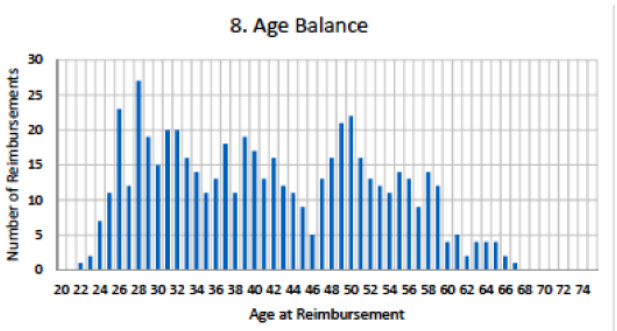
- to increase knowledge of cooperative communications applied to Green SEs (GSEs), by exploring and developing new methods, models, techniques, strategies and tools, in a context enriched by deep industry-academia links
- to play a supporting role to European industry through the focused interest of Working Groups
- to train young researchers in the field of cooperative radio communications for GSEs

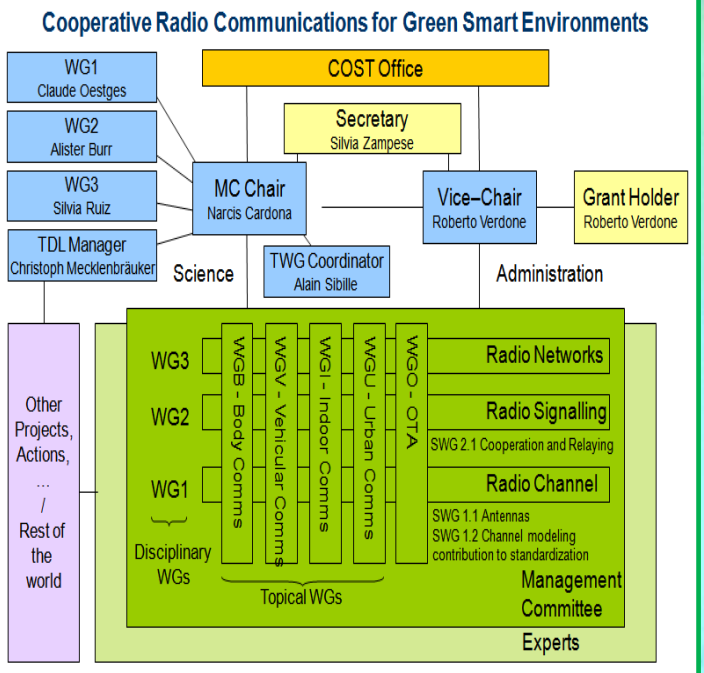
The MoU and all information can be found at http://www.ic1004.org or by contacting the secretariat at secretary@ic1004.org











Facts & Figures

Number of signatory countries: **30**
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom.

Number of COST International Partner Countries: **6**
Australia, Canada, China, Colombia, Japan, USA

Number of COST country entities (institutes, etc.) currently participating: **136**

Number of non-COST entities currently participating: **16 + 4**
(*including Montenegro as COST near neighbour country*)

Number of MC Members: **56** (+ Chair)

Number of registered experts: > **600**

Number of meetings / year: **3**

Number of training schools / year: **≥1**

Number of completed STSM: **22**

Number of presented TD/workshop papers: **629**

Average number of participants / meeting: **120**