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## Editor's Address

**Margot Deruyck**

Ghent University, Belgium

Dear reader,

I am honoured to present you the third issue of this newsletter, focussing on our latest meeting in Lisbon, Portugal. I would like to take the opportunity of this editorial to give prominence to our first COST IRACON women's meeting, which was held on the second day of our meeting. I will report on the outcome of this women's meeting on the IRACON blog on our website.

Although only 14% of the IRACON members are female, this does not mean that we are not highly involved in the action. Half of the female attendees presented a TD in Lisbon. One of these TDs was selected as scientific topic for this issue. I also want to highlight our interview with female ECI and one of the 4 female WG Chairs of IRACON, Chiara Buratti.

We hope that this newsletter will inspire you and can encourage you to join us (further) in the Action!

Enjoy the reading!

## About COST IRACON

This COST Action IRACON (Inclusive Radio Communications) aims at scientific breakthroughs by introducing novel design and analysis methods for the 5th-generation (5G) and beyond-5G radio communication networks. Challenges include i) modelling the variety of radio channels that can be envisioned for future inclusive radio, ii) capacity, energy, mobility, latency, scalability at the physical layer and iii) network automation, moving nodes, cloud and virtualisation architectures at the network layer, as well as iv) experimental research addressing Over-the-Air testing, Internet of Things, localisation and tracking and new radio access technologies. This COST Action started on March 2016 and will end in March 2020.

<http://www.iracon.org>



# Chairman's Address

Dear IRACON colleagues,

Welcome to the third issue of our Newsletter! Time is running fast, as we are already ending our first year. Since my last address, IRACON held two important events, about which I would like to report here.

The first one was our third Management Committee meeting, which took place in Lisbon (Portugal) in the very first days of February. It gathered more than 120 participants, among them a large number of newcomers. In Lisbon, the new sub-working group on "IoT for Health" was set up and a new platform for sharing experimental equipment was presented. During these days, we also organised the first "IRACON Women" meeting, where women in IRACON met and discussed about our gender policy and the role of women in COST Actions at large.

The second event was our first Training School, jointly organised with WiBEC (Wireless In-Body Environment) Innovative Training Network in Dresden in the beginning of March 2017. During three days, over 40 participants attended a holistic set of courses on antennas and propagation modelling for body environment communications and took home many new ideas from stimulating talks and inspiring discussions with their peers.

As I mentioned during my dinner speech in Lisbon, COST Actions are important because they truly enable people from different countries to meet face to face and discuss about what they are doing. In this way, COST also helps building cross-border understanding, and this is of very high value. IRACON is however much more than meetings. As an example, a record number of STSMs have been funded during this first year, enabling ECIs to pursue their research in a global environment. Meanwhile, our website has inaugurated his first blog entry: Prof. Roberto Verdone provided some thoughts about the disappearance of

telecommunications among the younger generation. Indeed, it is also our role to explain our bachelor and master students that communication technology as they know it results from innovative research and yet affects them every day.

Let me further continue the tradition of putting in the highlight a member of the IRACON core group. Our Vice-Chair, Prof. Narcis Cardona, is not new to COST Actions: as Vice-Chair, he is supervising the relationship with all Working Group Chairs, in order to build up scientific programs for our meetings. As you can notice from our meeting schedules, this works beautifully, as we try to maximise the interactions between all attendants.

Our next meeting will be held in Lund (Sweden), on May 29-31, 2017, and will be followed by a tutorial on massive MIMO. Then, in June 2017, we will also organise, in collaboration with the European School of Antennas our second training school on Large-Scale Propagation. As a COST Action, we are again committed to provide grants to enable IRACON PhD students to fund their participation. More information is already available on our website.

I would like to conclude this foreword by expressing my gratitude to all those who have contributed to IRACON in our workshop, training school and technical meetings during this first year term.



**Claude Oestges**  
Université catholique de Louvain,  
Belgium

## Tutorial on Integrating the Internet of Things into 5G and Beyond Networks - Testimonial by Charles Wiame

Before the start of the 3rd MC meeting, a tutorial was organised in Lisbon on the 31st of January.

The subject of the talk was "Integrating the internet of things into 5G and beyond networks" and was presented by Prof. Roberto Verdone (University of Bologna).

First, the main features and requirements of 5G and IoT were addressed (including performance metrics, software and air interface). A number of application areas of IoT were mentioned and characterised (as function of their delay constraint and node mobility). In addition, emerging radio technologies of interest (LoRa, NB-IOT, etc.) were detailed and compared. Possible network architectures were also highlighted according to the target application. The presentation ended with future perspectives beyond 5G, including multi-hop D2D transmissions, delay tolerant networking and UAV-aided networks.

I personally appreciated the important connections made between IoT and 5G since these two topics are not often presented jointly. I also liked the fact that the speaker listed and confronted the possible technologies in a systematic manner (rather than focusing directly on the one of interest). The conclusion with an opening on solutions including drones was to me particularly well chosen.



# Interview with a senior researcher

## Short biography

MSc (1990), PhD (1995), Prof (2001). Full Professor at the Universitat Politècnica de València (UPV), Director of the Research Institute on Telecommunications and Multimedia Applications (iTEAM) and of the Mobile Communications Master Degree at the UPV. Prof Cardona has participated in projects of the FP6, FP7 and H2020 frameworks, always in Mobile Communications aspects and has been involved in COST Actions since 1992, being Chair of IC1004 and Vice-Chair of COST2100 and CA15104.



**NARCIS CARDONA**

Professor, Director of iTEAM  
Research Institute at Universitat  
Politécnica de València (Spain)

## What are your favourite areas of interest and research?

I am a radio engineer, so any aspect that involves radio communications fits in my area of interest. I have worked in propagation modelling, resource management, optimisation, and broadcast technologies, amongst others, and in the last two years I am focussing my efforts in wireless medical devices, in cooperation with some European Hospitals.

## What is the “next big thing” in the wireless communication area?

It will be something that we still haven't imagined. Every decade, since the 80's we have seen a new device or human interface that has boosted the market. The last big thing was in my view the touch screen in mobiles and tablets, as it improved suddenly the way the users manage the mobile terminal, access the internet, the network, etc. This was between 2007 and 2009, so next big thing is expected to come before 2020, and I am sure that will be any element that improves the human-network interface. A few years ago, we thought that the augmented reality glasses were this big thing, then the autonomous car, but now ideas like the gestural interface and the graphene screen seem to be the new paradigms for the future of mobile services.

## What was your motivation to become a researcher?

I started my degree at the Telecom School in Barcelona not with the intention to become a researcher but to have a professional career in Telecommunications. After finishing the MSc in fact I started at the Industry for one year, but soon I was called by one of my professors to consider joining the new School in Valencia and I did. That was just at the beginning of the Mobile Communications era, late in the 80's, and the topic was at that time so new and attractive so to took me into the research world.

## What would you like COST IRACON to achieve?

One of the best things IRACON could end up being is a network of colleagues that wish to continue working together in the future, after ending IRACON period. From the scientific viewpoint, this COST Action should

become a global reference for the validation of propagation and radio channel modelling for the new scenarios of mobile communications (5G or related to the IoT concept). Nevertheless, one aspect that makes IRACON different from its predecessors is the increasing importance of the experimentation aspects, so one may expect that joint testbeds, research labs and field trials will have more relevance soon in IRACON and end up being one of the key results of the COST networking effect.

## What was your motivation to be part of COST IRACON?

I would better explain which was my motivation to be part of COST, as I joined COST actions in 1992. In COST I found a network of researchers working in the same topics that I do, that meet to share, not to report, on scientific matters. After some years in COST Actions I became Vice-Chairman of COST273, Chairman of IC1004 and the proponent of IRACON. So, I was here already 25 years ago.

## My favourite book, music(ian), movie, TV-series are ...

I am quite simple in this sense: I liked very much Star Wars (the very first movie), and I have many favourite “classical” musicians in several styles: Bob Marley, David Bowie, Queen, The Smiths, Talking Heads, and all the Spanish “movida” of the 80's, with Radio Futura in the top 1 of my list.

## I'm most passionate about ...

Any cultural or popular event shared with the people around me, including my family and friends. Ah, and of course I'm passionate about the Barcelona (Barça!)

## What is your country well known for?

Spain is, I guess, well known by the weather, being a touristic paradise in Europe, and I think this hides the very good skills of our scientists, engineers and entrepreneurs, not very lucky in these last two decades of globalisation, political stupidity and economical crisis.

## My favourite or personal quote is ...

I said about 15 years ago that *in COST we do not have partners but colleagues*. Today I could add that *in COST networks our budget is the mutual confidence*.

# Interview with an Early Career Investigator

## Short biography

Chiara Buratti received her Ph.D. degree in Electronics, Computer Science and Systems in 2009 from the University of Bologna, where she is currently Assistant Professor. Her research interest is mainly on Wireless Sensor Networks and Internet of Things with particular attention to medium access control and routing protocols. She won the 2012 Intel Early Career Faculty Honour Program Award, provided by Intel (USA) and the 2010 GTTI Best Ph.D. Thesis Award (Italy). She has co-authored more than 80 technical papers. She is General Co-Chair of ISWCS 2017.



**CHIARA BURATTI,**  
Assistant Professor at CNIT -  
University of Bologna

## What are your favourite areas of interest and research?

My research area is on the Internet of Things, which particular interest on Medium Access Control and routing protocols. I am interested in both, theoretical research, mainly based on Markov Chain analysis and graph theory, such as experimental research based on large-scale deployment of IoT devices.

## What is the “next big thing” in the wireless communication area?

For sure 5G will be the next big thing in wireless communications, also because reaching latencies lower than 1 ms, will enable new applications, as for example, tactile Internet, making tele-surgery a reality.

## Considering the innovations in the scientific world in the last 20 years, which was the most remarkable one, and which one finished with a “dead end”?

One of the most remarkable innovation in the last 20 years, from my viewpoint, are search engines, which changed the relationship between people and knowledge; such as the invention of social network, which changed the relationship among people themselves.

The innovation which finished with a dead end, according to me, is domotics.

## What was your motivation to become a researcher?

I always dreamed of becoming a teacher, this is the main reason why I am a researcher now: to teach in most wonderful place I can imagine.. that is the University.

## What was your motivation to be part of COST IRACON?

COST IRACON is a very friendly environment, able to foster exchanges among researchers and creating a

great community, where people participate to meetings in a very motivated and active way.

## What would you like COST IRACON to achieve?

I hope we will be able to create a good community of people working in the field of IoT.

## My favourite book, music(ian), movie, TV-series are ...

I mainly listen to Italian music, favourite singers are Battisti and Mina. I love going to cinema, I have many favourite movies, the first one which comes to my mind is “Erin Brokovic” by Steven Soderbergh; while among the favourite books I can cite “The Kite Runner” by Khaled Hosseini.

I do not watch TV series, sorry about that...:-).

## I'm most passionate about ...

travelling, cooking and going to the cinema.

## My favourite holiday is ...

on the mountain, both in summer and winter, since I love both, trekking and snowing.

## In a few words, I consider myself to be ...

not self-confident, but determined.

## What do you like the most about your country?

As everybody knows, Italy is famous for food (not only spaghetti and pizza..) and for our wonderful art cities, like Rome, Venice and Florence. Being passionate about travelling, I consider myself lucky to live near such beautiful cities; however, I must admit, I could never live without pasta..

## My favourite or personal quote is ...

“If you're not failing every now and again, it's a sign you're not doing anything very innovative.” - Woody Allen

## Selected scientific topic:

"Millimeter-Wave Outdoor-to-Indoor Channel Measurements at 3, 10, 17 and 60 GHz"

by C.A.L. Diakhate, J.-M. Conrat, J.-C. Cousin, A. Sibille - TD(17)03005

Millimeter-Wave (mmW) communication systems, capable of achieving high data rates thanks to the large bandwidth available in this frequency range, are a promising 5G technology. Investigation of mmW propagation channel properties is of great importance in order to gain more insight into these frequency bands for upcoming 5G mobile system. Studies in this paper investigate the radio propagation channel at 3.6, 10.5, 17.3 and 60 GHz in an Outdoor-to-Indoor (O2I) scenario. Measurements were performed inside Orange premises in Belfort, France and were conducted using a wideband channel sounder analysing a bandwidth of 125 MHz. Directive antennas were used to compensate the increased path loss in higher frequencies and were rotated during the measurement at Rx side. Synthesising methods were applied to data in order to simulate measurements performed with omnidirectional antennas and channel parameters such as building penetration losses and

Contact Person

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channel delay spread values were characterised. It was observed that signal attenuation is strongly material-dependent and also, to some extent, frequency-dependent as well. For instance, the building penetration loss for points located just behind standard double layer window is less than 10 dB regardless the frequency. It increases up to 25 dB at 3.6 GHz and 30 dB for mmW frequencies. The delay spread was weakly correlated with the frequency and less than 30 ns. This study has been conducted in the framework of the European 5G PPP mmMAGIC project.



Figure: Tx measurement van located in front of the building.

## Selected scientific topic:

"Routing based on FRET for in-body nanonetworks"

by P. Kulakowski, K. Solarczyk, K. Wojcik - TD(17)03030

Nanocommunications is commonly understood as communications between nanoscale devices that can be located e.g. inside human body for medical purposes. Solutions for point-to-point nanocommunications have been already proposed; one of them is Förster Resonance Energy Transfer (FRET) which enables information transfer between molecules located close to each other, usually up to 20 nm, with a relatively high throughput (tens of Mbit/s) and very small delay (few nanoseconds).

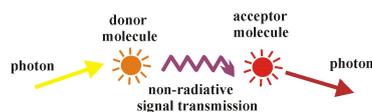
Here, we discuss how to route signals through in-body nanonetworks. We introduce five new routing mechanisms, relying on physical and biological properties of specific molecule types, mainly proteins and fluorophores. We experimentally validate one of these mechanisms.

Finally, we analyse open issues showing the technical challenges for signal transmission and routing in FRET-based nanocommunications.

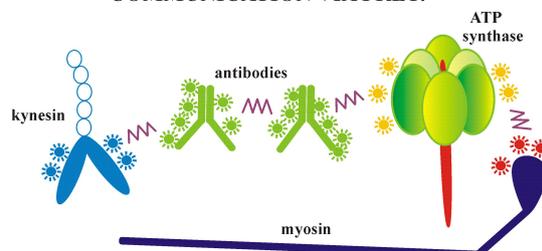
Contact Person

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### FRET PHENOMENON:



### COMMUNICATION VIA FRET:



Upper part: the FRET process occurs after excitation of the donor molecule by an external photon. The excitation energy is passed non-radiatively to the acceptor molecule and then can be e.g. released as another photon.

Bottom part: examples of proteins that may function as nanomachines: antibodies, kinesin, ATP synthase and myosin molecules. Each of them can have some fluorophores (marked as small circles with short rays) attached to it. The fluorophores work as nanoantennas transmitting and receiving signals via FRET.

## Selected scientific topic:

### "Achievable Rates and Applications of a Textile Massive MIMO Hub" by E.C. Bardera, A.G. Armada, M. Sánchez-Fernández - TD(17)03050

In the near future, a wide range of new services like augmented reality or telemedicine is expected. They will require greater data transmission capacity and strict real-time operation. Motivated with this target, we are increasing the uplink achievable rates using very-large multiple-input multiple-output systems (massive MIMO) which can theoretically offer the aforementioned requirements when using relatively simple signal processing (precoding techniques). Massive MIMO refers to the idea of using large antenna arrays formed by tens of radiating elements at the same time serving several terminals in the same time-frequency resource. Hence, in our current work we present a textile solution based on massive MIMO technology, which will enable to achieve symmetric data rates in both uplink and downlink. Moreover, our textile proposal minimises the impact on the base station since it will be developed directly on the end user (e.g. exploiting their own clothing or accessories). Specifically, we have compared the achievable rates applying several precoding schemes such as Matched

Filter, Zero-Forcing or optimum precoding based on perfect channel state information when using a large textile antenna array under the assumption of perfect and imperfect CSI. As a baseline for analysis we also compare with the results achieved in the absence of channel knowledge. In view of the results, the proposed textile solution based on massive MIMO technology shows very promising performance in terms of achievable data rates.



Figure: Textile antenna array deployed at user clothing (see left figure) and 3x5 textile prototype deployed at UC3M (see right figure).

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This work has been partly funded by the Spanish Government through projects MIMOTEX (TEC2014-61776-EXP), CIES (RTC-2015-4213-7) and ELISA (TEC2014-59255-C3-3R).

## Selected scientific topic:

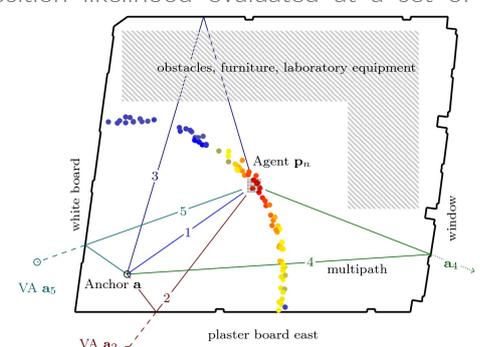
### "Low-cost or compost? Using DecaWave UWB Transceivers for High-accuracy Multipath-assisted Indoor Positioning" by J. Kulmer, S. Hinteregger, B. Großwindhager, M. Rath, M.S. Bakr, E. Leitinger, K. Witrisal - TD(17)03066

Robust indoor positioning at sub-meter accuracy typically requires highly accurate radio channel measurements to extract precise time-of-flight measurements. Emerging UWB transponders like the DecaWave DW1000 chip offer to estimate channel impulse responses with a reasonably high bandwidth, yielding a ranging precision below 10 cm. The competitive pricing of these chips allows scientists and engineers for the first time to exploit the benefits of UWB for indoor positioning without the need for a massive investment into experimental equipment.

dense multipath which provides no relevant position information. Our studies showed that the SINRs achieved by DW1000 are in a similar range compared with high-quality measurement equipment. Most remarkably, this comparison includes the impact of synchronisation errors and clock stability of a pair of DW1000 chips, while the reference measurements have been obtained with cable-connected TX and RX chains.

We investigated the performance of the DW1000 chip concerning position related information that can be extracted from its channel impulse response measurements. Our analysis is based on the signal-to-interference-plus-noise ratio (SINR) of deterministic multipath components (MPCs), a parameter that relates to the Cramér-Rao bounds on the range and position error variances. Interference is - in this case -

Our findings enabled the derivation of a positioning algorithm, which requires a single anchor only. It exploits impulse response measurements of the DW1000 and reaches an accuracy below 0.5 m. The figure shows the approximated position likelihood evaluated at a set of sample positions.



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# Highlights from the last meeting

COST (CA15104) IRACON started on March 2016 and will end on March 2020. From February 1st till Februari 3rd, the 3rd MC and technical meeting was organised in Lisbon, Portugal. During the plenary session, two keynotes were presented. Taro Eichler (Rohde & Schwarz, Germany) gave an overview of several OTA testing concepts and results from state-of-the-art measurements in his keynote "Challenges and Techniques for Characterising Massive MIMO Antenna Systems for 5G". Sebastian Schostek (Ovesco AG, Germany) convinced us in his keynote "Innovation in wireless in-body devices" about the power of wireless for medical applications. The highlights of each working group from the last meeting are presented below:

**DWG1 - Radio channels:** DWG1 covered various aspects of radio channels. Several new channel sounding campaigns were reported with frequency bands ranging from 146 MHz to 300 GHz and covering different propagation environments such as outdoor-to-indoor and maritime container environments. New channel modelling methods were also covered, including those for human blockage and angular-selective dense multipath components. Different methodologies, scenarios and platforms of radio channel simulators for coverage and system-level simulations were discussed, highlighting the need for such studies for 5G and beyond. Finally, it was agreed that an ad-hoc meeting is organised for those interested in a UK contribution of channel modelling for ITU-R SG3.

**DWG2 - PHY (Physical) Layer:** There were 2 sessions (1 joint with WG3) covering 2 major topics. The first one focused on PLNC technique, namely Compute and Forward in massive MIMO type of cell-free scenario, and the evaluation of the analytic approximation of BER in PLNC coded BPSK scenario. Second major area concentrated on the massive-MIMO technique, namely on the problem of iterative equalisation in MIMO system, and on effects of the estimation errors in MRC/ZF M-MIMO processing solved by user grouping. Somewhat new topic introduced to WG2 was the computation over the networks with aggregation algorithm at nodes, which might have useful connections to parallelised staging in PLNC networks.

**DWG3 - NET (Network) Layer:** 16 TDs were discussed at WG3 (NetLayer) Lisbon meeting, addressing research topics on RRM for Beyond 4G networks, HetNets, Spectrum Management, Moving Networks and 5G. Five of them were included in joint sessions with WG2 and with the experimental working group on Radio Access. Discussion was oriented to considering the possibility of organising a Workshop or a Training School on Spectrum Management or in 5G Virtualised Networks.

**EWG-OTA - Over-The-Air testing:** The EWG on OTA likes to highlight the gap between current work on ray tracing and the results from field measurements. This was evident in a number of papers and tells us we have a long way to go to resolve the theory of propagation modelling and real observations.

**EWG-IoT - Internet-of-Things:** Two other experimental facilities, LOG-a-TEC and CorteXlab, have been presented. A webpage including details about all available facilities and their main characteristics have been setup in order to facilitate dissemination inside and outside the project. Results of a STSM done by UNIBL at UNIBO were presented, such as different works related to joint scheduling and routing algorithms, also including energy harvesting constraints, and SDN-based solutions for the IoT. Finally, two works were related to testing antenna and protocols for vehicular applications, have been reported. A Sub-WG on IoT for Health (i.e. IoT-Health) has been established and the Co-Chairs, Slawomir Ambroziak and Kamran Sayrafian, have been elected. The focus of this subgroup is on the design, development, and experimental evaluation of IoT in healthcare applications such as health monitoring and therapy. The Sub-WG held two sessions. The results presented in these two sessions were mostly related to antenna and propagation issues for the human body environment.

**EWG-LT - Localisation and Tracking:** The EWG-LT has seen contributions focusing at aspects of measurement acquisition, measurement modelling, tracking filters and data fusion. The working group is currently preparing a workshop on dependable communications and positioning for the IoT, which is a joint event with the EWG-IoT to be held in Graz, Austria, on Sept. 12, 2017.

**EWG-RA - Radio Access:** The Experimental WG Radio Access had two dedicated sessions with 8 TDs in total. The contributions covered various aspects of massive MIMO, mm-wave, and cloud-RAN. Some presentations also included descriptions of test-beds and will thus be added to the list of test-beds, which is shared between the experimental WGs.



Newcomers to the Action.

# Experimental tutorial on Massive MIMO - from theory to practice: 1st June 2017, Lund, Sweden

by Prof. Frederik Tufvesson and Prof. Ove Edfors

**Start time:** 1th June, 09:00 - **End time:** 1th June, 13:00

**Abstract:** Currently, telecommunications providers face the challenge of increasing data rates while also expanding network capacity by orders of magnitude. Massive MIMO offer unique benefits that can address these concerns and enable 5G networks. To move Massive MIMO from theory to reality, however, advanced hardware must be combined with challenging signal processing. In this tutorial, we give an overview of massive MIMO and the theory behind. We explain radio channel properties being important for massive MIMO operation and cover lessons learned from the implementation of the world's first real time test bed for massive MIMO, the Lund University Massive MIMO testbed LuMaMi. With that, we also dive deep into the signal processing used, including reciprocity calibration, MIMO precoding, and MIMO decoding. Finally, we show the testbed in operation, with a number of simultaneous users using the same time-frequency resources for real time communication.



# Training School on Large-Scale Propagation (joint with ESoA): 12-16 June 2017, Louvain-la-Neuve, Belgium

**Organisers:** Vittorio Degli-Esposti (Uni. Bologna, Italy), Thomas Kürner (TU Braunschweig, Germany), Claude Oestges (UCLouvain, Belgium)

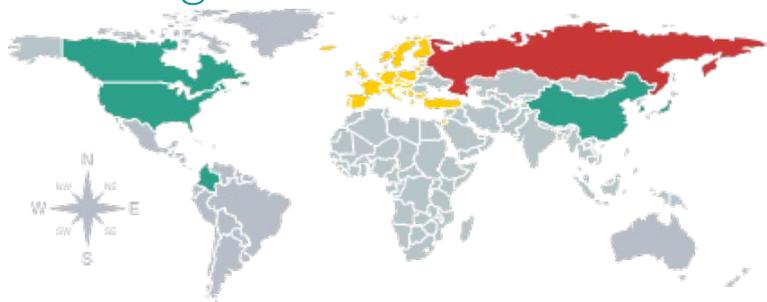
**Host:** UCLouvain, Louvain-la-Neuve, Belgium

**Start time:** 12th June, 09:00 - **End time:** 16th June, 15:00

**Abstract:** The course will cover propagation aspects for cellular and vehicular communication. Starting with the basics of propagation, modern methods used in cellular network planning as well as aspects relevant for future 5G networks, e. g. MIMO, multi-link aspects, localisation, car2X and railway communication, are taught. The course includes also computer-based exercises.

More information and registration can be found at the IRACON website.

## Facts & Figures



**Signatory countries: 34**

Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, FYR Macedonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Lithuania, Luxembourg, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

**COST international partner countries: 6**

Canada, China, Columbia, Japan, South Korea, USA

**COST international partner countries: 1**  
Russian federation

