



FIRST INTERNATIONAL WORKSHOP ON METAMATERIALS-BY-DESIGN

Theory, Methods, and Applications to Communications and Sensing

PARIS SACLAY, December 3-4, 2015

Event Book

Welcome to IWMbD2015

Dear Colleague,

Welcome to the first edition of the International Workshop of Metamaterial-by-Design: Theory, Methods, and Applications to Communications and Sensing, which we have the pleasure to organize in Paris Saclay, France, under the auspices of DIGITEO/DIGICO-SME and of CentraleSupélec.

IWMbD is supported by top level world-wide associations on ICT, Metamaterials, and Electromagnetics, and is aimed at presenting a comprehensive overview of the latest advances and emerging trends in the theory, methods, and the Communications and Sensing applications of the Material-by-Design paradigm. Moreover, it will highlight the current status and the envisaged frontiers in this research area.

The first edition of the Workshop features 7 Keynote Presentations from distinguished experts from international top institutions as well as 23 peer-reviewed contributions. Additionally, two round tables are organized at the end of each day to stimulate the open discussion among the presenters and the attendees.

I would like to thank all of those who have contributed to the success of the conference: the authors of the papers, the keynote speakers, the round table chairpersons, our sponsors and supporting institutions. Last, but not the least, I would like to thank all the colleagues on the Steering and Local Organising Committee, who worked so hard to make this edition of IWMbD possible.

My personal wishes that you enjoy both the conference and Paris. Thank you for coming.

Prof. Andrea MASSA
IWMbD2015 General Chair



Steering Committee



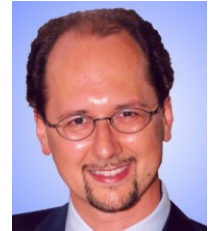
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Thales Alenia Space, France



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University of Trento, Italy



Prof. Alain SIBILLE
Télécom Paris Tech, France



Prof. Alessandro TOSCANO
University Roma TRE, Italy



Dr. Mauro VARASI
Finmeccanica, Italy

Workshop Program

Thursday, December 3

- 09:00 - 09:30 “Opening, Welcome Speech, and Introduction to Day 1”
- 09:30 - 10:00 “Metamaterials-by-Design: Challenges and Envisaged Developments”, Prof. Giacomo OLIVERI
- 10:00 - 11:00 “Metasurfaces-by-Design”, Prof. Sergei TRETYAKOV
- 11:00 - 11:15 *Coffee break*
- 11:15 - 12:15 “Engineered Materials by Design Based on Multi-objective Global Optimization Schemes”, Prof. Douglas H. WERNER
- 12:30 - 13:30 *Lunch break*
- 13:30 - 14:30 Poster Session
- 14:30 - 15:30 “Transformation Electromagnetics and Metamaterials for Antenna Engineering”, Prof. Yang HAO
- 15:30 - 16:30 “New Perspectives in Transformation-Optics-Inspired Metamaterial Design”, Prof. Vincenzo GALDI
- 16:30 - 16:45 *Coffee break*
- 16:45 - 18:00 *Round Table* “Metamaterial-enhanced Systems for ICT: Open challenges and Opportunities” (Chairs: Prof. Alain SIBILLE, Dr. Fabrice BOUST)

Dec. 3, Evening: Gala Dinner @ Restaurant “La Belle Epoque”

Friday, December 4

- 09:15 - 09:30 “Introduction to Day 2”, Prof. Andrea MASSA
- 09:30 - 10:30 “Modulated Metasurface Antennas by Design”, Prof. Stefano MACI
- 10:30 - 10:45 *Coffee break*
- 10:45 - 11:45 “Controlling Electromagnetic Waves using Metamaterials: From Fixed Functionality to Field Programmable”, Prof. Tie Jun CUI
- 12:00 - 13:00 *Lunch break*
- 13:00 - 14:00 Poster Session
- 14:00 - 15:00 “Theoretical Aspects of Light Scattering and Control by Disordered Materials”, Prof. Rémi CARMINATI
- 15:00 - 15:15 *Coffee break*
- 15:15 - 16:30 *Round Table* “Bridging the Gap between Academia and Industry in Metamaterial Applications” (Chairs: Prof. Giacomo OLIVERI, Dr. Hervé LEGAY)
- 16:30 - 17:00 “Closing Remarks”, Prof. Andrea MASSA

Invited Speakers



Prof. Rémi CARMINATI
ESPCI ParisTech, France
“[Theoretical Aspects of Light Scattering and Control by Disordered Materials](#)”

Light-matter interaction in disordered materials is at the core of current issues in photonics: the design of amorphous materials to enhance light emission or absorption, the transfer of information through a scattering medium, the use of light localization induced by disorder to explore cavity-QED regimes, to cite just a few. In this talk we

will discuss recent advances in the modelling of light scattering and transport in disordered media, and the connection to applications of current interest. The topics will cover speckle correlations and their implications in the context of wave control through scattering materials, the characterization of 2D Anderson localization and its use for enhanced light-matter interaction, and the possibility to engineer the disorder (correlated disorder) in order to tune the photonics properties.



Prof. Tie Jun CUI
Southeast University, China

“[Controlling Electromagnetic Waves Using Metamaterials: From Fixed Functionality to Field Programmable](#)”

Classically, metamaterials are described by effective media. I will present the strong abilities of this kind of metamaterials to control electromagnetic waves and their applications in microwave frequencies. However, once

the metamaterials are fabricated, the functionalities are fixed. To solve the problem, I proposed to describe metamaterials using the spatial coding of ‘0’ and ‘1’ particles with opposite phase responses. Based on the field-programmable gate array (FPGA), we realize coding and programmable metamaterials, making real-time controls of electromagnetic waves.



Prof. Vincenzo GALDI
University of Sannio, Italy

“[New Perspectives in Transformation-Optics-Inspired Metamaterial Design](#)”

In this talk, I will present an overview of results from recent and ongoing research in the field of metamaterials at the University of Sannio. In particular, I will illustrate some extensions of the transformation-optics framework

in order to deal with non-Hermitian (e.g., balanced loss/gain), nonlocal (i.e., spatially-dispersive) as well as multiphysics (e.g., thermal and electrical) scenarios.



Prof. Yang HAO
Queen Mary University of London, UK
“[Transformation Electromagnetics and Metamaterials for Antenna Engineering](#)”

Recent breakthroughs in the theory of Transformation Electromagnetics, such as the possibilities concerning cloaking and invisibility, have caught both the scientific and popular imagination, and have stimulated a huge growth in related research around the world. The potential of the underlying Transformation Electromagnetics

approaches however have much wider applicability than cloaking alone, in arguably more important applications that span communications, energy transfer, sensors and security. However, theory and concepts are outstripping practical demonstration and testing, leading to a mismatch in what may be theorised and computed and what can be realised for impact in society and commerce. In this talk, Prof. Hao will review the history of research on transformation electromagnetics and metamaterials for achieving the invisibility. He will demonstrate potentials and physical limitations of metamaterials through numerical simulations and microwave experiments. The roadmap for developing radically novel devices based on transformation electromagnetics and metamaterials engaging UK leading theorists, modellers and material scientists will be discussed.



Prof. Stefano MACI
University of Siena, Italy
“[Modulated Metasurface Antennas by Design](#)”

This presentation addresses design and analysis methods of planar antennas based on modulated metasurfaces (MTSs). These antennas operate on an interaction between a cylindrical surface-wave (SW) excited by an isotropic TM radiator, and an MTS having a spatially modulated equivalent impedance. The MTS is realized by using sub-wavelength patches printed on a grounded

slab. Therefore, the resulting structure is characterized by light-weight and low volume. Both features are appealing characteristics for space applications. Impedance-based amplitude synthesis of the aperture field distribution is introduced, together with several examples of antennas for space applications designed, fabricated and characterised in the framework of recent research projects financed by the European Space Agency. The design process is reviewed from analytical formulas to optimization.



Prof. Sergei TRETAKOV
Aalto University, Finland

“[Metasurfaces-by-Design](#)”

In this talk we will discuss metasurfaces optimally designed for application-required transformations of electromagnetic fields. We will explain what physical properties of metasurface unit cells are responsible for various field transformations and illustrate the potentials of this technology by several examples from our experimental work.



Prof. Douglas H. WERNER
Pennsylvania State University, USA
“[Engineered Materials by Design Based on Multi-objective Global Optimization Schemes](#)”

The term Engineered Materials by Design refers to a technique that seeks to create new artificial materials for specific applications by design. The goal is to achieve the desired physical properties in an engineered material system that enables a given functionality or targeted application. The primary focus of this presentation will be on refractive-index-engineered materials by design, but the techniques introduced could well be applied to tailoring other physical attributes of a given materials system. The rapid development of technology based on refractive-index-engineered materials coupled with the recent introduction of the transformation optics technique provides RF/optical device designers with an unprecedented ability to manipulate and control the behaviour of electromagnetic wave phenomena. This has led to an ever increasing demand for more sophisticated design tools which can be utilized to customize the electromagnetic properties of refractive-index-engineered devices. These refractive-index-engineered devices typically feature a large number of conflicting design objectives. Traditional optimizers require the user to combine these objectives in some way, but it is often difficult to know a priori the best approach for accomplishing this. Multi-objective optimizers require no a priori assumptions on the part of the design engineer, and they provide a set of solutions which reveal the various trade-offs between the different objectives. Several examples will be presented of RF and optical devices that have been realized by employing an engineered materials by design approach based on either a single- or multi-objective global optimization scheme.

Round Tables

Round Table I (Dec. 3, h. 16:45)

METAMATERIAL-ENHANCED SYSTEMS FOR ICT: OPEN CHALLENGES AND OPPORTUNITIES

Session Chairs



Dr. Fabrice BOUST
ONERA, France



Prof. Alain SIBILLE
Télécom Paris Tech, France

The introduction of engineered materials with field-manipulation properties not readily available in nature, collectively labelled as Metamaterials (MTMs), has spurred the introduction, development, and application of a huge number of new design approaches and technologies in microwave, Terahertz, and optical frequencies, as well as in heterogeneous application domains including acoustics and mechanics.

In this framework, ICT systems represents a wide and disruptive field of application of MTMs, as it has been already demonstrated in several devices and demonstrators recently developed. However, several fundamental challenges in MTM engineering still need to be carefully addressed in order to demonstrate the full capabilities of MTMs in ICT, including (i) wide band operation, (ii) realizability of arbitrary permittivity/permeability profiles, (iii) and implementability of fully reconfigurable MTMs.

In this scenario, this roundtable will be aimed at illustrating the current challenges, envisaged developments, research trends, and opportunities in the application of MTM engineering to ICT systems.

Round Table II (Dec. 4, h. 15:15)

BRIDGING THE GAP BETWEEN ACADEMIA AND INDUSTRY IN METAMATERIAL APPLICATIONS

Session Chairs



Prof. Giacomo OLIVERI
University of Trento, Italy



Dr. Hervé LEGAY
Thales Alenia Space, France

In the last 15 years, metamaterial science and engineering has emerged as a vast and innovative interdisciplinary research field encompassing several different disciplines including (but not limited to) physics, material science, electronics, chemistry, and photonics. The possibility to engineer the material properties with a “task-driven” process has paved the way for the development of completely new classes of devices where the designed media enable a degree of flexibility and reconfigurability not achievable with standard architectures. This opportunity has motivated a great interest from the academic and industrial communities to address the limitations of traditional designs through metamaterial-engineered solutions. Hence, the gap between laboratory experiments and industrial applications has progressively reduced, leading to several successful applicative experiments, especially in the fields of Communications and Sensing. This roundtable will be devoted to the discussion of the current trends in the design and fabrication of reliable, cost-effective, and high-performance metamaterial-enhanced devices for industrial applications, as well as to the illustration of the current challenges and trends within this research field.

Poster Session

P1 Controlling the Propagation of Elastic Waves with Negative Refraction

Benoît Gérardin, Jérôme Laurent, Claire Prada, Arnaud Derode and Alexandre Aubry (CNRS - ESPCI Paristech - Université Denis Diderot - Paris 7, FR)

P2 Inverse Scattering Design of Unconventional Devices

Tommaso Isernia*, Lorenzo Crocco**, Loreto Di Donato*** and Domenica Iero (*Univ. Mediterranea di Reggio Calabria, IT; IREA-CNR Napoli, IT; ***DIEEI Università di Catania, IT)

P3 Circularly Polarized Metasurface-based Antenna for X-band Applications

Son Xuat Ta and Ikmo Park (Ajou University, KR)

P4 Engineering dark mode resonances in Z-metasurfaces for sensing applications

Elena Bochkova, Shah Nawaz Burokur, André de Lustrac and Anatole Lupu (IEF, CNRS, UMR 8622, FR)

P5 Engineering non-uniform metasurfaces for radiation direction control

Badreddine Ratni*, André de Lustrac*, Gérard-Pascal Piau** and Shah Nawaz Burokur* (*IEF, CNRS, UMR 8622, FR; ** AIRBUS Group Innovations, FR)

P6 Material Parameters Extraction for 1D Fractal Metamaterial

Samaneh Moeini and José Carlos Pedro (Universidade de Aveiro, PT)

P7 Measurement of Local Density of States of Hyperbolic Metamaterials for Microwave Frequencies

Kaizad Rustomji*, Redha Abdeddaim*, Stefan Enoch*, Sebastien Guenneau* and Boris Kuhlmeiy** (*Institut Fresnel, FR; University of Sydney, AU)

P8 The Energy Point of View in Plasmonics: The Plasmonic Drag

Rabih Ajib, Armel Pitelet, Ziad Ajaltouni, Emmanuel Centeno and Antoine Moreau (Université Blaise Pascal, FR)

P9 Multiscale homogenization theory for periodic metamaterials: artificial electromagnetic chirality and bianisotropy

Carlo Rizza* and Alessandro Ciattoni** (*University of Insubria, IT; CNR-SPIN, IT)

P10 S-shaped split ring resonators (S-SRRs) for the design of spectral signature barcodes

Cristià Herrojo Prieto, Jordi Naqui Garolera and Ferran Martín Antolín (Universitat Autònoma de Barcelona, SP)

P11 A Simple Design Rule for Light Concentrating Using Polymer Metamaterial

Johnny Moughames*, Aurélien Bruyant*, Safi Jradi*, Sebastien Guenneau**, Stefan Enoch**, Suzanna Akil***, Yann Battie***, Aen Naciri*** and Ziad Herro**** (*UTT, FR; **Institut Fresnel, FR; ***Université de Lorraine, FR; **** Université Libanaise, LB)

P12 Magnetic Uniaxial Wire Medium

Tiago Morgado*, João Costa** and Mario Silveirinha* (*University of Coimbra, PT; CST, DE)

P13 Strong optical anisotropy of self-assembled lamellar metal-dielectric nanocomposites

Xuan Wang, Kévin Ehrhardt, Clémence Tallet, Philippe Barois, Ashod Aradian and Virginie Ponsinet (Univ. de Bordeaux, FR)

P14 Even-Odd Mode of a Tri-band Double-Lorentz Transmission Line Metamaterial

Fatima Mazeh*, Jalal Jomaah**, Fabien Ndagijimana*** and Hussam Ayad* (*Lebanese University, LB; **IMEP-LHAC, FR; ***Minatec, FR)

P15 Polarization coupling at oblique incidence of sub-wavelength array of Au-hemispheres on glass substrate: aberrations of Meta-Surfaces

Morten Kildemo (NTNU, NO)

P16 FSS-based metasurfaces for terahertz sensing at oblique incidence

Pablo Rodríguez*, Miguel Beruete* and Sergei Kuznetsov** (*Universidad Pública de Navarra, SP; **Novosibirsk State University, RU)

P17 Interferometric Control of the Absorption in Film-Coupled Nanocubes

Caroline Lemaître, Emmanuel Centeno and Antoine Moreau (Institut Pascal, FR)

P18 Analysis of Metamaterial Inclusions Using Characteristic Modes

M.Hassanein Rabah and Divitha Seetharamdoo (IFSTTAR, FR)

P19 Isotropic optical magnetism of raspberry-like self assembled metamaterials

Daniel Torrent*, Sergio Gomez-Grana*, Vasyl Kravets**, Alexander Grigorenko**, Etienne Duguet*, Mona Treguer-Delapierre*, Jacques Leng*, Jean-Baptiste Salmon*, Virginie Ponsinet*, Philippe Barois* and Philippe Richetti* (*CNRS and University of Bordeaux, FR; **University of Manchester, UK)

P20 Application of Aggressive Space Mapping (ASM) Optimization to the Design of Electromagnetic Bandgap (EBG) based Wideband Microwave Bandpass Filters

Marco Orellana*, Jordi Selga*, Paris Vélez*, Marc Sans*, Ana Rodríguez**, Vicente Boria** and Ferran Martín* (*Universidad Autónoma de Barcelona, SP; **Universitat Politècnica de València, SP)

P21 Impact of finite dimensions on performances of a Resistive High-Impedance Surfaces (RHIS) Absorber Material

Yenny Pinto Ballesteros*, Stefan Varault*, Anne Claire Lepage*, Xavier Begaud* and Nicolas Capet** (*LTCI, CNRS, Télécom ParisTech, Université Paris-Saclay, FR; **Centre National d'Etudes Spatiales, FR)

P22 Influence of Material Parameters in a Superstrate Made by Transformation Optics to Drastically Change the Radiation Pattern of an Antenna

Chetan Joshi, Mark Clemente Arenas, Anne Claire Lepage and Xavier Begaud (LTCI, CNRS, Telecom Paristech, Université Paris-Saclay, FR)

P23 Scalar metasurface antennas able to radiate polarized tilted beam

M. Casaletti*, M. Smierzchalski**, M. Ettore**, Ronan Sauleau**, and Nicolas Capet*** (* Sorbonne Universités, UPMC Univ Paris 06, FR; **IETR, UMR CNRS 6164, University of Rennes 1, FR; ***Centre National d'Etudes Spatiales, FR)

Posters will be on display in the hall located in front of Room F03-6. Each board will be marked with its ID-number. Presenters have to hang up their poster on during the Poster Sessions (both days). Posters left on the boards after the end of the second Workshop will not be returned.

Directions

Arriving at CentraleSupélec

By AIR

- From Orly Airport (about 30 min) - Take ORLYVAL to "Antony", then the RER B direction "Saint Rémy Lès Chevreuse", then see "by train+bus" or "by train + taxi"
- From Roissy Charles de Gaulle Airport (about 1 hour): take the RER B towards "Saint Rémy Lès Chevreuse", then see "by train+bus" or "by train + taxi"

By TRAIN+BUS

- Take the RER B towards "Saint Rémy Lès Chevreuse". Get off at the station "Le Guichet". Follow the indications to take the bus MOBICAPS 9. Take the bus MOBICAPS 9 in direction "Gare De Jouy-En-Josas". Get off at "IUT Maison de l'ingénierie". Turn left into Rue Joliot Curie. Walk about 500m, CentraleSupélec building is on your left. [Bus Timetable: www.transdev-idf.com/horaire-ligne-9-mobicaps_006]

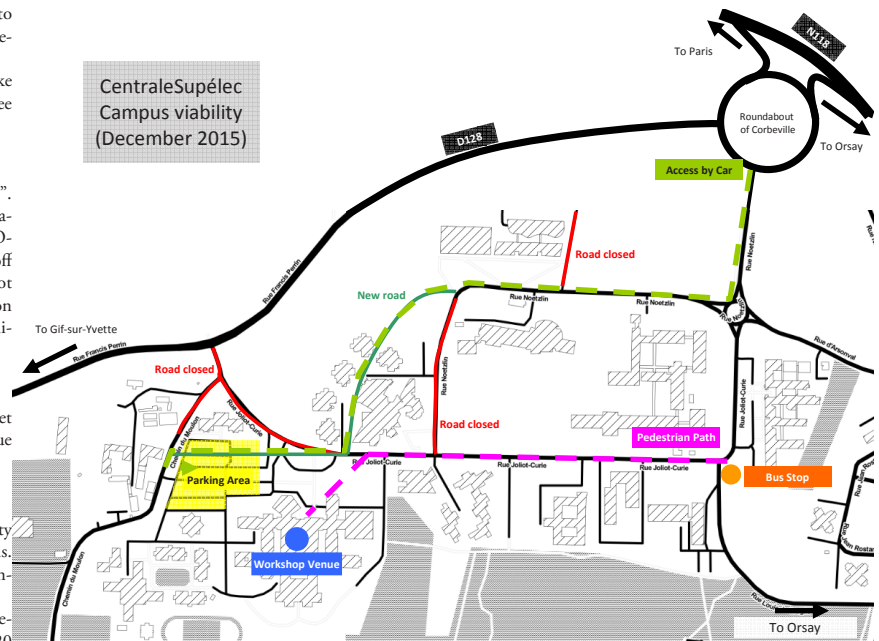
By TRAIN+TAXI

- Take the RER B towards "Saint Rémy Lès Chevreuse"; get off at the station "Massy Palaiseau" and take the taxi to rue Joliot Curie 3, Gif-sur-Yvette

By CAR

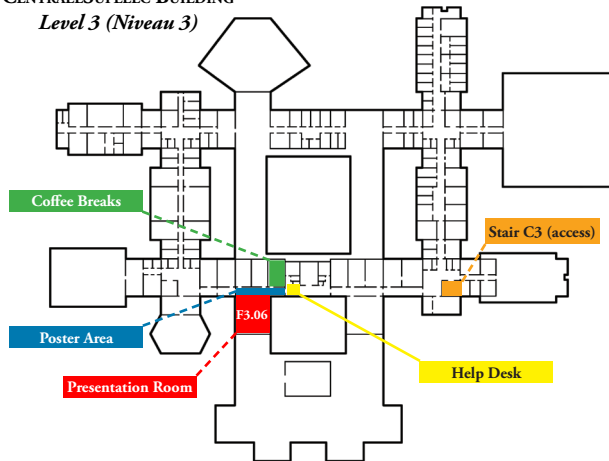
Because of the Paris Saclay construction progresses, the viability in the CentraleSupélec area may be modified on a daily basis. Please carefully check the temporary road instructions and contact the Workshop Help Desk if any support is needed.

- From Paris Porte Saint Cloud: Take the N118 (green sign) towards Nantes-Bordeaux. After about 20 Km: Exit 9 "Centre Universitaire". At the roundabout: 2nd right towards "IUT CentraleSupélec Campus" (yellow sign). Follow the yellow signs to get into CentraleSupélec parking.
- From Paris by A6-A10: Follow signs for Nantes-Bordeaux, then direction "Cité Scientifique" (left lane), then Saclay. Continue on the D36 and turn left on the D128 direction "Centre Universitaire". Pass 2 roundabouts. At the 3rd roundabout, take the 2nd right towards "IUT CentraleSupélec Campus" (yellow sign). Follow the yellow signs to get into CentraleSupélec parking.



Workshop Venue

CENTRALESUPÉLEC BUILDING Level 3 (Niveau 3)



IWMbD2015 will be held in the CentraleSupélec Building, 3 Rue Joliot Curie, 91190 Gif-sur-Yvette, France.

More in detail:

- *Registration and Help Desk* will be located in front of Room F03-6, Level 3
- **Presentations** will be held in **Room F03-6**, Level 3
- **Poster Sessions** will be held in the hall located in front of Room F03-6, Level 3
- *Coffee Breaks* will be held in front of Room F03-6, Level 3
- *Lunch Breaks* will be held in the "Salle de Prestige", Level 1

Gala Dinner

Venue: Restaurant La Belle Epoque, 10 Place de la Mairie, 78117 Châteaufort, France, on December 3, 2015.

Schedule: Thursday December 3, h. 19:30

Transfer: Shuttle bus service from/to Workshop venue starting from h. 18:30

Registration: all Full or PhD Students with a valid registration will receive a ticket to participate to the Gala Dinner. Please contact as soon as possible the Help Desk in case you need specific food options.



The restaurant La Belle Epoque is located in the village of Châteaufort, which has preserved its authentic character, close to Saclay, 30 km from Paris, and 10 km from Versailles. Behind its traditional façade, it boasts an elegant black and white decor that, as its name suggests, is typical of the turn of the century. The Chef Philippe Delaune creates carefully prepared dishes with a distinct contemporary flavour.

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Director Prof. Andrea MASSA

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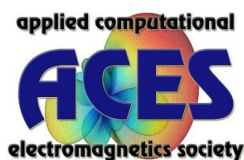
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Informations

WIFI Access

WIFI Access is available in the Workshop Venue, through

- the “**Supelec-Invite**” network (Login: IWMD; Password: December2015);
- the “**Eduroam**” network (Login and password provided by your institution, if affiliated to the Eduroam initiative)

Help Desk

For any information, please contact the Help Desk located in front of the F03-6 Room in floor 1 of CentraleSupélec Building, or call/write to:

Phone: +39 334 614 5457

E-mail: iwmbd2015@list.disi.unitn.it