



- **Project Title:** Future Wireless Communications Empowered by Reconfigurable Intelligent Meta-Surfaces
- **Call:** H2020-MSCA-ITN-2020
- **Type of Action:** MSCA-ITN-ETN
- **Coordinator:** CNIT (Consorzio Nazionale Interuniversitario per le Telecomunicazioni)
- **Coordinator person:** Dr. Stefano Buzzi
- **EU contribution:** 3 995 128.44 Euro
- **Project start date:** December 1, 2020
- **Duration:** 48 months



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MetaWireless Training

Alongside the research objectives, MetaWireless has the following main training objectives for the ESRs:

- Training Objective A: Providing a solid understanding of RIS-based communications, at all levels, i.e. electromagnetics for RISs, theory and algorithms for RIS-based networks, simulation of RIS-based networks.
- Training Objective B: Providing inter-sectoral experience, with training on both theoretical and applied research, as

well as in standardization procedures, and the creation of intellectual property rights.

- Training Objective C: Providing transferable skills training, (project management, entrepreneurship, gender issues, exploitation and dissemination of results, organization of outreach events, forming collaborations, etc.).

In addition to specificities one-day workshops, dissemination day and final conference, some Schools and Complementary courses will be organized.

Schools, delivered by experts from industry/academia on specific topics of the project, will be organized to give to the ESRs the time to learn and use the material for their individual project, while Complementary courses supplement those offered in academia.

Up to now, 3 complementary courses and a doctoral school have been held, as specified below.

Complementary Courses

Course: "Gender and underrepresented minorities issues"

- **Lead Organizer:** DEM (National Centre for Scientific Research "Demokritos")
- **Date:** 1-16/12/21
- **Instructor:** Dr. Petros Bouchoris
Dr. Petros Bouchoris is an academic teacher and executive with rich international professional experience in marketing management, business development & brand management. He has a reach experience in training executives from all over the world in an online and offline environment through his collaboration with EU Business School, and City Unity College.
- **Program:**
 1. Introduction to research and insight
 2. Defining the research problem and developing a research approach
 3. Research design
 4. Secondary data collection and analysis
 5. Internal secondary data and analytics

MetaWireless is the first training program that focuses on all aspects of RIS-based wireless networks, from fundamental electromagnetic analysis to communication theory, to networking and software aspects.

6. Primary data collection: issues in representing genders and minorities
7. Issues in Qualitative research
8. Emotion response by gender
9. Issues in Quantitative research
10. Sampling design and procedures: Representation of underrepresented minorities
11. Social Media research
12. Data integrity
13. Communicating research findings
14. Research ethics, privacy and trust
15. Limitations of research

Course: “Responsible Research Practices: Reflection, Research Ethics, Research Integrity”

- **Lead Organizer:** TUW (Technische Universitaet Wien)
- **Date:** 7-17/12/21
- **Instructors:** Dr. Marjo Rauhala, Dr. Lisa Sigl
Dr. Marjo Rauhala is the research ethics coordinator at TU Wien, responsible for developing research ethics and research integrity structures for the university. Marjo Rauhala has a broad experience in research ethics ranging from research to collaboration with various bodies responsible for assessment of research and innovation in the national and international contexts.
Dr. Lisa Sigl is researcher at the Research Platform “Responsible Research and Innovation (RRI) in Academic Practice”. Her main research interest lies in the conditions that allow societal responsibility (in its various dimensions) to be a legitimate and potent value in research cultures and practices.
- **Program:**
 1. Introductory round & Intro to Workshop plan
 2. Lecture Research Ethics
 3. Lecture Responsible Research
 4. Discuss Task
 5. Dossier including (1) Mapping of what issues and questions in Research Ethics and Responsibility matter most for student’s own PhD Project; (2) self-reflection essay
 6. Group Discussion
 7. Participant presentations of their mappings

Course: “Developing effective research papers and presentations”

- **Lead Organizer:** UPF (Universitat Pompeu Fabra)
- **Date:** 18/2/22-4/3/22
- **Instructor:** Dr. Lisa Mann
Dr. Lisa Mann has enjoyed a long career in the field of applied linguistics as an author’s editor, translator,

instructor of academic and business English, teacher trainer and professional development facilitator for international researchers and educators. She has collaborated with universities and research institutes in countries all over the world as both an editor and a research writing instructor.

- **Program:**
 1. Structure of a research article
 2. Academic language focus
 3. Writing and peer review
 4. Research presentations

First Doctoral School

- **Organizers:** TID, AALTO, WUP, EAB, CNIT
- **Date:** 8 – 10/03/22
- **Program:**
 1. Course on Metasurfaces (Part I) - Prof. Constantin Simovski (AALTO)
 2. Course on Metasurfaces: Exercise session I - Dr. M. Sajjad Mirmoosa (AALTO)
 3. Course on Metasurfaces (Part II) - Prof. Sergei Tretyakov (AALTO)
 4. Course on Metasurfaces: Exercise session II - Dr. Xuchen Wang (AALTO)
 5. Course on Metasurfaces (Part III) - Prof. Stefano Maci (UNISI)
 6. General discussion session - Prof. Stefano Maci (UNISI), Prof. Constantin Simovski, Prof. Sergei Tretyakov, Dr. M. Sajjad Mirmoosa, Dr. Xuchen Wang (AALTO)
 7. Intellectual Property and Research - Antonio Lopez-Carrasco Comajuncosas (TID)
 8. Standardization in ETSI/IETF from the POV of large telco - Diego R. Lopez (TID)
 9. MIMO and Massive MIMO in wireless networks - Dr. Carmen D’Andrea (CNIT)
 10. Standardization in practice: creation of a cellular system - Prof. Stefan Parkvall (ERICSSON)
 11. Reconfigurable Intelligent Surfaces: The standardization road towards 6G - Dr. Vincenzo Sciancalepore (NEC)
 12. Research units in industry: roles, management, and practical examples - Dr. Diego Perino (TID)

ESRs Presentation

In the following, a presentation of the new recruited ESs is given with details on his research project and background.

MetaWireless Project Newsletter

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Fahad Ahmed

- **Project Title:** Large bandwidth and multi-band RIS designs for high frequencies bands
- **Host Institution:** DEM
- **Ph.D. Enrollment:** UNIPI
- **ESR supervisors:** Dr. Angeliki Alexiou, Dr. Fotis Lazarakis
- **Name:** Fahad
- **Surname:** Ahmed
- **Gender:** Male
- **Birthdate:** 11/02/1993
- **Nationality:** Pakistani



Short Biography: Fahad received his BS Telecommunication engineering degree from University of Engineering and Technology, Taxila, Pakistan, and MS Electrical engineering (RF & MW) degree from Research Institute for Microwave and Millimeter-wave studies (RIMMS), National University of Sciences and Technology (NUST), Islamabad, Pakistan.

During his masters he worked on metasurface based cross and circular polarizers in reflection mode, metasurface-based polarizers in transmission mode, absorbers, asymmetric transmission, circular dichroism, polarization selective metasurfaces, FSS based filters, ultrathin flexible beam-splitters, partially reflective surfaces, reconfigurable polarizers, and bianisotropic omega metasurfaces for Low RCS and Fabry Perot cavity antennas applications.

After his master's program, he started a job as a research assistant and done many industrial projects, i.e., spiral antennas with fixture and radome, helical antennas for jammers, Biconical antennas with fixture and radome, and patch antenna arrays. After one year of experience, he joined SPRC Lab as an RF Engineer and worked mainly on software defined radios. He has designed blade antennas, dual band MIMO antennas, pass band and notch filters. Moreover, he also gained experience in link budgeting of transmitter/receiver chains and co-site interference analysis.

ESRs Research Activities

In the following, a presentation of the research activities of some ESRs is given with details on their first accepted papers, if available.

Javad Shabanpour

- **Project Title:** Multi-function reconfigurable meta-surface structures for wireless networks
- **Host Institution:** AALTO

- **Ph.D. Enrollment:** AALTO
- **ESR supervisor:** Dr. Sergei Tretyakov

Recently, reconfigurable intelligent surfaces (RISs) gained notable consideration due to their capability to provide efficient and cost-effective wireless communication networks.

There is no doubt that RIS-based wireless communication necessitates real-time channel estimation both in indoor and outdoor applications with moving users and objects. The angular and polarization stability is vital to remain the condition of real-time and reconfigurable channel estimation. In Javad Shabanpour's study, for the first time, the angular stability of the two-state of reflection phase-frequency dispersion (RPF) for non-polarized incident wave is considered. The proposed unit cell can keep the properties of the two states of RPF in the range of $\pm 45^\circ$ of the incident angles for both TE and TM polarized waves with 20% of the frequency bandwidth. Leveraging such a technique, his dual-polarized angle insensitive RIS meets well the future industrial demands in the real implementation of "smart radio environment".

Robert Kuku Fotock

- **Project Title:** Radio resource allocation in RIS-based wireless networks
- **Host Institution:** CNIT
- **Ph.D. Enrollment:** UNICLAM
- **ESR supervisor:** Dr. Alessio Zappone

Robert Kuku Fotock's research activity is focusing on:

- i. conduct individual research and studied some background-related topics like MIMO wireless communication, RIS, Convex, and non-convex optimization theories and analyses;
- ii. exploit several mathematical optimization techniques used to solve Rate, Spectral, and Energy Efficiencies resource allocation problems in wireless networks;
- iii. attend several educative online training workshops and doctoral schools which offer vital skills needed for professional growth together with the solid foundational knowledge to understanding RIS-based wireless networks and their applications;
- iv. work on the literature review on the current state-of-art in RIS-based wireless networks. This helped me understand the current research trend, challenges, and lapses;
- v. develop several algorithmic frameworks using powerful computational software.

In a nutshell, though there exists an exhaustive list of research works that address most of the research questions on resource allocation for RIS-based wireless networks, most of these research works have only been focused on passive RIS which only acts as a guiding reflection system that dynamically controls

the propagation environment and whose limitations have already been discussed in the existing literature.

However, there is only a handful of research work that has been focused on Active RIS and its superiority over passive RIS. Much is yet to be done in the field of Active RIS especially when it comes to the Energy Efficiency optimization problems since Active-RIS consist of active elements which consume extra power than its passive counterpart.

His research will therefore mostly be focused on the study of the Radio Resource Allocation problems involved in Active RIS-based wireless networks.

Georgios Mylonopoulos

- **Project Title:** Localization and sensing through meta-surface structures
- **Host Institution:** CNIT
- **Ph.D. Enrollment:** UNICLAM
- **ESR supervisor:** Dr. Stefano Buzzi, Dr. Carmen D'Andrea, Dr. Giovanni Interdonato

Georgios Mylonopoulos' research activity is focusing on:

- individual studying on Telecommunication engineering to reinforce essential theoretical skills;
- attending online workshops and courses to gain skills vital for any researcher;
- analyzing scientific papers related to RIS enabled telecommunication networks to properly understand the current state of the art and RIS research trends;
- participating in research promoting activities.

The state of the art analysis led to novel idea of active RIS enabled localization. There is a lot of discussion on RIS enabled localization, since RISs actively alter the propagation environment and create a spatial dependency on the improved signal quality. However, all prior research considers a passive RIS. He has summarized his findings in a conference paper. The idea of utilizing active RIS elements for target localization and tracking is uncharted research territory and has publication potential.

Below the details of the submitted paper:

- **Title:** Active Reconfigurable Intelligent Surfaces for User Localization in mmWave MIMO Systems
- **Authors:** Georgios Mylonopoulos, Carmen D'Andrea, Stefano Buzzi
- **Publication venue:** IEEE-SPAWC 2022 (pending approval)

Guillermo Encinas Lago

- **Project Title:** Scalable software-configurable large-scale intelligent radio environments
- **Host Institution:** NEC

- **Ph.D. Enrollment:** UNICLAM
- **ESR supervisor:** Dr. Vincenzo Sciancalepore

Guillermo Encinas Lago can exhibit the following accepted paper:

- **Title:** RIS-Aware Indoor Network Planning: The Rennes Railway Station Case
- **Authors:** Antonio Albanese, Guillermo Encinas-Lago, Vincenzo Sciancalepore, Xavier Costa-Perez, Dinh-Thuy Phan-Huy Stéphane Ros
- **Publication venue:** ICC 2022

Sravan Vuyyuru

- **Project Title:** Ray-tracing module for RIS-based wireless networks
- **Host Institution:** NOK
- **Ph.D. Enrollment:** AALTO
- **ESR supervisors:** Dr. Sergei Tretyakov, Dr. Risto Valkonen and Dr. Marco Di Renzo

The main objective of Sravan Vuyyuru's research activity is to integrate the RIS scattering properties into the Nokia bell lab's ray tracer. During the first three months, he studied the concepts related to scattering by physical optics approximations for a simple rectangular metal plate and continued the study on scattering properties for arbitrary oblique incidence and any arbitrary receiver. The researcher has performed a literature review on ray-tracing techniques and acceleration methods for propagation prediction for the next three months. Then he continued to study the modeling of ray field theory propagation, including the study on geometrical optics, geometrical theory of diffraction, and uniform theory of diffraction approximations. The researcher has also started designing perfect anomalous reflectors using patch arrays. The learned theories are applied in electromagnetic and circuit simulations, which have started with modeling the scattering of loaded dipoles and infinite arrays of such dipoles. Subsequently, this methodology is applied to patch arrays with a target in a practical RIS design.

Le Hao

- **Project Title:** Open-access system-level simulator for RIS-based wireless networks
- **Host Institution:** TUW
- **Ph.D. Enrollment:** TUW
- **ESR supervisor:** Dr. Markus Rupp

Le Hao's research is focused on system level modelling of signal propagation in RIS-empowered wireless networks. From early investigation, the main challenges in system level modelling of

RIS include the RIS modelling, channel modelling, pathloss modelling, RIS deployment, cell association, blockage modelling and interference management. These issues are considered in developing the RIS-tailored system level simulator. After several times of updating, the Vienna System Level Simulator can now simulate RISs in large-scale scenarios with different setups for downlink transmission. The MIMO and uplink transmission in the simulator is under progress and optimized RIS deployment strategies are under investigation.

Joaquín García Fernández

- **Project Title:** Meta-surfaces for low-complexity transmitter design in RIS-based wireless networks
- **Host Institution:** WUP
- **Ph.D. Enrollment:** UNISI
- **ESR supervisor:** Dr. Francesco Caminita

The research carried on by Joaquín García Fernández is mainly focused on the design of reconfigurable transmitters based on metasurface topologies. The studied structures are composed by small elements in terms of wavelength whose status are switched by tuning lumped elements controlled through biasing. In this way, the problem can be studied from the point of view of an equivalent surface impedance as a boundary condition, which can be modified to control the propagation phase and amplitude of the waves running over the antenna in such a way that fast beam-hopping can be achieved.

Fahad Ahmed

- **Project Title:** Large bandwidth and multi-band RIS designs for high frequencies bands
- **Host Institution:** DEM
- **Ph.D. Enrollment:** UNIPI
- **ESR supervisor:** Dr. Angeliki Alexiou

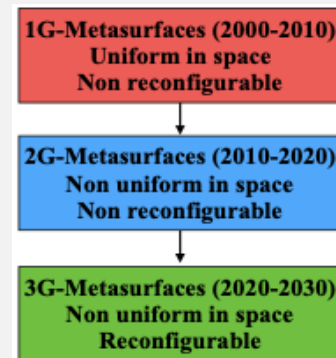
Fahad Ahmed has designed a wideband 1-bit reconfigurable reflecting surface with a miniaturized unit cell to control the phase and amplitude for beamforming and beam splitting in reflection mode. Moreover, the 2-bit and 3-bit reconfigurable RIS for mm-wave are also in progress to control the reflection phase, and the direction of the beam in specific direction by incorporating it in metasurface coding.

In the next issue...

The next issue will contain a description of the further training and dissemination activities carried out within the MetaWireless project.

What are RISs?

Present meta-surfaces are planar structures made of special materials, known as meta-materials, that contain elementary electromagnetic units. This non-uniformity in space enables meta-surfaces not to adhere to conventional reflection and diffraction laws, but they are able to modify the phase and wavefront of the radio waves impinging on them, in a fully customizable way. They can be used to coat objects or can be deployed on the facades of buildings, enabling the customization of the electromagnetic response of a wireless environment. While the use of meta-surfaces has been demonstrated in small indoor links, their use in real-world networks requires the capability of configuring their electromagnetic behavior in real-time, so as to compensate for channel fluctuations.



As shown in the figure, present (i.e. 2nd generation) meta-surfaces do not provide this possibility. RISs, are considered the 3rd (future) generation of meta-surfaces], granting the chance of configuring their electromagnetic response fast enough to follow the fluctuations of wireless channels.

Contacts

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