MAY, 2023

RISE-6G

Reconfigurable **I**ntelligent and **S**ustainable **E**nvironments for **6G**

TWO YEAR PROGRESS REPORT

All-in-one architecture - The project has forged a system-level vision needed to unleash the high potential of RISs in B5G/6G systems, developing wireless network architectures, over-the-air communication and localization protocols, control strategies, and related signal-processing and AI frameworks and algorithms.

Evolutionary hardware development and experimental prototyping - The technology challenge of RIS hardware design has been addressed by demonstrating their cost-effective realization. Aside from modeling and characterization advancements, multiple prototypes have been developed, and the ongoing measuring campaign is designed to aid the design of the final field-trial demonstrations.

Intelligent control mechanisms - The joint orchestration and control of RIS components with the conventional wireless transceivers' settings has been a primary focus of investigation. Intelligent mechanisms are being developed and proposed that self-adapt RIS configurations and refine communication network parameters to achieve high KPI performance in terms of enhanced QoS, localization accuracy, EE, low EMF, as well as increased secrecy rates in dedicated boosted service areas.

PROJECT UPDATES IN NUMBERS

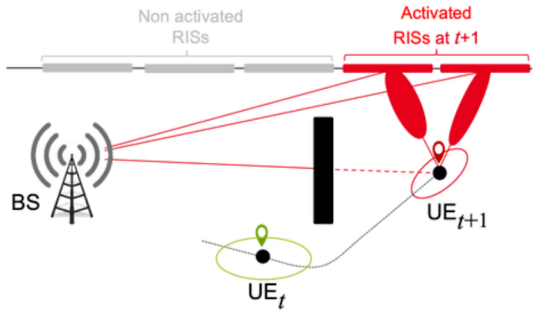
20 Deliverables	160 Publications
9 Plenary meetings	70 Dissemination actions

NEWSLETTER #03

Newsletter Highlights

WP2 - Scenarios, Use Cases, KPIs

D2.1 & D2.3 - Reference system, scenarios and use cases analysis (initial & final results)



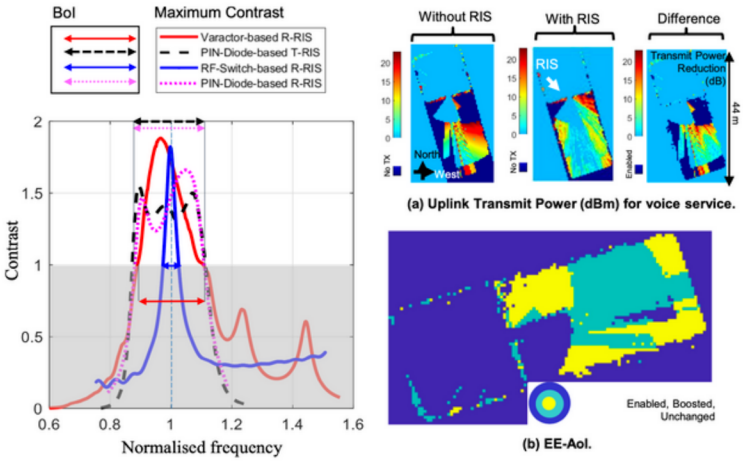
The objective of those deliverables is to investigate high relevance B5G scenarios and use cases where RIS technology can be successfully exploited while making the difference delivering advanced services. The following categories are covered:

1. Enhanced connectivity and reliability.
2. Enhanced localization and sensing.
3. Enhanced sustainability and security.

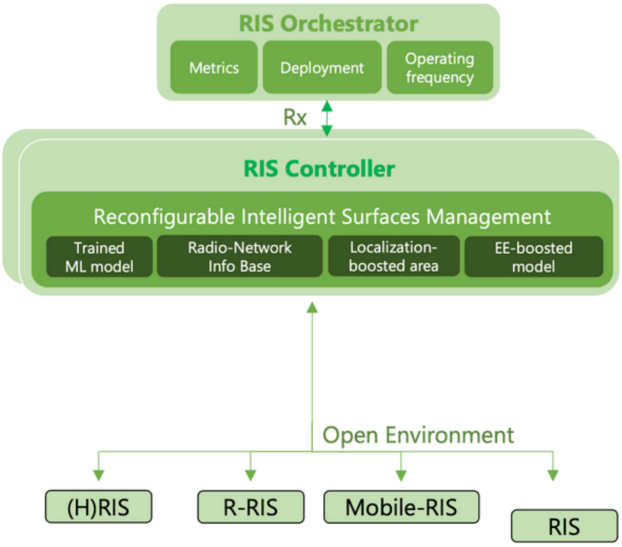
Reference scenarios are identified for each category, and situations and conditions are described that might require the ful exploitation of the RIS technology, showcasing exemplary applications of RIS technology.

D2.2 & D2.4 - Metrics and KPIs for RISE wireless systems analysis (initial & final results)

The documents summarize the initial and final results of identifying traditional and beyond-state-of-the-art relevant performance metrics and KPIs, to be further used by the technical WPs to assess the performance of RISE wireless systems for identified scenarios. In those deliverables, the novel concepts of “Area of Influence” and “Band of Influence” have been introduced as the area of significant improvement of wireless connectivity enabled by RISs and as the frequency bandwidth in which any wave hitting the RIS gets reflected, respectively.



D2.5 - RISE network architectures and deployment strategies analysis (first results)



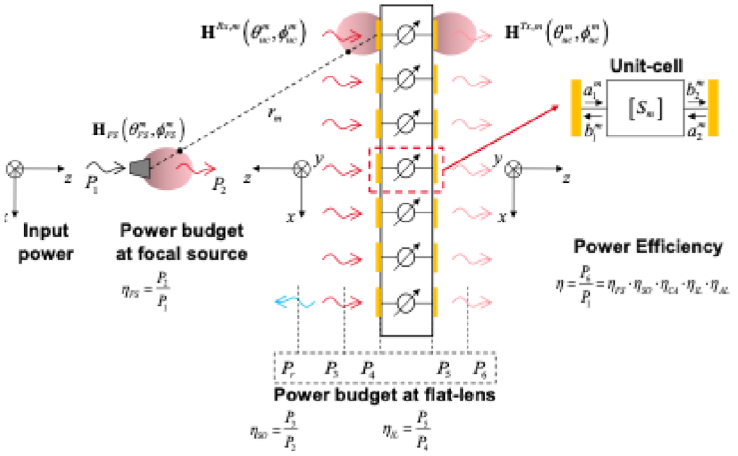
D2.5 reports on the first results within the RISE-6G project related to RIS Empowered (RISE) network architectures and deployment strategies analysis. The work builds on the initial deliverables within the technical work packages 4,5, and 6 and also serves as a point of collection and harmonisation of all contributions towards the proposed RISE network architecture so far within the project. Its contents include:

- Network architecture requirements from technical WPs,
- A general RISE-6G network architecture, deployment strategies from a technical perspective,
- Relations to existing architectures and potential extensions.

The presented results are first results, and more mature and refined results will be reported in deliverable D2.6 by the end of the project.

WP3 - RIS Modeling, Design, and Characterization

D3.1 - Preliminary RIS model and measurement campaigns

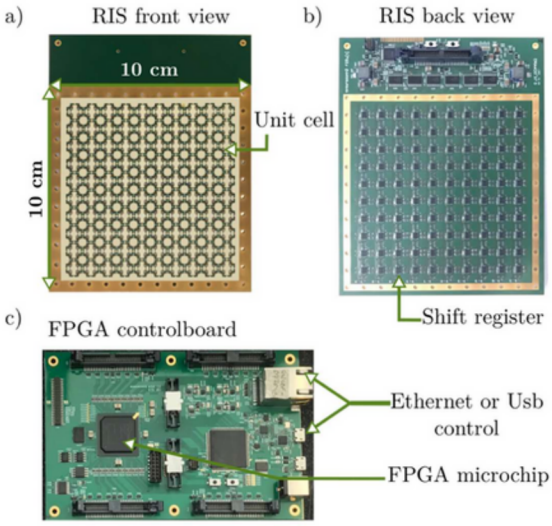


This deliverable tackles the main issues related to the electromagnetic modeling of the unit cell and the overall RIS, its impact on the radio "reconfigurable" channels and the main technology challenges related to the design and prototyping in a large frequency range from sub 6 GHz up to D-band. The general objectives are to:

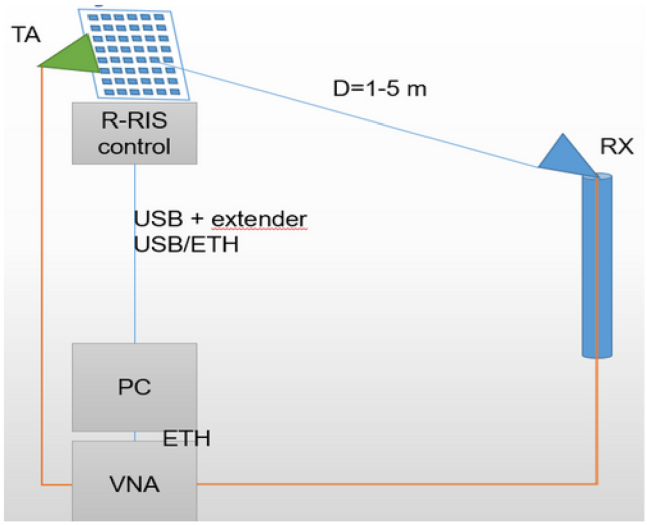
1. Provide an electromagnetic RIS model and a system level abstraction.
2. Characterize and model the RIS-empowered reconfigurable radio channel.
3. Design, prototype and characterize the RISs and control logic for the roof of concept (PoC).

D3.2 - Design, prototype and characterize the RISs and control logic for the PoC

This document describe the first RIS designs and prototypes developed in the framework of RISE-6G. Different Transmitting, Reflecting, Dual or Hybrid designs are presented based on different technologies (PiN diodes, MEMS, Varactors). The designs are being developed to cover different bands of interest in sub-6GHz, mmW and THz bands. The RIS prototypes developed in this WP will also be integrated in the final project demonstrations and PoCs.



D3.3 - RISE-6G RISE environment final model

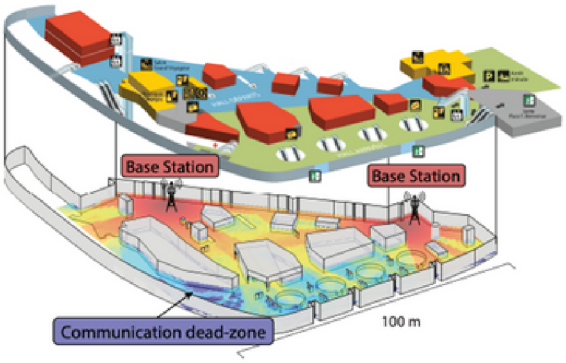


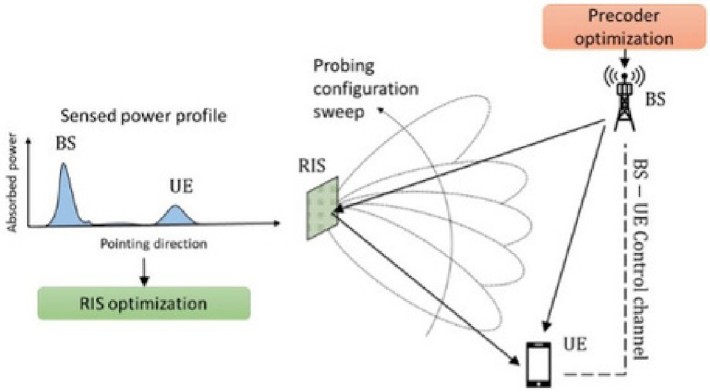
D3.3 describes the RISE-6G modelling activity in detail, presenting its main components, and elaborating a harmonization strategy that brings together all the different angles through which reconfigurable meta-surfaces are characterized, i.e. circular, scattering, field, and phase-space. Central to the harmonization strategy is the novel paradigm of environment-aware RIS modelling, whose goal is to predict the best reflection phase matrix of the RIS by including the back-reaction of the environment into the radiative properties of the loaded RIS UCs self-consistently. This integration requires the understanding of the RIS re-radiation properties under spatial and frequency dispersion, building upon and extending the models introduced in D3.1.

WP4 - RIS for Enhanced Connectivity

D4.1 - Deployment and control strategies of RIS based connectivity (Intermediary Specifications)

This document provides the intermediate results related to the first aim of WP4 and covers different KPIs, architectural alternatives, RIS control strategies, as well as data flow and signalling, derived from the various contributions within WP4.

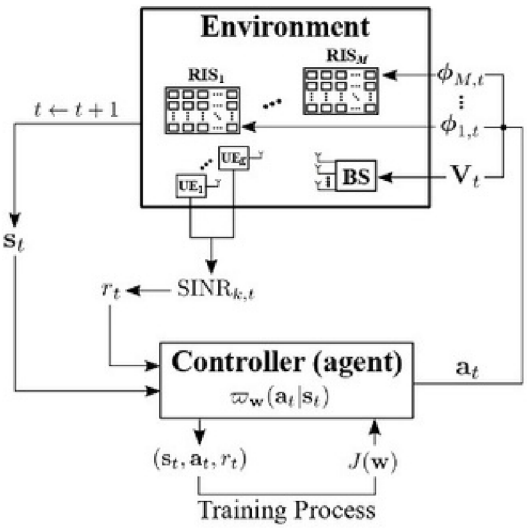




The objective is to determine the best strategies for a flexible deployment of RISs considering boosted connectivity areas. Two principle operating modes will be considered for the RIS: (1) *autonomous*, where the RIS is able to sense/decode the radio communication signals and make local decisions; and (2) *controlled*, where the RIS is controlled by another network element in-band or out-of-band.

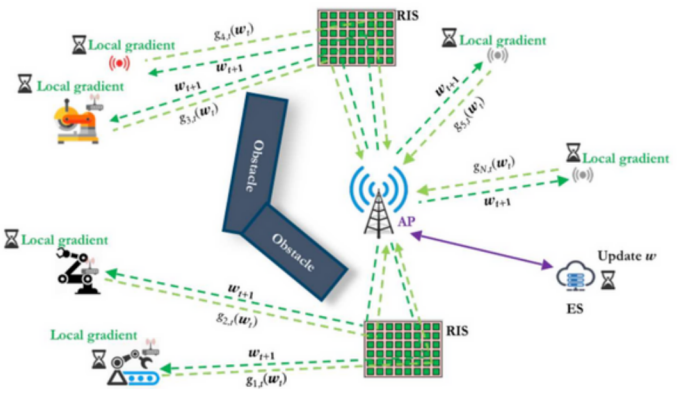
D4.2 - Multi-user techniques and connectivity of RIS based communication and mobile edge computing (Intermediary Specifications)

In the present deliverable, we report the research work carried out by the consortium of RISE-6G on multi-user algorithms and protocols for application to RIS-aided smart radio environments. The research findings reported in the present deliverable are in agreement with the initial specifications reported in deliverable D4.1. The results reported in the present deliverable constitute initial specifications that will be further elaborated and finalized in deliverable D4.4.



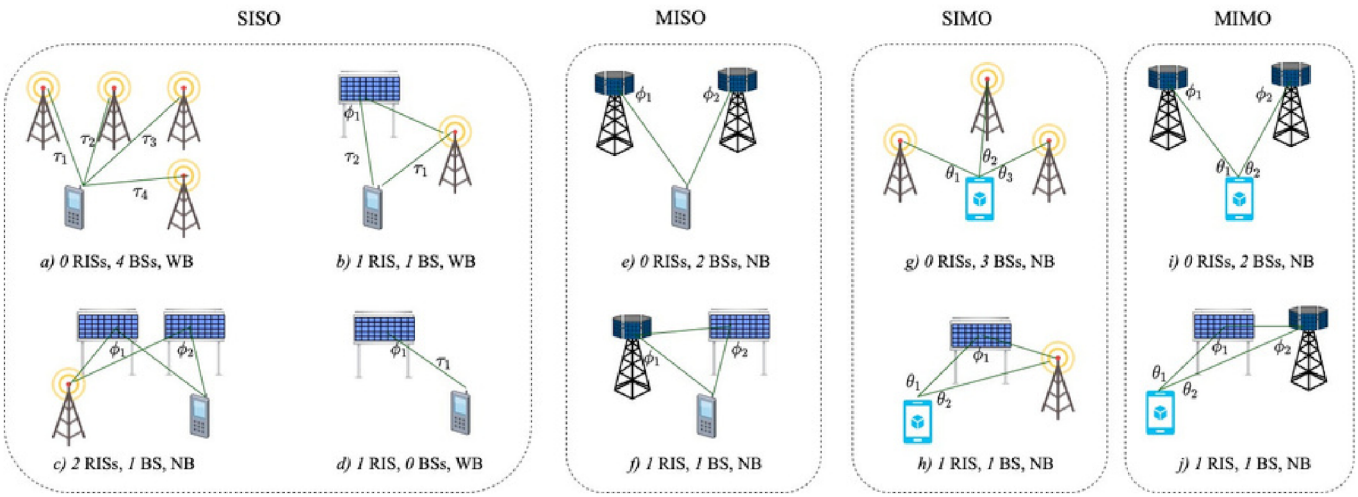
D4.2 includes reports on specifications and intermediate results regarding:

1. Fundamental performance limits in RIS-aided environments, accounting for RIS channel models and control overheads.
2. The design and optimization of control signalling protocols, channel estimation algorithms, and resource allocation and scheduling policies.
3. The design and optimization of resilient, energy efficient, and joint communication and computation mechanisms with low EMF exposure for application to power- and latency-constrained (edge) cloud services.



WP5 - RIS for Enhanced Localisation and Sensing

D5.1 - Control for RIS-based localisation and sensing (Intermediary Specifications)

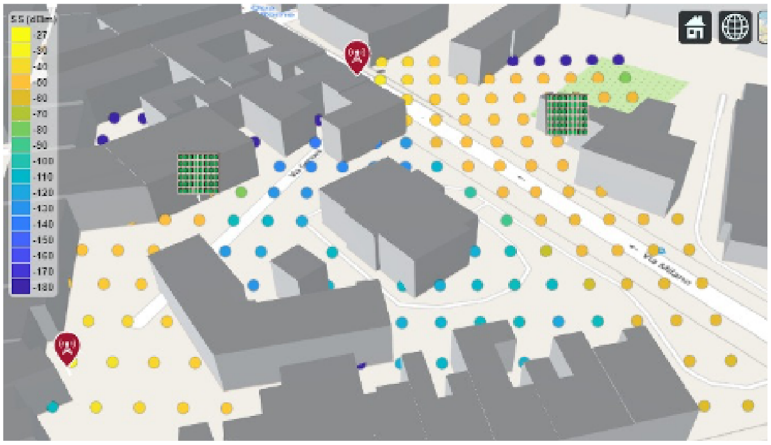


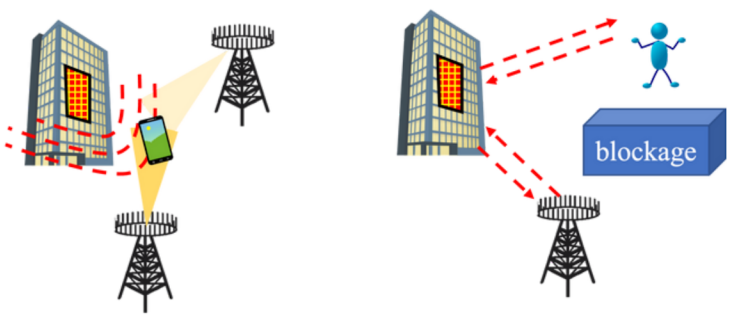
This deliverable provides the intermediate results related to RIS deployment and profile control to optimise the key performance indicators (KPIs), architectural alternatives, RIS control strategies, as well as data flow and signalling, derived from the various contributions within WP5. These results serve as input for the work in WP2 on architectures, deployment strategies, and RIS control.

D5.2 - Algorithms for RIS-based Localisation and Sensing (Intermediary Specifications)

This deliverable provides the intermediate results related to the development and evaluation of detection and estimation algorithms that enable RIS-based localisation and sensing, localising connected wireless devices, building dynamic environments and radio maps, as well as passively sensing physical features.

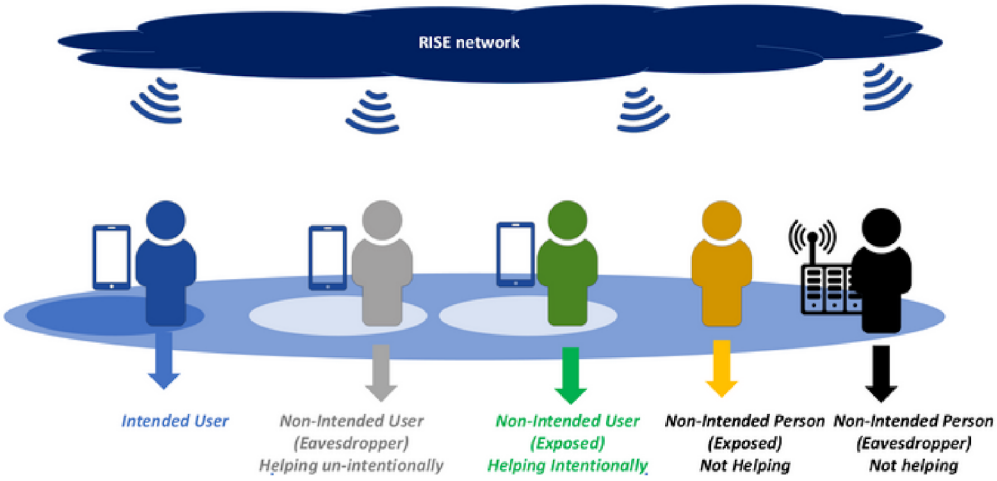
The results and algorithms presented here serve as an input to WP6, where localization and sensing information is used to control EMF exposure and to WP7, where a subset of methods will be implemented and used in proof-of-concept validations relying on real hardware.



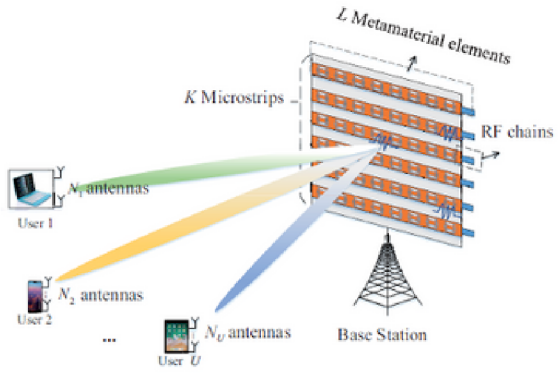


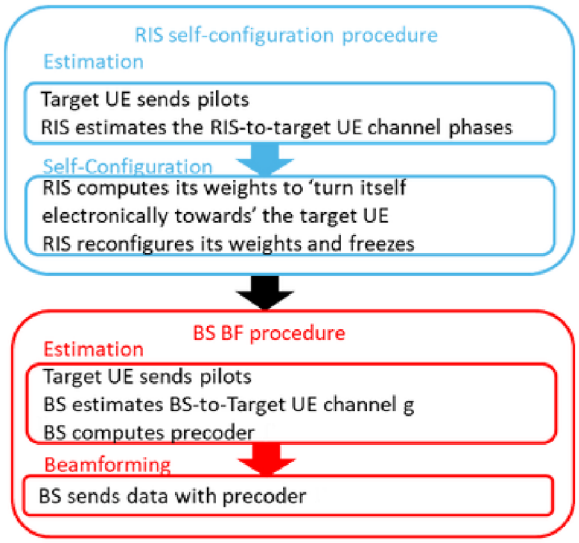
WP6 - RIS for Enhanced Sustainability and Security

D6.1 - Network architectures & deployment strategies with RIS for enhanced EE, EMFEU, and SSE (Intermediary Specifications)



This document provides the intermediate view and results from WP6, on network architectures, deployment strategies and control signalling with RIS for enhanced EE, EMFEU and SSE metrics defined in D2.4, for the use cases and deployment scenarios listed in D2.3. The current deliverable follows a bottom-up approach: First of all, the various solutions or innovations proposed by WP6 to boost SSE or EMFEU are all briefly described and analyzed, in terms of deployment, architecture and control signalling requirements. Hence, for each proposed scheme, separately, one option of architecture and control signalling is derived. In addition, for each scheme, the impact on the EE metric is briefly analyzed. Then, all requirements from all proposed schemes are gathered into a single set of requirements.





D6.2 - Sustainable RIS solutions design for EE, EMFEU and SSE (Intermediary Specifications)

The first objective of the deliverable is to design innovations in PHY-MAC layers to reach the target objectives in the target "EE/EMFEU/SSE boosted areas". Innovative schemes to optimize the trade-off between EE and EMFEU or the trade-off between EE and SSE are proposed, in the particular cases where EMFEU and/or SSE is improved at the expense of EE.

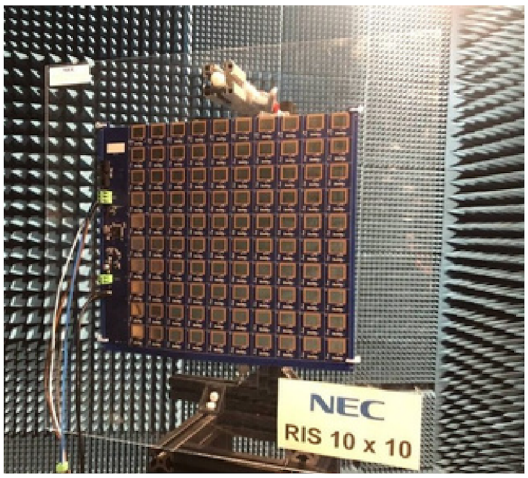
The second objective of D6.2 is to assess the improvement in terms of EE, EMFEU and SSE brought by RISE network with architectures identified in D6.1 and innovations from the previously proposed methods based on advanced realistic models provided by WP3. To do so, measurements of actual RIS (built and conducted by the project) are used as well as true 5G BS in a Reverberating Chamber (RC), advanced modelling tools developed in WP3, FDTD or Finite Elements simulations, and new mathematical frameworks, exploiting a Random Coupling Model (RCM) .

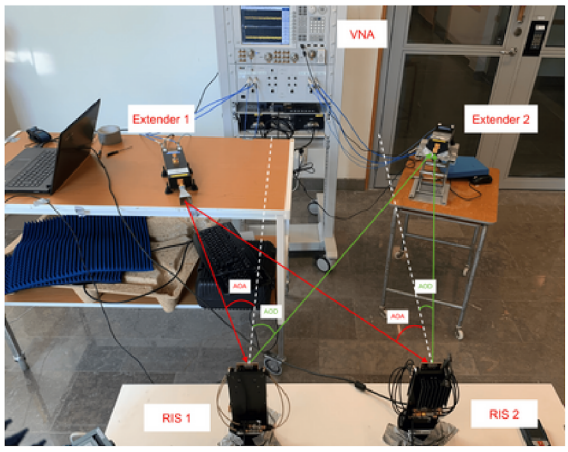
WP7 - Evaluation through Proof-of-Concepts and Field Trials

D7.1 - Integration methodology and impact measurements through advanced KPIs

In this deliverable, the experimental hardware and setup for RIS prototypes are described, including available instruments and test environments. Different application use cases including communication and localization are defined. RIS protypes are validated for communication and localization use cases separately, which cover a wide frequency range from sub-6 GHz to 150 GHz. RIS integration plan considering different use cases towards expected field-trials is also described.

The general objective of WP7 is the analysis and design of an overall RIS-based solution that encompasses different RIS-empowered equipment together with advanced transmitters and receivers to build new-generation wireless networks. In particular, it will be obtained by assembling RIS components and fine-tuning realistic equipment settings. Additionally, WP7 will validate innovations and demonstrate the feasibility of technological proposals by means of two different field-trials. D7.1 serves the first step that summarizes main RIS-based Proof-of-Concepts analysed and developed in WP3 in the perspective of their functionalities in different use scenarios.





General objectives of D7.1:

1. Validation of various RIS components including S-band, Ka-band, V-band and D-band, up to 130 GHz;
2. Development of RIS components that will be integrated into a unified solution for generic communication applications;
3. Development of RIS components that will be integrated into a unified solution for generic localization applications.

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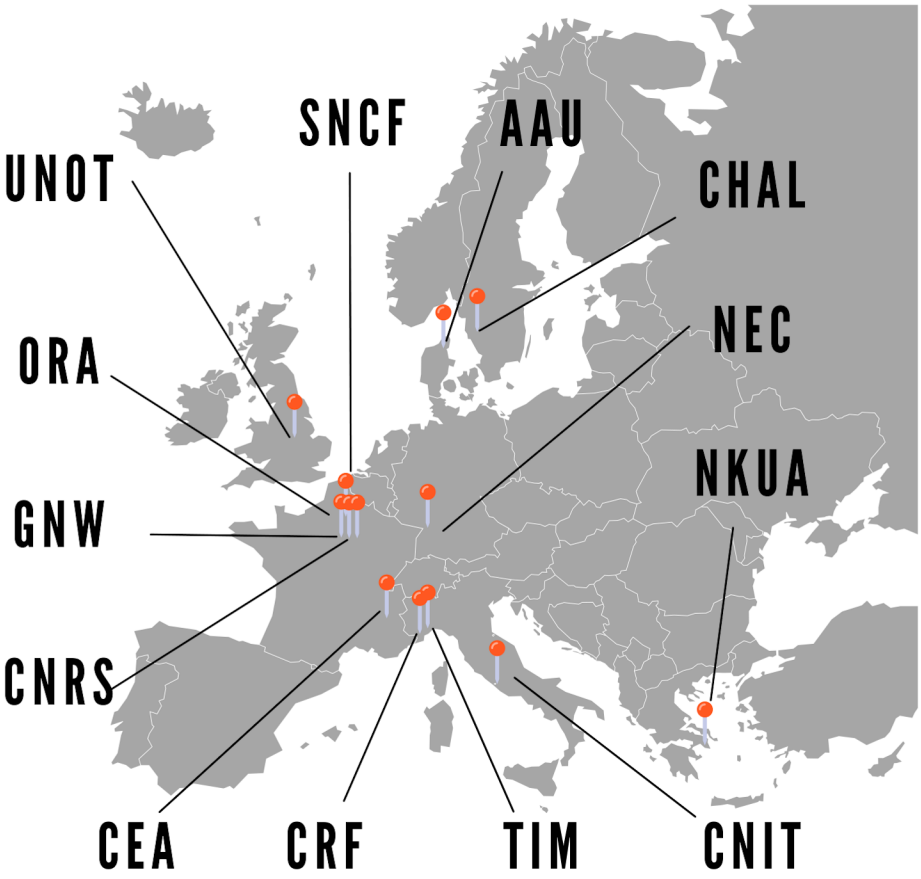

PROJECT PARTNERS

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- NEC LABORATORIES EUROPE GMBH **(NEC)**
- ORANGE SA **(ORA)**
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