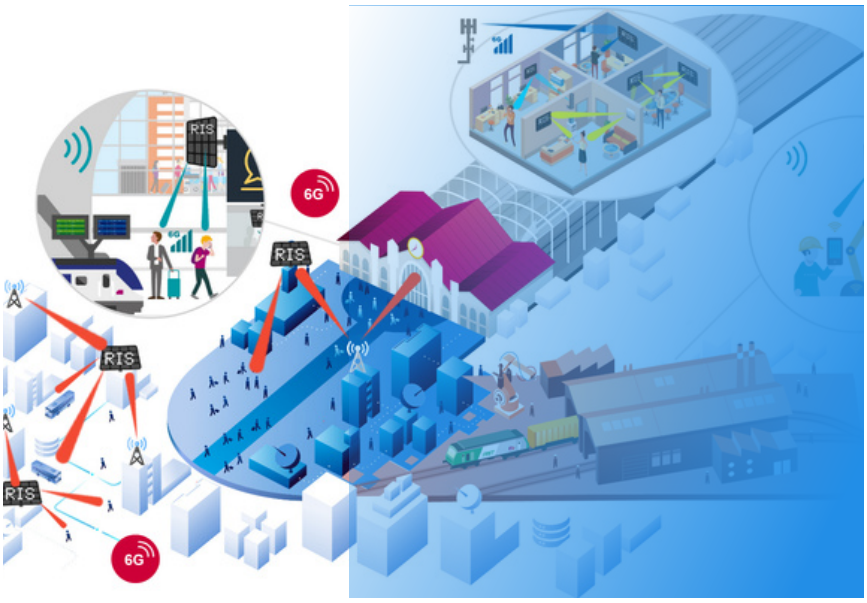
DECEMBER, 2023

RISE-6G

Reconfigurable Intelligent and Sustainable Environments for 6G



IN THIS ISSUE

FINAL REPORT

The RISE-6G Project is completing its lifecycle at the end of 2023. It has been three years of exciting moments and adventurous endeavors. Most importantly, it has been a most fruitful period of academic and technological achievements for everyone involved. The RISE-6G Consortium has produced results spanning from metasurface modelling and design to novel algorithms and from network architectures to proof-of-concept demonstrations. Apart from its immense number of publications, RISE-6G Partners have developed RIS prototypes, submitted patent applications, and made contributions to standardisation bodies. To maximise the impact of the Project, a Training Workshop was held on December 12, so that the produced outcomes are shared with the community.

NEWSLETTER #04

Project Results

34
Deliverables

188
Publications

100
Dissemination Actions

30
Pre-Standardisation Contributions

5
RIS Prototypes

5
Patent Applications

2
Proof-of-Concepts

1
Training Workshop

Project Achievements

Research Outcomes

80+ Individual Contributions

- ✓ Scenarios
- ✓ Use cases
- ✓ Signalling
- ✓ Algorithms
- ✓ Deployment
- ✓ Control
- ✓ Analysis
- ✓ Modelling

Exploitation

- ✓ **5** Patent applications
- ✓ **5** RIS prototypes
- ✓ **7** Individual exploitable developments
  - Startup, simulator software, algorithms

RIS Equipment

- ✓ Design, building, and validation of RIS prototypes
- ✓ Operating at S, Ka, V, and D bands

Architecture Impact

- ✓ Network interface architecture based on:
  - 3GPP, ORAN, ETSI NFV

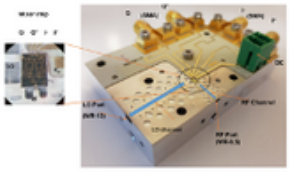
Contributions to Pre-Standardisation Bodies

- ✓ ETSI ISG RIS
- ✓ ETSI ISG THz
- ✓ ETSI ISG ISAC

Outreach and dissemination

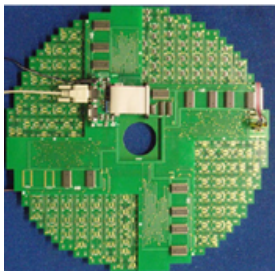
- ✓ **188** Publications
- ✓ **7000+** Citations
- ✓ **43** H-index
- ✓ **6000+** Website visits
- ✓ **10** Workshop events
- ✓ 5GPPP Arch. WG
- ✓ **2** Summer schools
- ✓ **2** Proof-of-concept demos
- ✓ **9** Panels and booths
- ✓ **46** Talks and tutorials
- ✓ **24** Special Sessions
- ✓ **15** Public events
- ✓ Social media & YouTube
- ✓ Training Workshop

Developed Prototypes

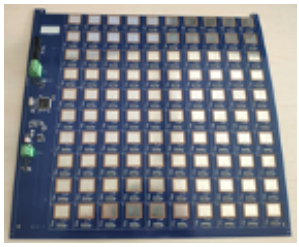


BiCMOS - 145GHz
Chalmers

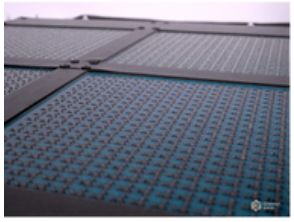
Pin diode - 27.31GHz
CEA-Leti



Varactor - 5.2GHz
Orange



RF-Switch - 5.3GHz
NEC



Pin diode - 27.31GHz
Greenerwave

Final round of deliverables

During the last six months of the project, RISE-6G submitted 13 deliverables, cross its eight work packages. A number of them concern updated and final specifications of the previous round of deliverables appeared in the third newsletter issue. In parallel, results regarding architectures, prototypes, and field trials are reported in other deliverables. The project management as well as the team's efforts on dissemination, standardisation, and industrial exploitation have submitted their final reports. The highlights of the final deliverables from the technical WPs are illustrated below. The next pages are dedicated to the proof-of-concepts and field trials under WP7.

WP2

D2.6 - RISE network architectures and deployment strategiesanalysis: Final results

The work builds on the final deliverables within the technical work packages as a point of collection and harmonisation of all contributions within RISE-6G towards a novel network architecture framework, including two proposals building upon the current O-RAN and 3GPP architectures.

WP3

D3.4 - Optimised RIS prototypes for PoCs and model assessment

Reflecting and transmissive RIS prototypes are presented that have been characterised in laboratory environments and employed in channel measurement campaigns. Their final assessment is completed under WP7 deliverables.

WP4

D4.3 - Deployment and control strategies of RIS based connectivity (Final Specifications)

- 15 new contributions on deployment strategies, control plane, and protocol structures supporting widespread RIS connectivity.

D4.4 - Multi-user techniques and connectivity of RIS-based communication and mobile edge computing (Intermediary Specifications)

- 23 contributions on the fundamentals of multi-user connectivity along with novel techniques for RIS communications, as well as for RIS-empowered multi-access edge computing.

WP5

D5.3 - Control for RIS-based localisation, mapping and sensing (Final Specifications)

- 11 new architecture and control proposals for RIS-aided localisation and sensing.

D5.4 - Estimation Algorithms for RIS-based localisation, mapping, and sensing (Final Specifications)

- 14 estimation algorithm proposals for parameter estimation, RF mapping, active UE localisation, and simultaneous localisation and mapping.
- 4 practical algorithms for laboratory demonstrations and field trials.

WP6

D6.3 - Network architectures & deployment strategies with RIS forenhanced EE, EMFEE, and SSE (Final Specifications)

- 11 contributions for energy efficiency, electromagnetic field exposure minimisation, secrecy spectral efficiency.
- A unified deployment architecture and control signalling methodologies.

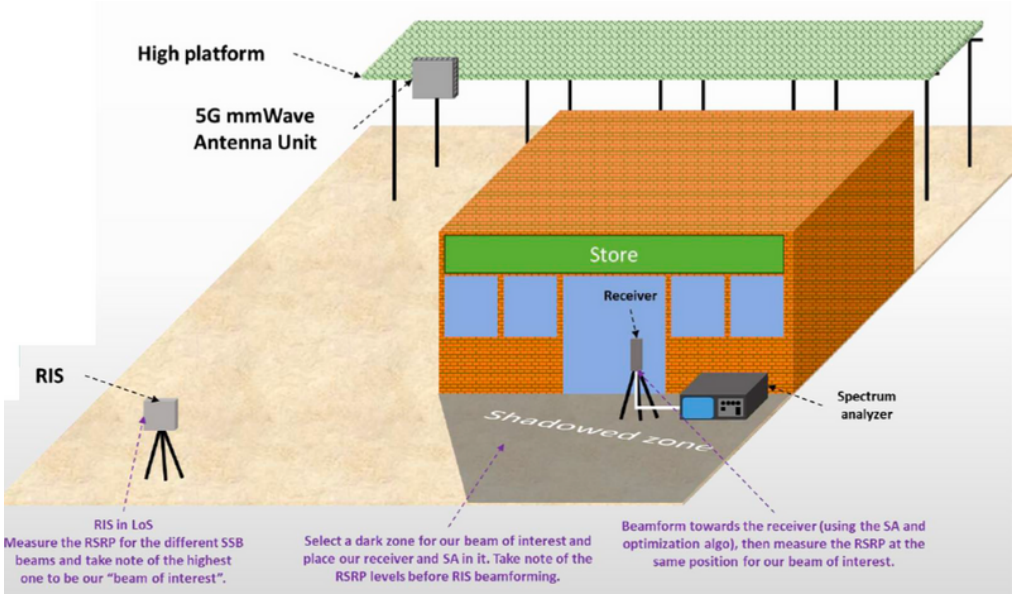
D6.4 - Sustainable RIS solutions design for EE, EMFEE and SSE (Final Specifications)

- 20 contributions for sustainable RIS solutions.
- 5 novel performance assessment methodologies.

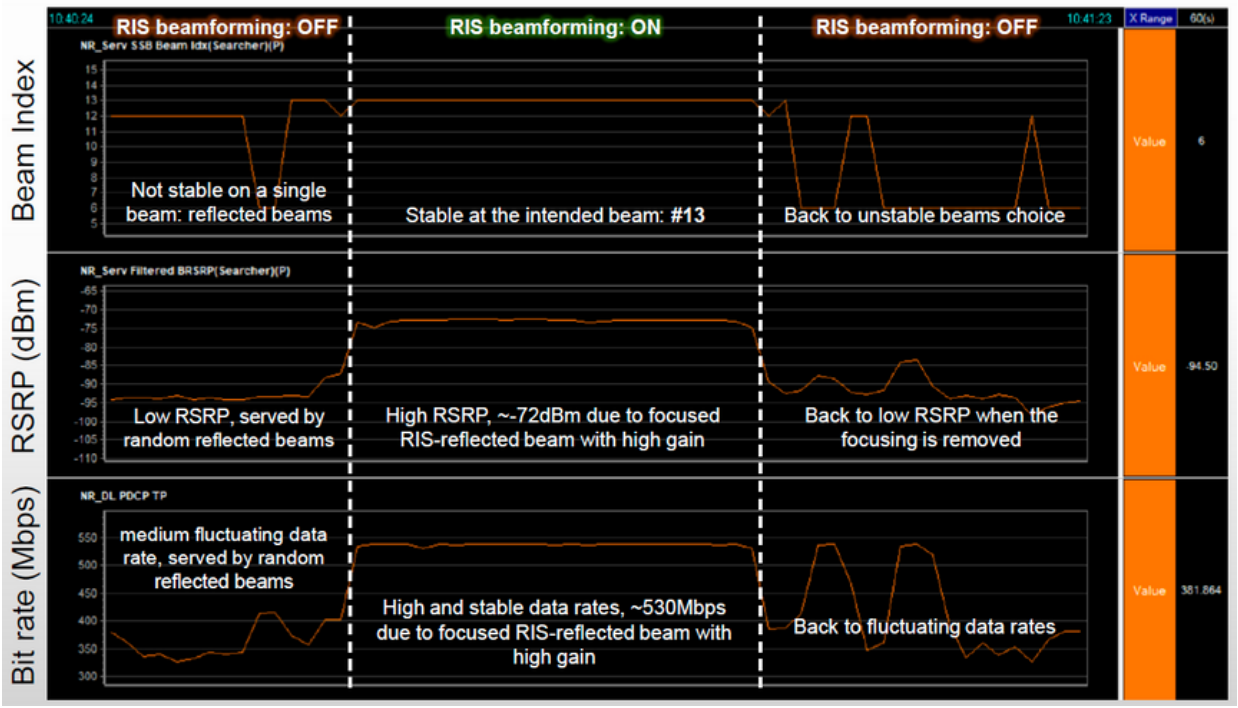
Field Trials and Proof of Concepts (1/2)

Boosting the connectivity of a commercial 5G network at mmWave in a train station thanks to an RIS

- The trial took place inside SNCF Rennes Train Station in France, where travellers' access to the train platforms and services.
- The objectives were to validate the operation and identify KPIs of the RIS in a real environment using an operational 5G network at Frequency Range 2 (FR2), i.e., mmWave.



- The tested use case was the following: To use the RIS to cover a poorly covered area with 5G mmWave, using narrow reflected beams with high gain to improve the received power and the achieved throughput. Boosted link budget can be translated into connectivity gains, energy efficiency, or electromagnetic field exposure reduction gains.

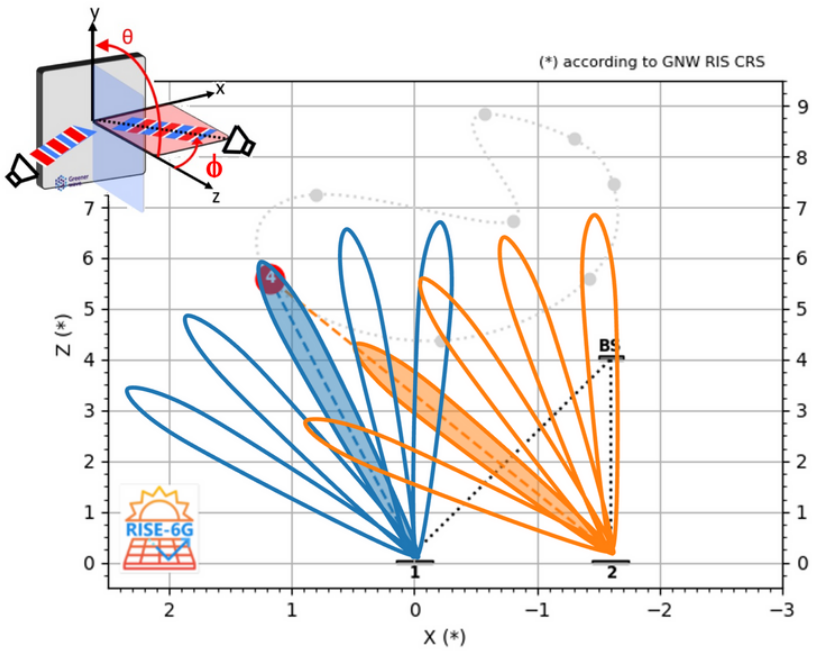


- The 5G BS mmWave was never been aware of the RIS. It simply operated in a propagation environment that had been improved by the RIS.
- Results show that an **RSRP boost of around 17 dB**, translates into a throughput boost of more than 4% in a scenario where, even in the absence of RIS, the received SNR is high due to multipath effects.
- Additional improvements on channel stability have also been observed: When the RIS is "off," the BS switches between many different beams very fast due to multipath. **When the RIS is present, the BS selects the beam that points at the RIS and remains stable.**

Field Trials and Proof of Concepts (2/2)

Enabling a RIS-based localisation procedure in a factory environment served by a commercial 5G network operating at mmWaves

- The trial took place at Centro Ricerche Fiat (CRF) premises in Orbassano (Torino, Italy), inside an emulated factory environment. Two mmWave RISs with an operating bandwidth compatible with the spectrum of the 5G commercial network were installed along with a commercial gNodeB.
- The localisation objective behind the implemented methodology was to identify the two reflected beams (one for each operating RIS) that better point in the direction of the UE, i.e., the ones that allow to serve the UE with the highest measured RSRP level. The localisation of the UE was then obtained by calculating the geometrical intersection of the two beams.
- The algorithmic approach involved sweeping through spatially diverse beams in the two RISs in turns to reach the highest RSRPs.
- In many cases, it was observed that the RIS-based localisation procedure successfully identifies the UE position with an average error **in the order of a few centimeters**. However, in certain cases, the localisation error was more significant (up to 1m) due to unfeavourable characteristics of the environment: strong reflective mettalic objects, walls, and other components.
- During the experiments, it was observed that a **signal level improvement of up to 20 dB** can be achieved, even under poor coverage conditions, with RIS optimisation.



The RISE-6G Training Workshop

- A four-hour virtual workshop that took place on Dec. 12, 2023.
- The focus was on the outcomes and results developed throughout the project, with the end goal to train participants on latest advancements on reconfigurable, intelligent, and sustainable environments in the context of 6G.
- Highlights included:
  - A comprehensive tutorial of the RIS technology.
  - Overview of the results of the technical work packages.
  - RISE-6G outcomes in terms of innovation, standardisation, and industrial exploitation.
  - In-depth presentation of the field trials and proof-of-concept results.
  - Panel discussion on the commercialisation of the RIS technology including leading experts from Academia and the Industry.

Panel Participants

Luca SANGUINETTI
Full Professor
University of Pisa

Mohsen KHALILY
Senior Lecturer
University of Surrey

Sérgio MATOS
Assistant Professor
University Institute of Lisbon

Youssef NASSER
5G/6G Business Line Tech.
Greenerwave

Dinh-Thuy PHAN HUY
Research Project Manager
Orange Innovation

Vincenzo SCIANCALEPORE
Principal Researcher
NEC Laboratories Europe

The workshop material is available on the RISE-6G Website and YouTube channel!

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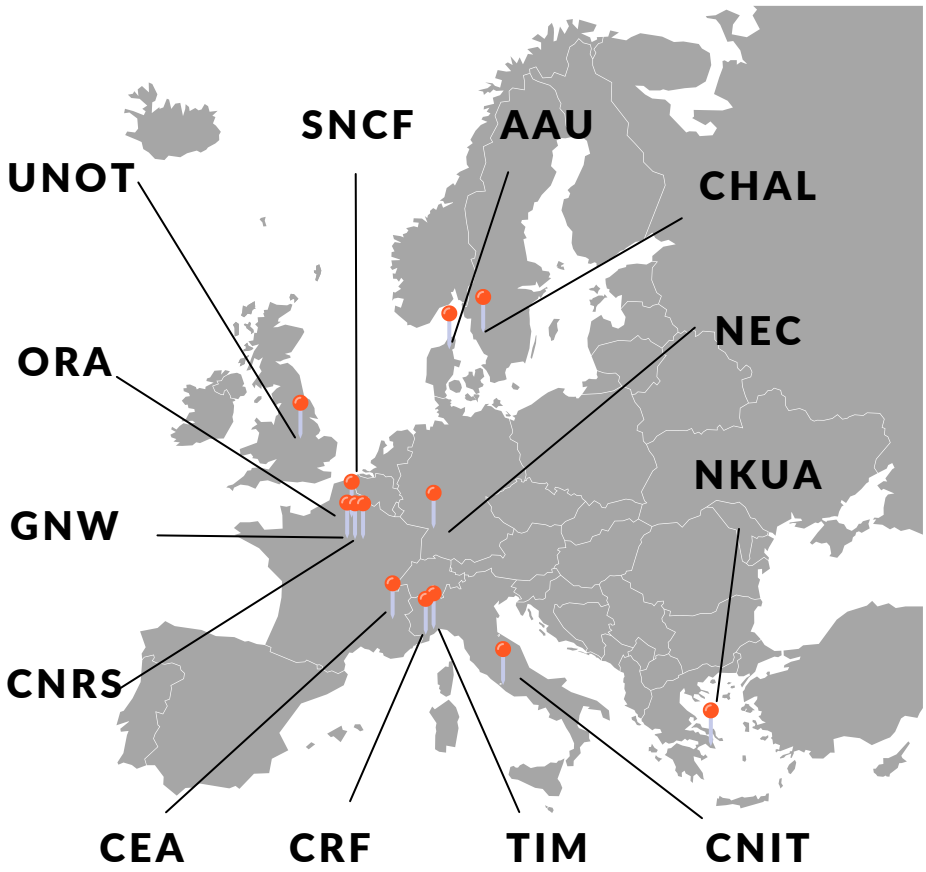
THE RISE-6G CONSORTIUM



PROJECT PARTNERS

- COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES **(CEA)**
- NEC LABORATORIES EUROPE GMBH **(NEC)**
- ORANGE SA **(ORA)**
- *TELECOM ITALIA SPA* **(TIM)**
- GREENERWAVE **(GNW)**
- CHALMERS UNIVERSITY OF TECHNOLOGY **(CHAL)**
- AALBORG UNIVERSITET **(AAU)**
- CENTRO RICERCHE FIAT S.C.P.A. **(CRF)**
- NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS **(NKUA)**
- CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE TELECOMUNICAZIONI **(CNIT)**
- CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE **(CNRS)**
- UNIVERSITY OF NOTTINGHAM **(UNOT)**
- SOCIETE NATIONALE DES CHEMINS DE FER FRANCAIS **(SNCF)**

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