CELTIC-NEXT
eureka Cluster

# Project Information

Multi RACS

# MUTLIRACS

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Closure date: 30 April 2028

**Partners:**

AALTO University, Finland

ANSYS Sweden AB, Sweden

Chalmers University of Technology, Sweden

EMMS Antennas, South Africa

Ericsson AB (EAB), Sweden

Northern Waves AB, Sweden

Optenni Oy, Finland

Radientum Oy, Finland

SAAB Group Finland, Finland

Sivers Semiconductor, Sweden

Stellenbosch University, South Africa

Tampere University of Technology, Finland

Thales Aerospace Communications, South Africa

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**Project Website**

www.celticnext.eu/project-multiracs

## Multi-functional full-duplex radios for terrestrial and non-terrestrial communication and sensing

The MULTIRACS project is developing an innovative, largely digital transceiver for the 7-24 GHz frequency band, a key spectrum for the upcoming 6G era. This adaptable technology aims to deliver energy-efficient, full-duplex communication and sensing capabilities for both terrestrial and non-terrestrial applications. By focusing on sustainable resource management, MULTIRACS seeks to significantly improve crucial performance indicators for future communication systems: specifically, it targets a **3-4 times reduction in energy consumption** compared to current state-of-the-art solutions. This substantial improvement in **energy efficiency** means less power consumption for wireless networks, leading to lower operational costs and a reduced environmental footprint, making it a highly attractive solution for public authorities and network operators alike.

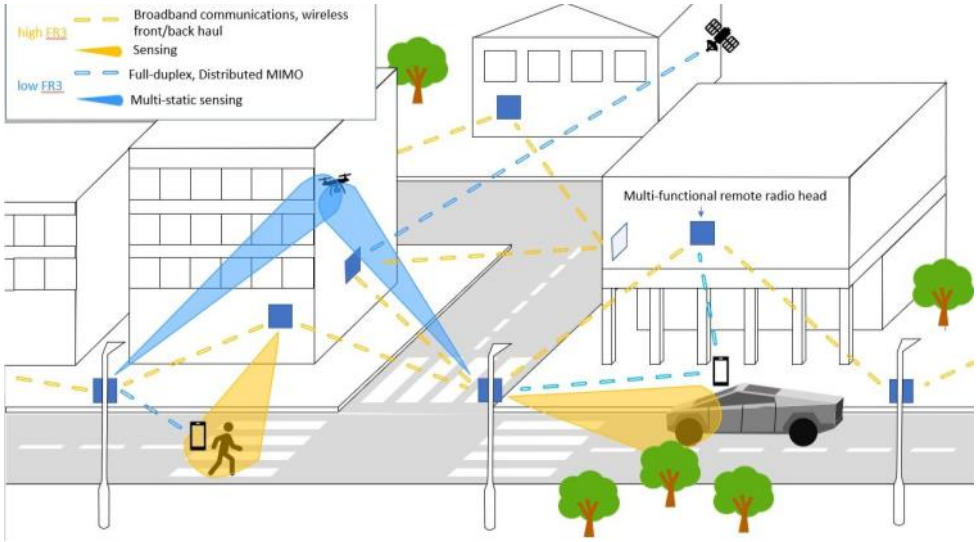
## Main focus

The MULTIRACS project addresses the critical need for multi-functional and reconfigurable wireless systems in the upcoming 6G era, where current solutions lack the necessary adaptability. A key problem is the trade-off between spectrum and energy efficiency, which often cannot be simultaneously improved in existing wireless systems. The project aims to overcome technological barriers to build multi-functional full-duplex systems that improve both spectrum and energy efficiency, crucial KPIs for future communication system upgrades. Specifically, the project targets a 3-4 times reduction in energy consumption by improving state-of-the-art solutions by 15-20 % across various areas such as antennas, filters, RF front-ends, power amplifiers, signal processing, integration, waveforms and array processing.

The impact includes enabling the same hardware to support diverse applications, unlike the current scenario requiring separate equipment, leading to energy efficiency and sustainable resource management. This innovative transceiver will support mobile communications, mission-critical directional radio links (e.g., drones, vehicles), and satellite applications, leveraging the same hardware for managing numerous IoT devices in 6G. The project also aims to secure a leading market position for some consortium companies within five years.

## Approach

The project takes a cross-disciplinary approach to fulfill its objectives, integrating expertise across antennas, filter design, circuit design, signal processing, communication, and sensing. The core approach involves developing an innovative, multi-purpose, fully digital radio transceiver where each radio frequency chain includes a digital-to-analogue/analogue-to-digital converter. A new approach involves utilizing, rather than avoiding, mutual coupling between antenna elements to achieve greater reconfigurability by altering feed signals and modifying digital waveforms.




*The MULTIRACS project develops a multi-purpose radio transceiver, which can be utilized for various communication and sensing applications in future 6G telecom infrastructure.*

Key steps and new approaches include:

- **Novel Antenna Arrays:** Developing unconventional, irregular, and non-periodic antenna arrays capable of covering exceptionally large frequency bands and beam steering ranges, with software reconfigurability. These arrays use partly coupled elements whose properties can be altered via feed signals. Also, developing antenna elements with minimal coupling and additional decoupling structures for ultra-high isolation in full-duplex operation.
- **Integrated Design**: Co-designing transmit circuits with coupled antenna arrays, treating load modulation from neighboring elements as a design parameter. This includes a compact, connectorless 3D packaging concept that integrates active components on PCBs with antennas, filters, and digital processing units, potentially incorporating cooling.
- **Advanced Filtering**: Developing compact, low-loss, and novel switchable filter topologies for reconfigurability without increasing loss or reducing linearity.
- **Self-Interference Cancellation**: Developing new RF and digital cancellation solutions for future array systems to enable simultaneous in-band transmit and receive capabilities for two-way data communications and monostatic sensing.
- **Multi-functional Waveforms**: Innovating new multi-functional waveforms and beamforming solutions for integrated sensing and communications, allowing for simultaneous digital MIMO communications and MIMO radar/sensing functions.

By consolidating these activities, the project aims to establish a solid technological foundation for multi-functional radio transceivers for 6G, defense, and satellite applications.

## Main results

The project expects to achieve significant advancements by improving the current state-of-the-art by 15-20% across various areas. Main achievements and expected results include:

- **Sustainable and Energy-Efficient Antenna Technology:** Development of low-loss, highly decoupled FR3 arrays, potentially 3D, supporting element-specific band-selection filters and multiple simultaneous beams. Irregular, non-periodic arrays will offer increased reconfigurability over frequency and beam steering range.
- **Compact Filter Topology**: Creation of highly integrated antenna-filter arrays with reconfigurable capabilities.**Multi-functional Front-end Circuits:** Co-design strategies for power amplifiers (PAs) for coupled massive MIMO arrays and co-design of transceiver IC and antenna arrays.
- **Advanced RF Front-end with Self-Interference Cancellation (SIC):** Co-design of CMOS and GaAs/GaN implementations with SIC in both domains, focusing on tuning precision and noise reduction, including ultra-linear amplifiers for full-duplex operation.
- **Adaptive Signal Processing:** Scalable algorithms for low average energy consumption that adapt to network load better than current solutions.
- **Integration Platform:** A 3D antenna array supporting integrated element-specific PAs, high-Q filters, and cooling, significantly reducing power needed for mechanical cooling units.
- **Waveform and Array Signal Processing:** Design of high-efficiency waveforms for full-duplex integrated sensing and communications, and multi-beam synthesis for nonlinear PAs, suppressing TX-RX leakage and self -interference.

The expected value lies in providing a holistic solution for future telecommunication needs, enabling the design of core hardware modules with optimal RF performance, power consumption, cost-effectiveness, and mass production possibility.

## Impact

The project's results are expected to have a substantial impact on business, R&D, and industry activities, particularly within the rapidly growing wireless technologies and ICT sectors. By addressing the challenges of managing escalating mobile data traffic while maintaining profitability, the project's focus on enhancing spectral and energy efficiency is vital for improved network performance and reduced operational costs.

For key industry players like Ericsson, the project's success in optimizing network performance and cost will solidify its position as a technology and market leader five years post-project. The project also enhances Finnish capabilities to penetrate new, high-growth market segments beyond traditional telecommunications, such as small satellites and security solutions, evidenced by the exponential expansion of "New Space" enterprises like ICEYE.

Furthermore, the project fosters innovation through fruitful collaboration among leading academic universities and industrial partners across different segments of the telecom and ICT market value chain. The novel solutions in antenna array configuration, filter design, interference cancellation, and integrated sensing and communication will address the future mobile market needs, providing a solid knowledge base and platform for continued advancements.

## About CELTIC-NEXT

CELTIC-NEXT is the EUREKA Cluster for next-generation communications enabling the digital society. CELTIC-NEXT stimulates and orchestrates international collaborative projects in the Information and Communications Technology (ICT) domain.

The CELTIC-NEXT programme includes a wide scope of ICT topics based on new high-performance communications networks supporting data-rich applications and advanced services, both in the ICT sector and across all vertical sectors.

CELTIC-NEXT is an industry-driven initiative, involving all the major ICT industry players as well as many SMEs, service providers, and research institutions. The CELTIC-NEXT activities are open to all organisations that share the CELTIC-NEXT vision of an inclusive digital society and are willing to collaborate to their own benefit, aligned with their national priorities, to advance the development and uptake of advanced ICT solutions.

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