6G-SENSES

SEamless integratioN of efficient 6G wirelesS
tEechnologies for communication and Sensing

Presenter (s): Jesús Gutiérrez (IHP)   Date: 2024-03-14

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HORIZON-JU-SNS-2023-STREAM-B-01-02

- **Main goal**:

  Integration of novel 6G RAN technologies such as Cell-Free Massive Multiple-Input Multiple-Output (MIMO) and Integrated Sensing and Communications (ISAC) to support the 6G vision that is sustained by the current (and future) architectural framework based on 3GPP and O-RAN

- **Duration**: 30 Months (2024-01-01 – 2026-06-30)

- **Budget**: €3,627,081.00

- **Consortium**: 11 partners, 7 countries (operators, vendors, academia, SMEs)
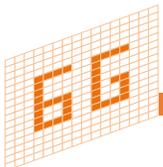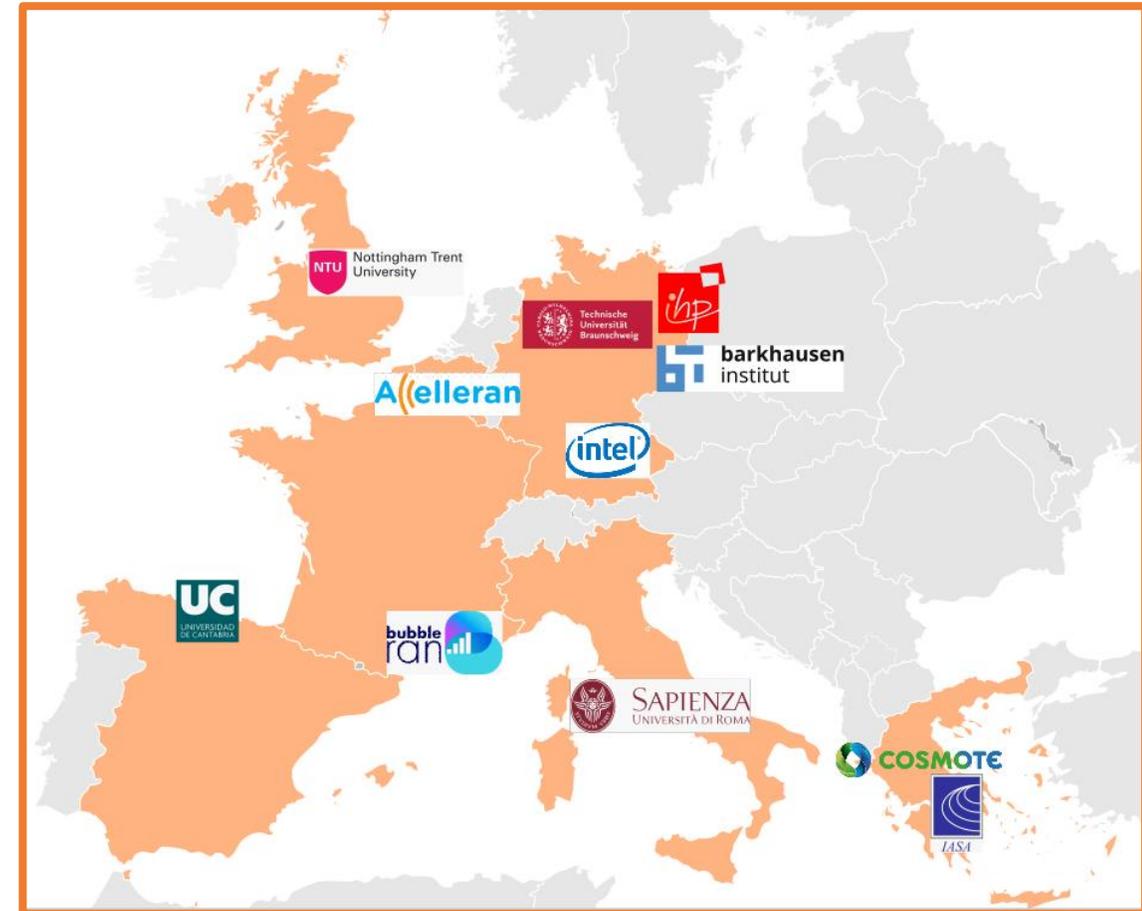
6G-SENSES Objectives

Main Objectives

- Design, develop and demonstrate a **cell-free (CF) architecture** able to offer **ISAC services** that exploit the distributed antenna and sensing environment from CF and distributed MIMO architectures

- Provide a **Multi-WAT** (Sub-6, mmWave, Wi-Fi and 5G NR technologies) **ISAC platform** assisted by **Reconfigurable Intelligent Surfaces (RIS)** that ingests cross-technology sensing to evolved O-RAN RICs integrating to achieve sub-cm precision

- Analyse and prove the **function mapping and network placement of the CF-mMIMO / ISAC RIS-assisted** technology with the **3GPP and O-RAN** functional splits and specifications

Specific Objectives

- Extension of **O-RAN RIC** for heterogeneous WATs for sensing capabilities support

- '**Cross-domain AI optimization**', understand and optimize the underlying transport and heterogeneous access technologies, to ingest cross-technology sensing, telemetry and control into the evolved 6G RIC

- Cross-layer approach to **improve the edge caching mechanism** based on network traffic characterization, mobility information and content characterization

- Design and development of an '**Intelligent Plane**', incorporating O-RAN, along with user plane and data plane

6G-SENSES - Multi-technology RAN
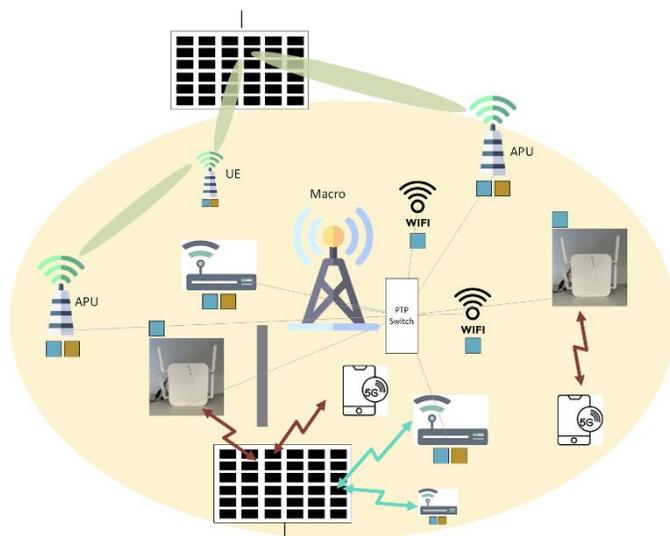
- UE: User Equipment
- APU: Access Point Unit
- ISAC: Integrated Sensing and Communication
- CF-mMIMO: Cell-Free massive MIMO
- RFSoC: Radio Frequency System on Chip

- **Xilinx RFSoC-based** system for mmWave (60 GHz) and Sub-6 connectivity. compact and scalable solution to implement massive MIMO systems with a large number of antennas

- Novel Wi-Fi capabilities featured for **ISAC**, active sensing, **MLO** for wider sensing bandwidths, controllable from a 3GPP control infrastructure

- Sub-6 GHz platforms with DSP support in the **delay-doppler domain**

- Creation of **RIS-assisted links** and joint optimization of RIS panels (active, passive, BD-RIS, etc.) for ISAC

- The 5G NR implementation to be used in 6G-SENSES is that of OAI, with necessary modifications to be made to the protocol stack

- Develop a **novel ultra-low-power scalable MIMO front-end @ 60 GHz** supporting CW and FMCW radar and communication
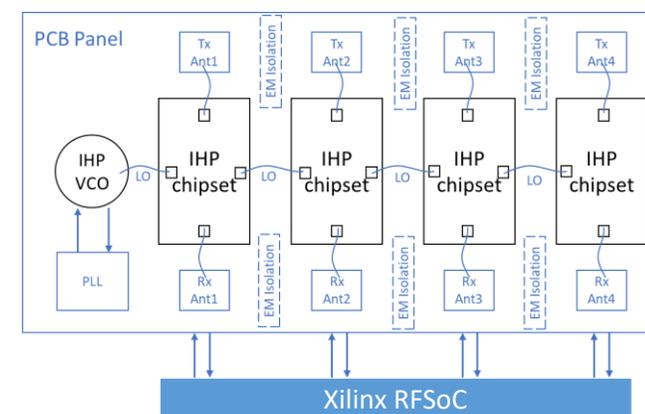
6G-SENSES – Architecture
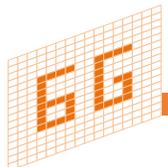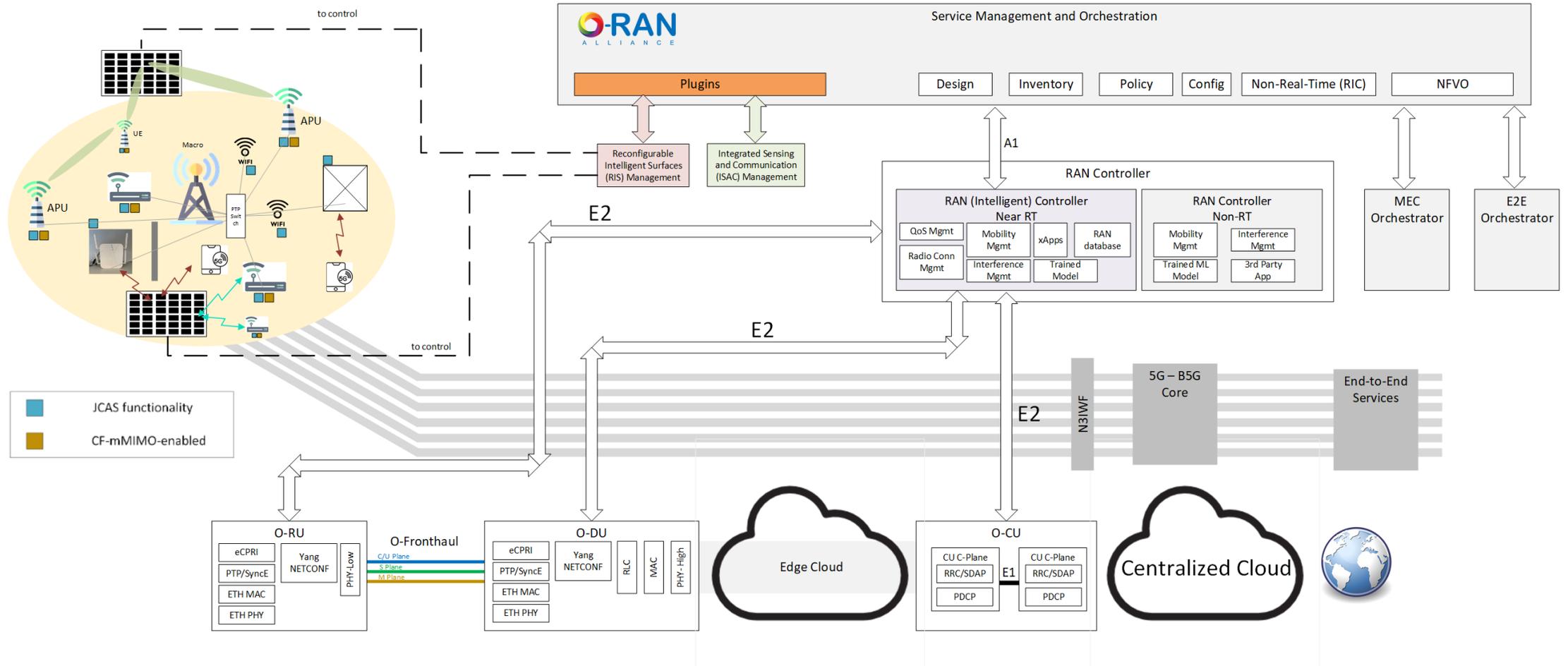
6G-SENSES – Enhanced control capabilities

- Flexible control fabric

  - provides real-time programmability to control RAN network functions and resources beyond just parameter reconfiguration and policies, by regulating the behaviour of the RAN function in real time via a runtime control loop driven by the control commands to serve massive number cells simultaneously.

  - Use of the RT-RIC, achieving down to 20 μs control loop. This means that we could have a control loop for mini-slot (200 μs) for large number of cells. This will be an enabler for distributed CF-mMIMO systems

- Open 6G RAN Intelligent Controller (RIC), cross-domain AI optimization

  - 5G Non-3GPP interconnections (with N3IWF/TNGF for Wi-Fi & LiFi) were demonstrated already in the 5G-PPP Phase 3 5G-CLARITY

  - RAN control-plane and the intelligent RIC are needed for maximal benefit

  - xApp/rApp extensibility of this evolved RIC, hosting the 6G Native AI/ML automation and zero-touch optimization, throughout all RAN layers, 3GPP and Non-3GPP
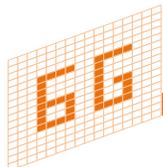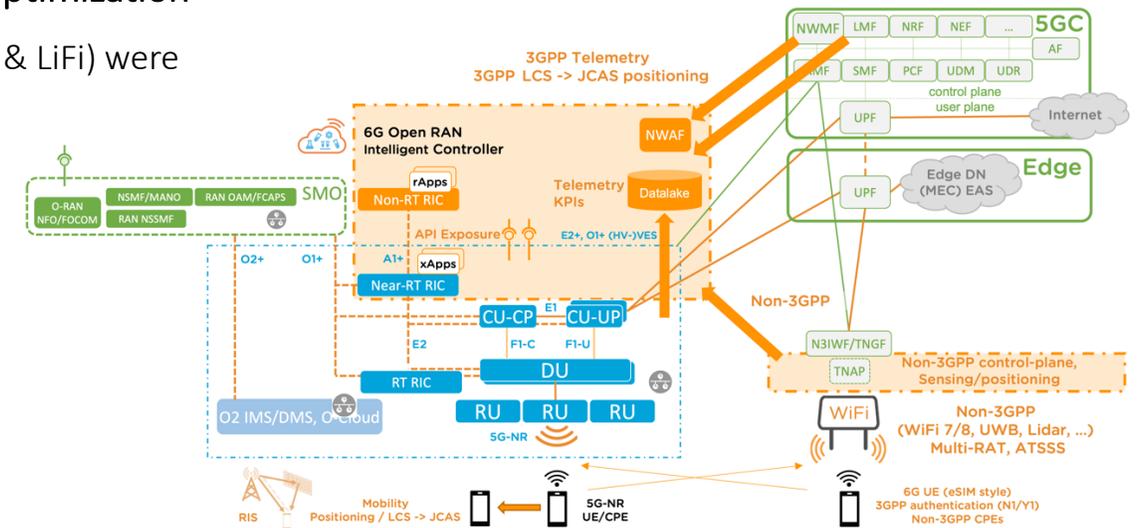
6G-SENSES – PoC #1

- End-to-end small-scale proof-of-concept prototype to demonstrate performance and energy efficiency of ISAC

- Operated RU, DU, and CU/UPF pools with a real-time control fabric providing sub-millisecond control loop over each network component.

- The PoC includes the following components:

  a) an SMO will be used to facilitate validation and experimentation and provide reproducibility;

  b) a network of RUs forming CF-mMIMO are connected to the OAI-based disaggregated RAN and CN network functions in a form of container images;

  c) real-time control fabrics enriched with five JSAC control logics including spectrum management, RAN sensing, RAN monitoring, RAN control, and user positioning enhanced with CN location management functions (LMF) deployed as edge applications, i.e. xApps

 d) 5G-optimized compute nodes all synchronized using IEEE 1588v2 Precision Time Protocol (PTP)
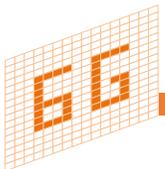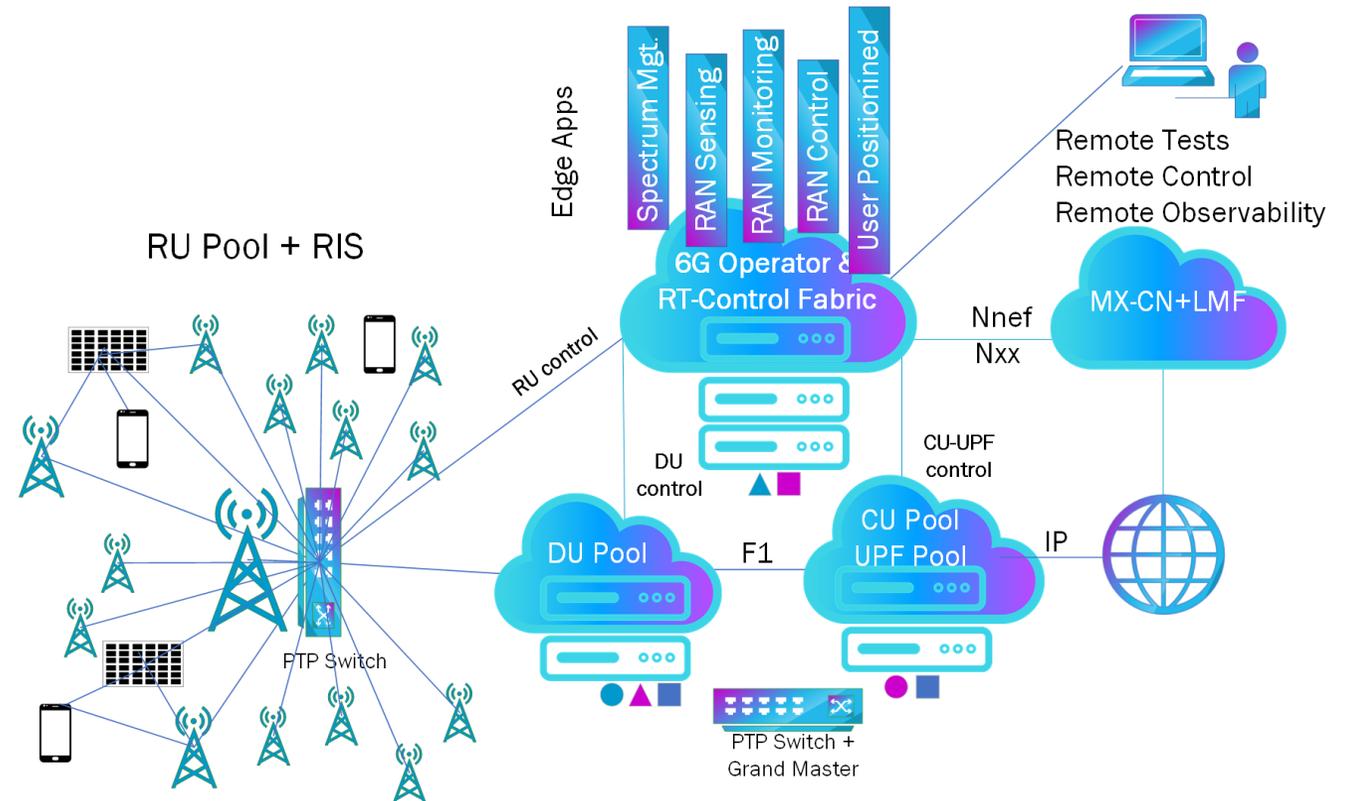
6G-SENSES – PoC #2

- **6G CF-mMIMO PHY prototype** and extend it to support real-time control loop. The proposed prototype comprises Sub-6 and mmWave APUs

- Additionally, it comprises the following components:

  a) BS and UE CF-mMIMO PHY layer able to establish a data plane and expose interfaces to be monitored and controlled.

  b) RAN RT control fabric enabling real-time RAN sensing, and control.

  c) Edge applications providing logics for RAN sensing, and controlling, e.g. instructing each AP to be active or passive (on/off strategy similar to phantom cells)

Edge Apps

RAN Policy RAN Control RAN Monitoring RAN Sensing

6G Operator & RT-Control Fabric

UE-PHY

Cf-mMIMO - PHY

UE-PHY

UE-PHY
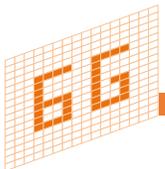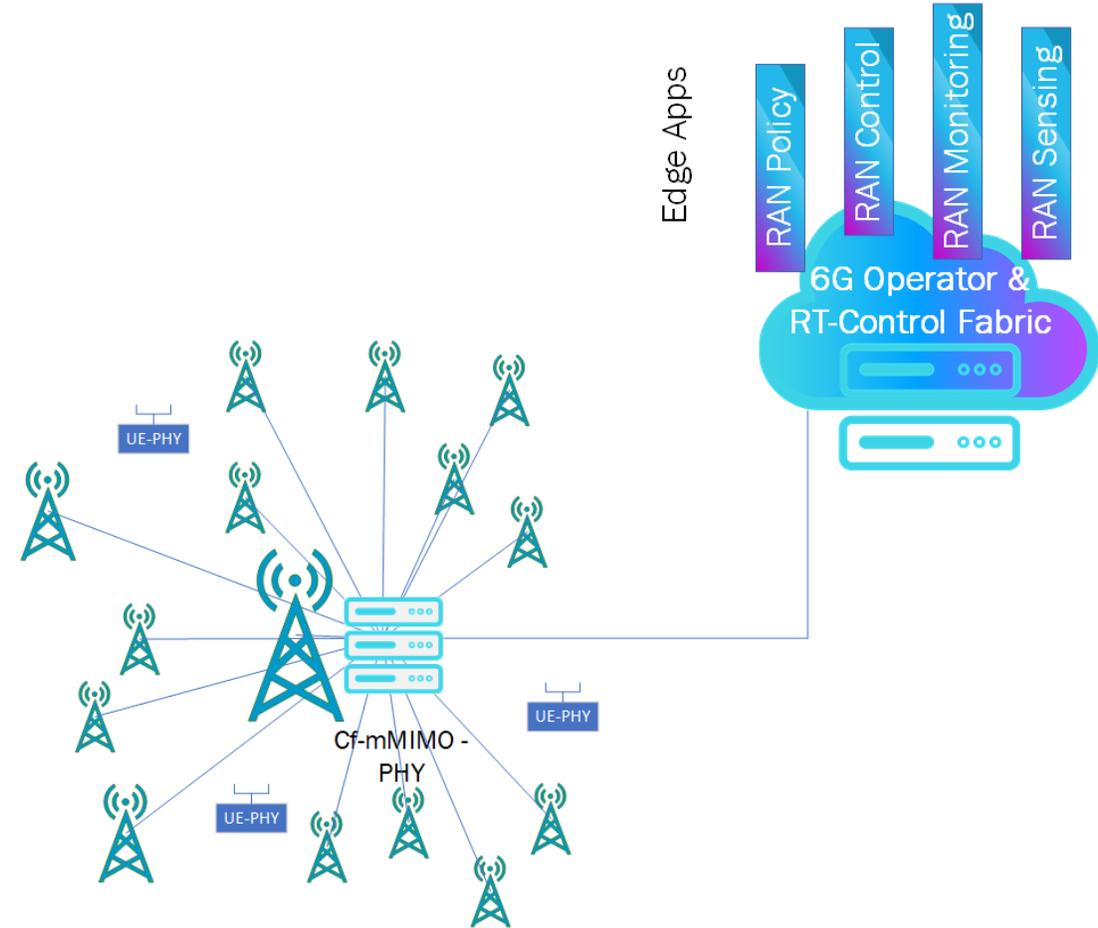
6G-SENSES – PoC #3

- Leverage a variety of WATs to ingest cross-technology sensing, telemetry, and control into the evolved 6G RIC

- O-RAN RIC to be extended to support cross-domain integration of Non-3GPP RAT control-plane and injection of Wi-Fi sensing for Sub-6 and mmWave networks

- Improvement of the accuracy and reliability of network sensing and monitoring to enable proactive network management and optimization to mitigate potential issues and ensure seamless service delivery
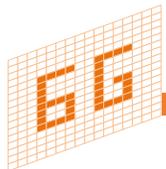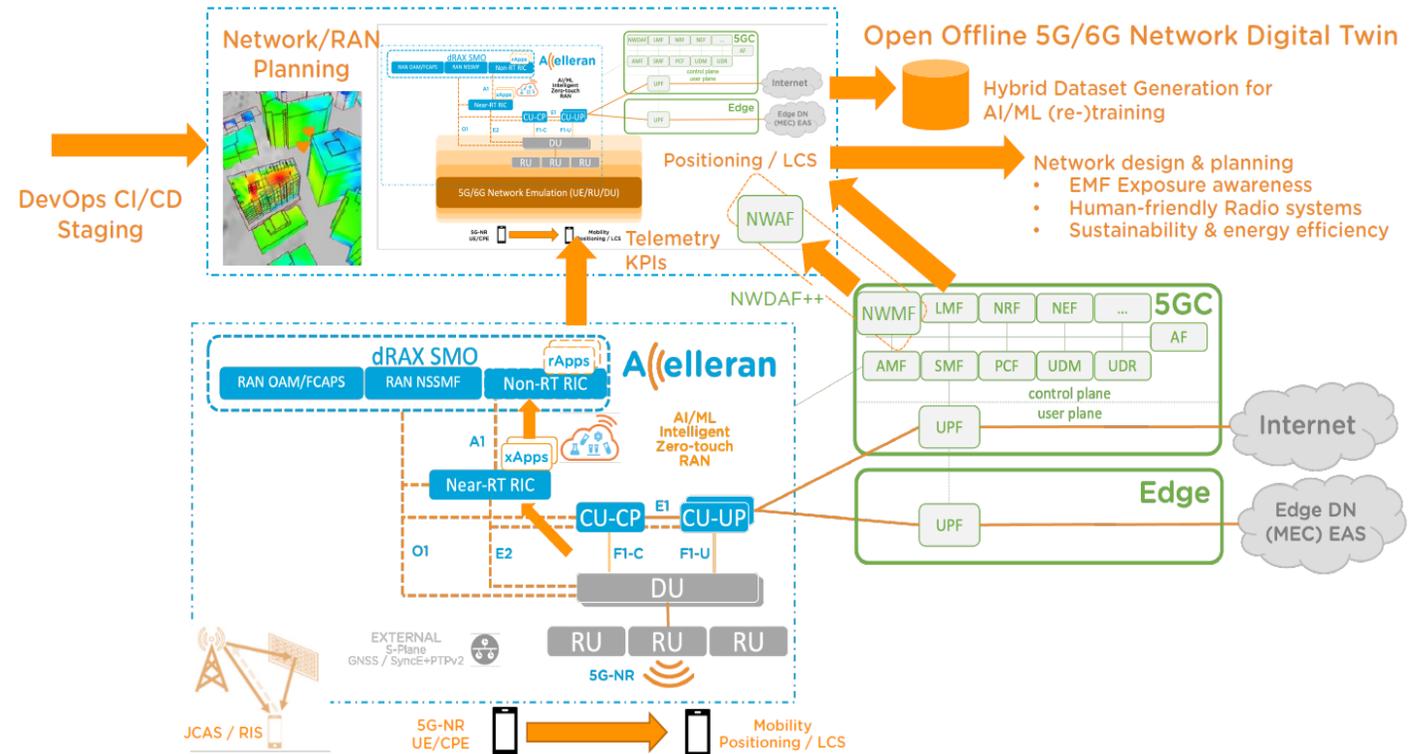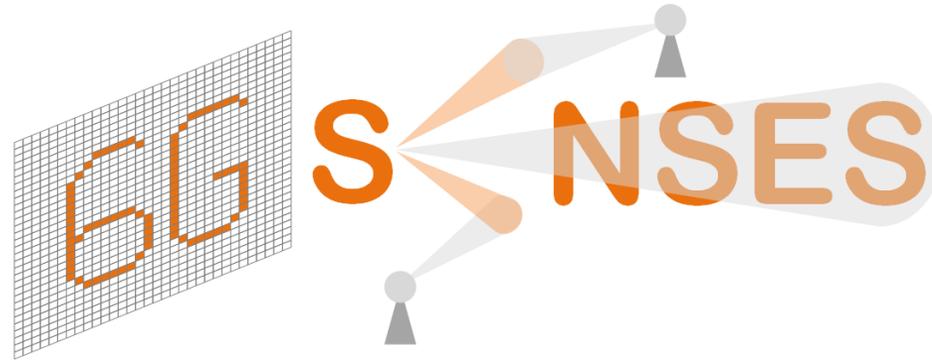
Thanks for your attention!

6G-SENSES Project
Project Coordinator: Jesús Gutiérrez (teran@ihp-microelectronics.com)
Technical Manager: Shahid Mumtaz (shahid.mumtaz@ntu.ac.uk)