6GSNS

Open Calls – Results
6G-XR Project

6GXR

SUMMARY OF EXPERIMENTS AND IMPLEMENTATIONS

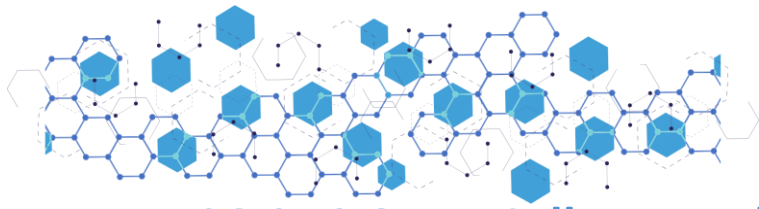Results Achieved by 3rd Parties involved in 6G SNS Projects through the mechanism of Cascading Funding – Open Calls

6G SNS Open Calls – Results

SUMMARY OF EXPERIMENTS AND IMPLEMENTATIONS

Results Achieved by 3rd Parties involved in 6G SNS Projects through the mechanism of Cascading Funding – Open Calls

6G-XR PROJECT

6G eXperimental research infRastructure to enable next-generation XR services

OVERVIEW

6G-XR project "6G eXperimental Research infrastructure to enable next-generation XR services" is a Horizon Europe-funded initiative under the umbrella of the Smart Networks & Services Joint Undertaking (SNS JU). Its core ambition is to strengthen European leadership in 6G technologies by enabling the next generation of immersive XR (Extended Reality) services — including virtual reality, augmented reality and mixed-reality — by building an experimental, multi-site research infrastructure (RI) that supports "beyond 5G" and future 6G use-cases.

More specifically, 6G-XR aims to develop enablers for networking and computing, radio access technologies beyond 5G, XR service enablers (including federation, trial-management, abstraction tools), and an energy-measurement framework supporting sustainable operation of immersive services. It will validate multi-access edge computing (MEC) scenarios, their integration into a cloud-continuum, and immersive, demanding applications such as real-time holography and digital twins.
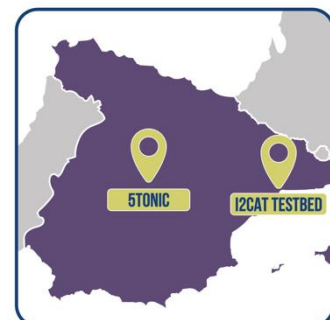
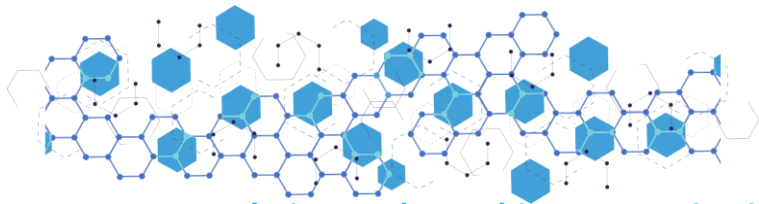### Use-Cases and Research Infrastructures

6G-XR project has identified three different application areas that would benefit from the large-scale deployment of B5G/6G networks:

- Real-Time Holographic Communications
- Collaborative 3D Digital Twin-like Environment
- Energy Measurement Framework for Energy Sustainability

around which five internal Use Cases have been developed: UC1, UC2, UC3 under Real-Time Holographic Communications, UC4 under Collaborative 3D Digital Twin-like Environment and UC5 under Energy Measurement Framework for Energy Sustainability.

The infrastructures are divided between the North and South Node. Within the South Node, the following Use Cases have been internally developed, leveraging the advanced network capabilities of the infrastructures of 5TONIC (Madrid) and i2CAT (Barcelona) testbeds.

Real-Time Holographic Communications

Three of the internal 6G-XR Use Cases (UC) revolve around real time holographic communications, by incorporating novel XR, network and cloud continuum enablers to enhance their performance and interoperability.

- UC1: Resolution Adaptation or Quality on Demand - Detect network congestion or Quality of Service (QoS) dropped to trigger network-assisted Rate Adaption recommendation or request Quality on Demand (QoD)
- UC2: Routing to the Best Edge - Discover, select and make use of the most appropriate Edge resources to run XR processing or communication functions, based on specific criteria and goals
- UC3: Control Plane Optimizations - Integrate holographic communications to the network control plane

Under the North node other internal Use Cases have been developed leveraging the advanced capabilities of the VTT 5GTN, UOULU 5GTN testbeds located in Oulu (Finland).

Collaborative 3D Digital Twin-like Environment

Infrastructure: UOULU 5GTN

Remote collaboration enhances societal and team productivity/efficiency. Real collaboration around of a common asset, machine, manufacturing place or environment is enabled thanks to a collaborative 3D DT environment. Key outcome is extracted due to the capabilities of bridge regional disparities and provide equal opportunities regardless of the geographical location. Traditional example of gaps covered is the disparity between industrial and rural locations.

- UC4: Collaborative 3D Digital Twin-like Environment - Enable real-time collaboration and control of physical assets in virtual reality

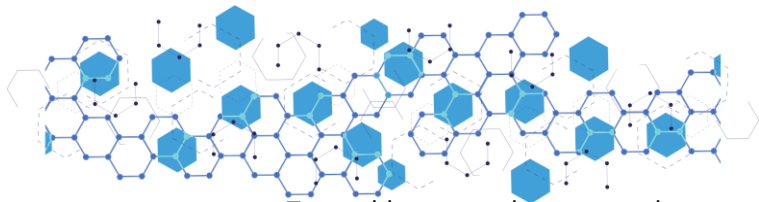## Energy Measurement Framework for Energy Sustainability

- UC5: Energy Measurement Framework for Energy Sustainability - Measure and optimise end-to-end energy consumption in mobile networks

Infrastructures: VTT 5GTN, UOULU 5GTN

The 6G-XR project aims to deploy an extensive energy measurement framework for the test sites as well as to introduce the required intelligence and functionality into the network components so that the energy consumption data can be utilized to optimize the end-to-end energy consumption and use of local renewable energy for variety of different XR related applications.

Open Calls: Rationale and Structure

To achieve its objectives and to open up the infrastructure to broader innovation, 6G-XR implements a series of three cascading Open Calls (OCs) to attract third-party innovators (SMEs, industry, research organisations). The reason for these OCs is threefold:

- To enable external teams to leverage the RI and enablers developed by 6G-XR, thereby extending the impact of the project beyond the core consortium.
- To validate and trial novel XR services, components and architectures in realistic research/testbed environments aligned with the 6G era.
- To foster vertical replicability, i.e., uptake by industry verticals, cross-sector innovation and faster deployment of immersive XR services.

Three Open Calls Key information

- **6G-XR-OC1: Platform & Network Enablers**: Focused on providing access to the core RI, network and platform enablers developed by the project.
- **6G-XR-OC2: Stream B Enablers**: Builds on OC1, offering further access and support for enabler development under the Stream B Enablers thematises.
- **6G-XR-OC3: Vertical Replicability Enablers**: Targeted at innovators who want to deploy, replicate and validate XR use-cases in verticals (e.g., industry, media, mobility) using the 6G-XR infrastructure. Access to advanced testbeds and enablers, with focus on real-world demonstrators.
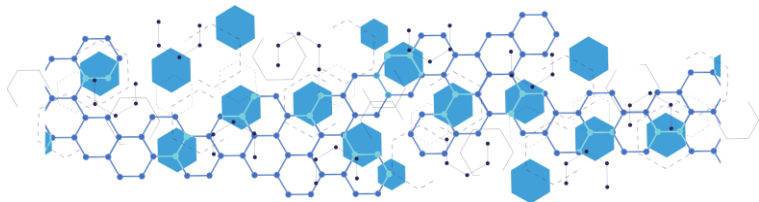
The budget allocated for this cascading funding is approximately €1.8 million, and around 30 proposals are projected to be selected over the 2023–2025 timeframe.

Open Call	Project duration	Max funding (€)	No of projects	Total funding (€)
6G-XR-OC1	6 months	60.000	8	480.000 €
6G-XR-OC2	6 months	60.000	10	600.000 €
6G-XR-OC3	6 months	60.000	12	720.000 €

6G-XR Intended Impacts of the Open Calls

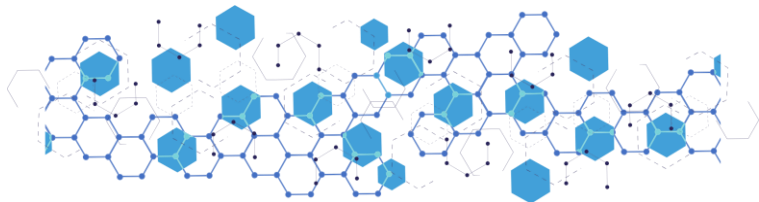Through these open calls the project intends to:

- Stimulate innovative XR-services and applications using next-generation connectivity and compute infrastructure.
- Provide third-party actors with access to high-end research/testbed infrastructure which would be otherwise difficult to access, lowering the barrier to experimentation and validation.
- Foster a broad ecosystem of XR service providers, network enabler developers, vertical domain actors and research institutions in Europe, thereby strengthening European competitiveness in 6G/XR.
- Enable the integration of vertical use-cases (industry manufacturing, media, mobility, digital twin domains) to test and validate 6G-XR enablers and infrastructure in real-life-relevant settings.
- Collect valuable data and feedback around key performance indicators (KPIs) and key value indicators (KVIs) for XR-services over 6G-capable networks (e.g., latency, throughput, energy consumption, reliability) which will feed into standardisation and future network deployments.
- Promote energy-efficient deployment and operation of immersive XR services, aligning with sustainability goals within the 6G framework (via the Energy Measurement Framework use-case).
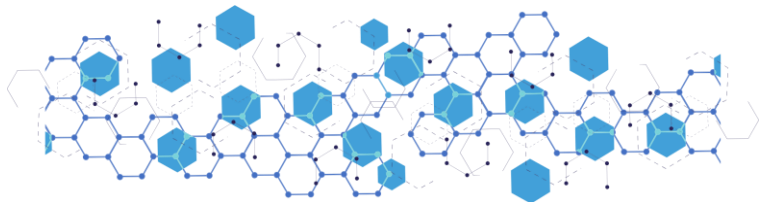
PRESENTATION OF OPEN CALLS PROJECTS

6G-SLICE

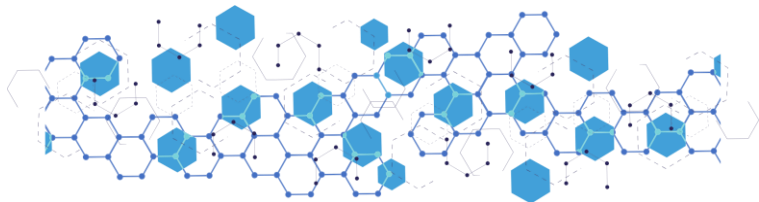|	
OC1 Project Title	6G-SLICE: Enabling end-to-end O-RAN slicing in 6G-XR
Beneficiary(s)/Country	Allbesmart LDA, Portugal
Project Description	A network slice is a logical network comprising a set of network functions supporting the communication services for a particular use case deployed on a common physical infrastructure. In this context, the main objective of this experiment is to implement and validate end-to-end network slicing configurations for 6G-XR scenarios, leveraging the O-RAN architecture. This will be achieved by enhancing the Oulu University open-source OpenAirInterface (OAI) testbed.
Vertical	Networking and computing enablers
Testbed	UOulu 5GTN
Results & Impact	**Results:** The OAI-based 5G lab platform at the University of Oulu was enhanced to fully comply with the O-RAN architecture, integrating a Near-RT RIC and developing xApps for near-real-time monitoring and slice configuration to ensure SLA compliance. A web-based dashboard was created to simplify RAN slicing management, offering predefined configurations and intuitive control for 6G-XR experimenters. Validation was achieved through a joint demonstration with Allbesmart, Kaiotek, and Finwe at EuCNC & 6G Summit 2024, showcasing a "Co-creative Cyber Studio" use case. This demo connected remote VR/AR participants in a digital twin environment over a sliced 5G O-RAN network, demonstrating RAN sharing between VR and IoT applications. The slice management xApp dynamically controlled MAC scheduling and SLA enforcement, enabling differentiated throughput for eMBB and URLLC slices and validating real-time resource orchestration in multi-slice scenarios. **Impact:** The 6G-XR OC1 project accelerated the development of Allbesmart's OAIBOX product line, resulting in a new OAIBOX O-RAN test solution featuring automated RAN slicing. The project outcomes matured the technology to commercial readiness, enabling proof-of-concept trials with partners and new customers. For exploitation, Allbesmart will leverage its global distributor network to promote advanced O-RAN capabilities integrated into its OAIBOX 5G solution. Its strategic partnership with NI (National Instruments) further extends its reach in the test and measurement market, strengthening Europe's position in beyond-5G network innovation and accelerating the adoption of intelligent, programmable O-RAN systems worldwide.

BANQ

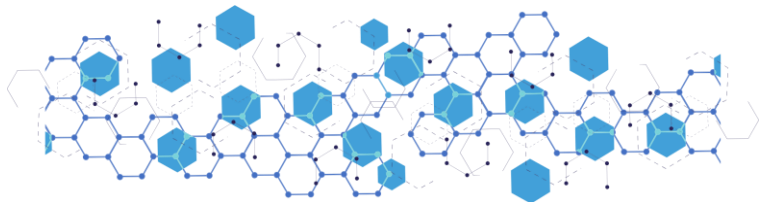|	
OC1 Project Title	BANQ: Bringing Automated Network QoS Monitoring Capabilities for Research Infrastructures
Beneficiary(s)/Country	Kaitotek / Finland
Project Description	The project focuses on automating network quality measurements with a passive, real-time Quality of Service (QoS) solution. This enhances network quality, situational awareness, and security. Real-time measurement and monitoring allow for immediate resolution of performance issues, improving user experience and providing valuable data for researchers. Data analysis further enables proactive traffic monitoring, anomaly detection, and real-time threat identification.
Vertical	Networking and Computing Enablers, Sustainability Enablers
Testbed	OULU 5GTN & VTT 5GTN
Implementation timeframe	February – July 2024
Results & Impact	The BANQ project successfully implemented and validated four key experimental developments within the 6G-XR framework: - Automated QoS Monitoring: A new experimental feature was developed to enable fully automated QoS measurements controlled centrally through the Qosium Storage REST API. This significantly enhances the measurement capabilities of the North Node research infrastructure. During implementation, an additional unplanned improvement was made to GTP decapsulation, further refining network monitoring performance. - Centralized Flow Monitoring: Qosium's flow monitoring capabilities were extended to allow tracking of multiple simultaneous measurement flows, providing a strong foundation for advanced cybersecurity monitoring. This represents an important step toward integrating performance and security insights in real time. - Alerting and Reporting Engine: A completely new alerting engine was introduced, capable of real-time visualization and flexible extensions for both QoS and flow-based alerts. This feature lays the groundwork for future ticket-based or automated event systems, improving responsiveness to performance and security anomalies. - Enhanced Historical Analysis and Reporting: A new reporting view in Qosium Storage now enables automatic generation of high-level performance summaries, replacing the previous single heatmap visualization. This provides more accessible and actionable insights for research and industrial use. Extensive unit and integration testing was carried out both at Kaitotek's facilities and in the University of Oulu research infrastructure, validating the new capabilities in realistic 5G-Advanced and XR environments. While full system integration with the North Node will continue post-project, all implemented components are operational and ready for deployment. Finally, the BANQ experiment contributed to a joint 6G-XR demonstration at EuCNC 2024, showcasing multiple open call projects in an integrated setup. The demo received highly positive feedback and was the basis for a joint research publication submitted to IEEE GLOBECOM 2024.

ExCalibAR

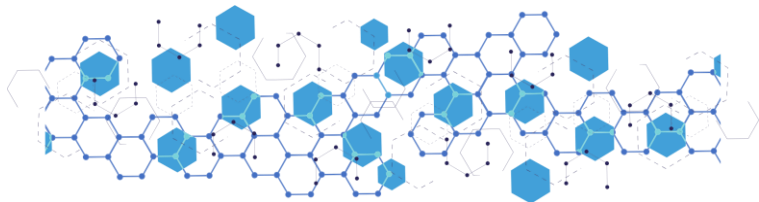|	
OC1 Project Title	ExCalibAR : User-friendly intrinsic and extrinsic calibration for multilight-field-cameras for Augmented, Virtual, and Extended Reality
Beneficiary(s)/Country	Karlsruhe University of Applied Sciences / Germany
Project Description	The ExCalibAR project implements a comprehensive, easy-to-use pipeline for intrinsic and extrinsic calibration of setups with multiple light field cameras by utilizing Structure from Motion (SfM). The proposed method allows non-expert users to get reliable and swift calibrations by following an easy-to-understand process without requiring precise calibration targets. In contrast, calibrating light field cameras and other multi-camera setups following state-ofthe-art methods can be daunting for laypeople as it relies on multiple steps with many pitfalls and requires accurate calibration targets for which the exact geometry must be known.
Vertical	XR Enablers, RAN Enablers
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	February – July 2024
Results & Impact	**Results:** The ExCalibAR project successfully developed and validated a self-calibration pipeline for light field cameras that operates without the need for calibration targets. Extensive experiments were performed using multiple camera setups with focal lengths of 12.5 mm, 16 mm, and 35 mm, and results were compared to a state-of-the-art reference calibration method. The deviation between ExCalibAR and the reference results was below 1% for nearly all parameters, confirming both high accuracy and reproducibility. A second validation used arbitrary light field camera sequences from a public dataset (Zeller et al., 2018), achieving accurate intrinsic calibration even without any structured calibration scene. This demonstrates that ExCalibAR performs robustly in real-world, unstructured environments. At project completion, the full ExCalibAR pipeline is operational and ready for extrinsic calibration once the 6G-XR volumetric setup becomes available. Final calibration results will be shared via the open-source GitHub repository based on 6G-XR Capturer data. **Impact:** ExCalibAR directly supports the 6G-XR objective of Advancing Heterogeneous XR Capture Systems, providing a user-friendly, open-source self-calibration pipeline for multi-camera light field systems. The software will be released under the GNU GPLv3 license for public access and reuse by all project partners. To maximize reusability, the system was designed for easy adaptation to different sensor types, including RGB-D and stereo camera setups, by modifying only the camera model and optimization metric. The project has already attracted interest from 6G-XR partners seeking to apply the pipeline to new sensor modalities, reinforcing its potential to become a standard tool for multi-sensor XR calibration within future 6G research and development efforts.

FALADIN

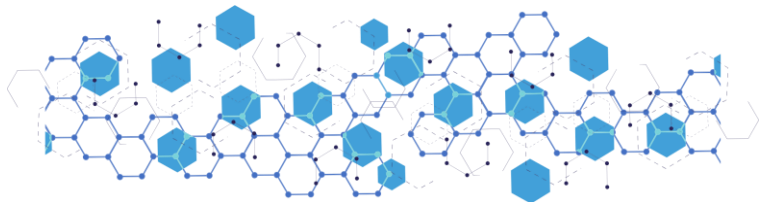| OC1 Project Title	FALADIN: FAb LAb DIgital TwiN
Beneficiary(s)/Country	FINWE / Finland
Project Description	FALADIN project innovated in the field of co-creation process by developing a digital twin platform for FabLabs. The result is an online web service that facilitates seamless collaboration between users and FabLab operators, streamlining 3D model review and 3D printing process.
Vertical	XR Enablers
Testbed	UOulu 5GTN
Implementation timeframe	February – July 2024
Results & Impact	**Results:** To ensure inclusivity and accessibility, the developed solution was built entirely on open and freely available technologies. The core web platform — supporting user authentication, model uploads, review scheduling, and textual discussions — was implemented using Node.js and SQLite for the backend and React.js for the frontend. For the XR component, WebXR and the open-source Babylon.js framework were adopted instead of Unity to avoid licensing costs, support all major XR headsets from a single codebase, and eliminate app store delays. Real-time communication features, including voice, low-latency video streaming, screen sharing, and synchronized multi-user interactions via avatars and shared objects, were implemented using the OpenVidu system based on WebRTC protocols. A 3D printer was integrated through OctoPrint running on a Raspberry Pi, enabling seamless physical prototyping.Testing was conducted with Meta Quest 2, Meta Quest 3, and Apple Vision Pro headsets. The solution was integrated with two other 6G-XR projects, where the user (on Apple Vision Pro) and the FabLab operator (on Meta Quest 3) were connected through sliced 5G links in the 5GTN test network. For final validation, the integrated three-project setup was demonstrated at the EuCNC & 6G Summit 2024 in Antwerp, Belgium. **Impact:** The project successfully met and exceeded its objectives, demonstrating a cutting-edge multi-user digital twin environment that combines XR headsets, avatars, and hand-tracking for intuitive real-time collaboration and object manipulation. This use case serves as an ideal testbed for advanced mobile networks, given its stringent low-latency and high-bandwidth requirements driven by synchronized 3D interactions and multiple high-quality audio/video streams. A major milestone was the successful integration with two other 6G-XR projects and the live demonstration at EuCNC & 6G Summit 2024, just four months after project kick-off. The public showcase highlighted the potential of XR-enabled collaboration over sliced 5G networks and was met with strong positive feedback from visitors and industry stakeholders. The digital twin concept has since been presented to local FabLabs, generating significant interest for its applications in 3D printing education and operator training. By enabling safe, immersive, and cost-effective learning environments, the solution supports both industrial and educational adoption.

METAPHOR

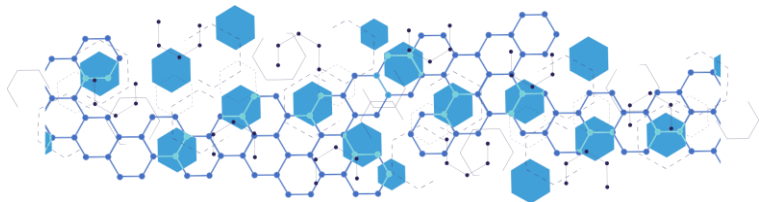| OC1 Project Title	METAPHOR
Benefiaciary(s)/Country	Brainstorm Multimedia / Spain
Project Description	METAPHOR allows to seamlessly extend the eXtended Reality (XR) enablers from 6G-XR by integrating its resulting holographic communication platforms with InfinitySet, Brainstorm's main virtual production engine. This integration allows InfinitySet to determine optimal viewpoints and settings from a volumetric rendered scene by 6G-XR components (e.g., including multiple remote 3D holograms and other content sources) to be interfaced with an interactive virtual scenario to provide new interactive and compelling experiences to large audiences. The resulting integration enables hyper-realistic real-time dialogues between remotely captured 3D participants and presenters from broadcast settings, seamlessly integrated within shared virtual environments in an adaptive, affordable and scalable manner.
Vertical	RAN enablers
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	February – July 2024
Results & Impact	**Results:** The METAPHOR project successfully demonstrated the integration of remote participants into live broadcast environments using the HoloMIT platform, in collaboration with i2CAT and Brainstorm. The validation took place in a real broadcast production setup, showcasing three modes of actor integration within a virtual scene. Local Actor with Chroma Key – An actor captured via iPad against a green background was composited in real time using Brainstorm's InfinitySet, with a live preview monitor providing immediate visual feedback. Remote Volumetric Actor – A second actor joined through the HoloMIT client using RGB-D or light-field cameras enabling high-quality audio-visual interaction.Lightweight 2D Avatar Setup – A third participant used only a standard webcam, represented by a 2D head and simple avatar body, demonstrating accessibility without advanced hardware. The system architecture combined Unity and InfinitySet via NDI, ensuring seamless synchronization between virtual elements. InfinitySet managed camera tracking and scene composition, while Unity rendered specific scene components, such as interactive objects. The final demonstration achieved high-quality and low-latency for multiple participants (local, remote, and lightweight) within a single interactive virtual production environment, validating the METAPHOR concept. **Impact:** METAPHOR offers unprecedented benefits across a wide range of sectors, including education, entertainment, and broadcasting. By leveraging SoA interactive and immersive XR technologies, combined with advanced distributed 6G research infrastructures, METAPHOR enables new forms of real-time collaboration, creative production, and experiential learning. This integration also paves the way for scalable, network-aware XR applications that can transform both industrial workflows and end-user experiences**.**

MST

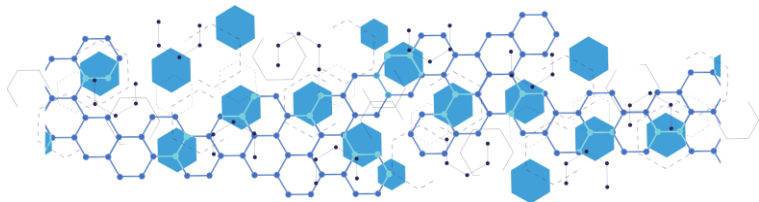| OC1 Project Title	MST: Magos Surgical Training
Beneficiary(s)/Country	Quanta & Qualia - Greece
Project Description	MST demonstrate the development of a VR collaborative medical training application based on the Magos Platform. It enables 2 surgical trainees in the healthcare industry to remotely interact using their fingers in near real-time, thanks to 6G technology. So, it provides a lifelike experience, enabling users to interact with their virtual environment as if it were the real world. This realism in finger interaction is crucial for developing the dexterity required for complex surgical tasks.
Vertical	Networking and Computing, Enablers XR Enablers
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	February – July 2024
Results & Impact	**Results:** The MST project developed and validated a multiplayer VR medical training application enhanced by Magos haptic gloves, enabling realistic, collaborative surgical simulations. The system follows a peer-to-peer (P2P) Unity Netcode architecture that ensures low-latency, synchronized interactions. The Magos Player Netcode streams real-time data from hand and head tracking, allowing multiple users to train simultaneously with high accuracy and realism. The application streams detailed finger-joint and headset data, maintaining smooth, synchronized animations across participants. Key challenges—mainly in multiplayer synchronization, data streaming, and firewall restrictions—were resolved through optimized Unity network configurations and connectivity tuning. A total of ten Magos glove sets were produced. Overall, MST delivered a validated, networked VR training prototype combining haptics, realism, and multi-user interaction, providing a strong foundation for future 6G-XR healthcare applications. **Impact**: The MST project addresses a major global health crisis, the lack of access to affordable surgical care, affecting nearly 5 billion people. The MST project accelerates the transition toward medical Virtual Reality (VR) training, offering an innovative hardware and software platform that enables hyper-realistic, collaborative surgical practice through natural hand and finger interactions using Magos haptic gloves. By digitizing touch sensation, MST enables certifiable, cost-effective, and portable surgical training, reducing reliance on expensive simulators and real operating rooms. The platform enhances time efficiency, accessibility, and training repeatability, while providing data-driven performance assessment. These capabilities improve medical skill acquisition, reduce setup time, and democratize access to high-quality training worldwide. Socially, MST promotes equal training opportunities and directly contributes to two EU priorities: protecting citizens and freedom and strengthening Europe's leadership in VR and XR technologies. Within 6G-XR, MST contributes by delivering six sets of Magos gloves to i2CAT for testing, deploying a high-demand VR surgical application, and enabling research into network optimization, physics, and holographic rendering.

OpenCAMARA

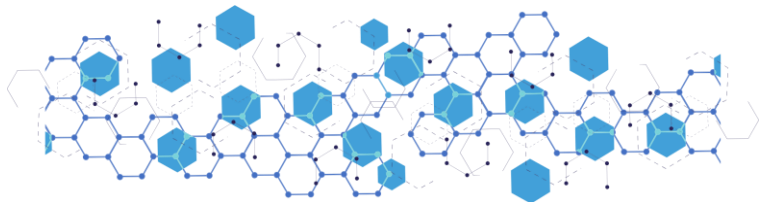| OC1 Project Title	OpenCAMARA: Open source solution to integrate CAMARA QoD API to 5G stack
Beneficiary(s)/Country	Neutroon Technologies / Spain
Project Description	In the concept of Open Gateway, OpenCAMARA implemented CAMARA Quality on Demand (QoD) APIs over Open5GS as the 5G core. AMBR, priority tagging, 5QI and slicing are 4 means to prioritize data flows, hence offering different levels of QoS. Dealing with different features for dedicating necessary network resources to obtain desired KPI is not easy for non-expert persons. This project aims to facilitate this process by employing CAMARA QoD API as a standard way to enforce desired QoS configuration to the 5G stack elements.
Vertical	Networking and Computing Enablers, XR Enablers, RAN Enablers
Testbed	I2CAT (formerly 5GBarcelona)
Implementation timeframe	February – July 2024
Results & Impact	**Results:** The OpenCAMARA project provided two series of validation and technical results. • Validation and performance results while applying Camara QoD APIs. It is worth mentioning that even though we have proposed in the proposal to validate the OpenCAMARA with Amarisoft as 5G RAN, we decided during the project to expand the experience by validating the OpenCAMARA with Node-H as well. • Technical and comparison results of the performance when employing external UPF for Open5GS. Testing was initially carried out in Neutroon's Lab using the Nomad5G testbed, then deployed at 5GBarcelona (i2cat) for final validation.Key outcomes included:Successful AMBR and 5QI enforcement, confirming OpenCAMARA's ability to dynamically control UE throughput and prioritize traffic according to QoS profiles.Verification that Amarisoft effectively handled AMBR-based QoS, while Node-H enabled full 5QI-based prioritization, demonstrating flexibility across RAN vendors.Validation of OpenCAMARA with multiple UPFs (Embedded Open5GS, external Open5GS, eUPF, and UPF-VPP). Results showed that UPF-VPP achieved the lowest RTT and highest downlink throughput, while Open5GS UPFs performed best in uplink communications. **Impact:** OpenCAMARA implementation has been deployed at the 5GBarcelona testbed in i2CAT site, which is part of the 6G-XR south node, and will become available to experimenters applying to future 6G-XR open calls. It will be up to the 6GXR consortium and the trial site owner to study whether to open source the developed CAMARA implementation, which can benefit the research community at large because Open5GS is a very commonly used tool in research environments. With OpenCAMARA, use cases running in the 6G-XR trial site can dynamically adjust their network resource requirement. This results in saving time and resources toward a sustainable network.

REQUIEM

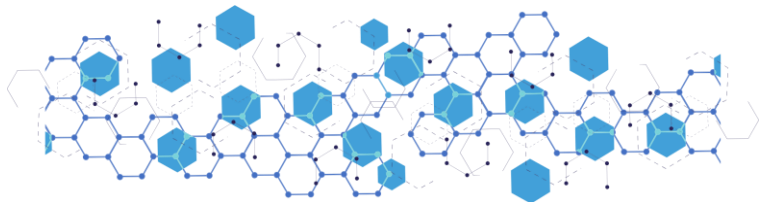| OC1 Project Title	REQUIEM: Research on QUIC client mobility
Beneficiary(s)/Country	HUN-REN Tamogatott Kutatocsoportok Irodaja- Hungary
Project Description	In this project, REQUIEM designed and implemented QUIC-based real-time media transmission suitable for the 6G-XR Remote Renderer. Standardized QUIC can migrate client connections between networks such as WiFi and cellular without breaking connections. It was developed automated measurement tools to quantify the effects of different protocol settings, which was used to evaluate the currently unknown effects of client mobility on the quality of real-time media in a Mininet based testbed and on the 6G-XR South Node. The solution has been integrated into the 6G-XR Remote Renderer. REQUIEM released code as open-source and published the key findings. The improved Remote Renderer enables inherent end-to-end security, fate sharing in control and data planes, reduced connection establishment times, improved Quality of Experience (QoE), etc. Our contributions enable novel XR applications involving client mobility.
Vertical	Networking and Computing, Enablers XR Enablers
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	February – July 2024
Results & Impact	**Results:** The project developed novel media streaming methods for the 6G-XR architecture, focusing on media transmission over QUIC: • Raw media transport stream over QUIC, integrated via new GStreamer elements. • Media-over-QUIC support for the 6G-XR Remote Renderer. An automated measurement tool was developed to assess both network performance (latency, migration behavior) and video quality (using VQMTK and iqa metrics) across virtual and real testbeds. The evaluation covered multiple migration strategies: • Planned migration—where clients switch paths proactively—delivered better video quality. • Involuntary migration performance improved when using shorter keep-alive intervals. Additional tests showed that QUIC stream mode achieved higher video quality but increased latency, while datagram mode was preferable under bandwidth constraints. The complete QUIC-based streaming system was successfully deployed and validated in the 6G-XR South Node Kubernetes cluster (5GBarcelona), confirming consistency between virtual and real testbed results. **Impact:** Firstly, REQUIEM contributions are beneficial for the 6G-XR project as an enabler for XR applications involving client mobility thanks to seamless client migration of the QUIC protocol. QUIC also enables enhanced end-to-end security, reduced connection establishment times, etc. Moreover, REQUIEM contributed to6G-XR open-source repositories creating multiple patches most of which have been merged and we opened issues resulting in new features and fixes from the developers.

5G-slAIce

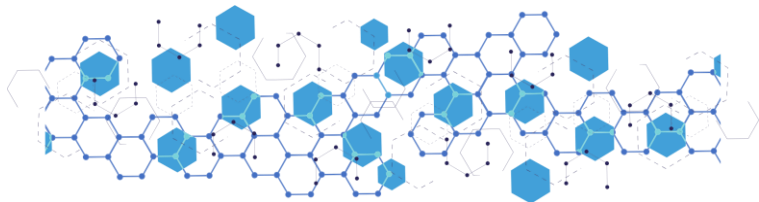| OC2 Project Title	5G-slAIce: 5G network SLicing enhancement using AI teChniquEs
Beneficiary(s)/Country	GRADIANT - Galician Research and Development Center in Advanced Telecommunications - Spain
Project Description	The objective of 5G-slAIce is to develop an AI/ML-based system that dynamically manages the resources of the different slices of a 5G network core deployed in a Cloud-Native environment. The AI/ML block will consist of two types of ML algorithms: an incremental learning based algorithm, which will be responsible for predicting the number of users of each type of slice in the future; and the reinforcement learning based algorithm, which will be responsible for prescribing actions on the resources of the different slices and the 5G network core based on the current state of the network and the prediction of the IL algorithm, trying to anticipate possible situations of oversaturation or underutilization. The work carried out will provide a solution that anticipates certain undesirable situations by dynamically managing the resources of the different slices, thus facilitating progress towards the implementation of 6G mobile networks.
Vertical	AI/ML algorithm for efficient resource optimization in the 5G slicing techniques
Testbed	UOulu 5GTN
Implementation timeframe	SEP 2024 – MAR 2025
Results & Impact	**Results:** The project has produced multiple results. Firstly, in relation to the preparation of the AI/ML algorithms, we have developed the necessary tools to generate datasets with the metrics of this project (which can be extended to acquire others) using a simulator of user connections of different slices. Secondly, the AI/ML models themselves have been developed: the CL model and the RL model. These models produce the expected results for various evaluation metrics, forming the basis for resource management actions. Finally, an action controller for cloud infrastructure has been developed to implement these actions on Kubernetes, the de facto standard for cloud-native orchestration. For more details on the technical results achieved, please refer to the attached deliverable. **Impact:** The main outcomes are an automatic and dynamic resource controller in a 5GC with different slices using two specific ML techniques, and a simulator of connections to a 5G network with the possibility of creating datasets with metrics related to the 5GC and the infrastructure in which it is deployed. The potential lies in further improving the connections simulator to support a larger configuration of the environment and, on the other hand, in increasing the capabilities of the AI/ML block in several aspects: (i) predicting more variables by using the continuous learning algorithm; (ii) increasing the performance of the models. It can be commercialised as an additional module of a 5G network core deployment in the cloud.

REMIX

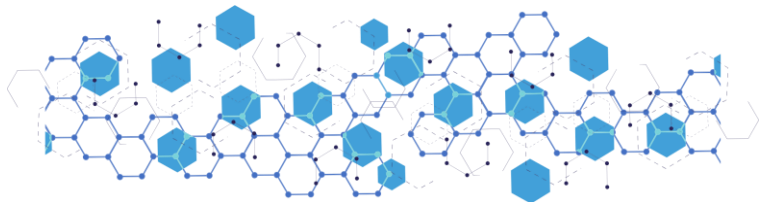| OC2 Project Title	6G REMIX: 6G Real-time Energy Monitoring for XR
beneficiary(s)/Country	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. - Germany
Project Description	6G REMIX aims to analyze the energy consumption of 5G networks by monitoring and visualizing real-time data. Determining energy consumption through measurements of the individual components along the streaming chain and collecting and analyzing existing operating data on power consumption are essential prerequisites for modeling an end-to-end video streaming service. To achieve this goal, 6G REMIX focuses on enhancing the 6G-XR nodes, particularly the South Node (5GBarcelona), by developing tools and procedures for collecting and measuring energy consumption throughout the streaming chain, as well as recording and evaluating existing operating data.
Vertical	Energy: (Residential/industry) energy management and provisioning
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	Oct 2024 - Mar 2025
Results & Impact	**Results:** Main findings and outcomes: • The gNodeB and the Edge are the most energy-intensive components. It is necessary to focus on optimizing the power usage of these components for improved energy efficiency. • The impact of the video bitrate on the UE power is minimal. We do not recommend reducing the video bitrate to save energy because of unnecessary deductions in video quality. • Edge component shows a significant power consumption increase (by 71%) when remote rendering is activated. We suggest developing and implementing strategies to limit remote rendering usage or optimize its efficiency. • Switching from 100 MHz to 40 MHz bandwidth does not significantly reduce energy consumption. It is not necessary to reduce the bandwidth to save energy. **Impact:** Potential for further developments and commercialization: • The insights gained from real-time energy monitoring can lead to the development of advanced energy management systems for 6G networks. These systems could optimize power usage dynamically, offering solutions to network operators aiming to reduce operational costs and environmental impact. • The project's analysis of energy consumption across different streaming scenarios can inform the development of adaptive streaming techniques. These technologies can adjust video quality based on network conditions and energy availability, enhancing user experience while minimizing energy use.

AI4EE

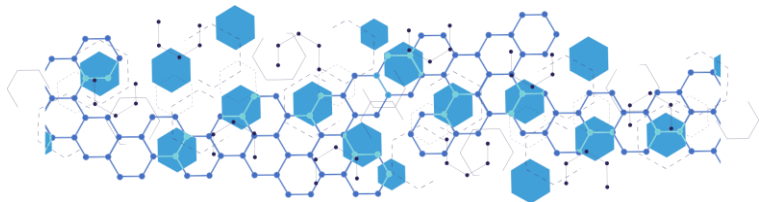|	
OC2 Project Title	AI4EE: A holistic approach for energy efficiency driven by AI-based deep understanding of the process stability
beneficiary(s)/Country	Nissatech - Serbia
Project Description	Based on a previous work on the energy optimization in the industry domain, we proposed an innovative approach for analyzing optimization potential in the 5G Test network infrastructure, applied on 6G-XR north node. The result is an energy analysis framework, which uses AI for a deep understanding of the energy consumption and discovering optimization potential, achieving E2E energy efficiency and self-sustainability in next generation mobile networks. The approach is validated with the energy consumption data collected from the existing energy measurement infrastructure, consisting of accurate power meters for continuous measurement of the power consumption at different network elements. The conclusion from the validation is that the tool can identify anomalies in the monitored network infrastructure's energy consumption data accurately.
Vertical	Energy measurement
Testbed	VTT 5GTN
Implementation timeframe	Sep 2024 – Mar 2025
Results & Impact	**Results:** Main result is an energy analysis tool AI4EE, which uses AI for a deep understanding of the energy consumption and discovering optimization potential, achieving E2E energy efficiency and self-sustainability in next generation mobile networks. AI4EE tool is an extension of the D2Port framework with the new methods for data analysis, which are developed as a specialization for the energy measurement provide in the 6G-XR north node. The methods are results of intensive discussions between Nissatech and energy experts and mentors from 6G-XR north node. Main goal was to detect and understand situations where some deviations in the energy consumption have occurred and validate if these situations are caused by some anomalies in energy management system. The work is based on the data collected from the energy management system installed in the 6G-XR north node. Main conclusion is that the tool can identify anomalies in the monitored network infrastructure's energy consumption data accurately. Both high load / overload and maintenance / fault situations are highlighted in the produced graphs at the expected time windows. **Impact:** Proposed energy management system (AI4EE) is based on the D2Port framework (d2port.rs), which offers set of services (data collection, observation, analysis, visualization) for the development of advanced data-driven systems. As a part of the impact creation, D2Port will be extended with new developed data analysis methods (anomaly detection) in order to offer new services for the energy market. The approach for the deployment is very general/universal and can be applied in any similar infrastructure.

DYNAMICOM

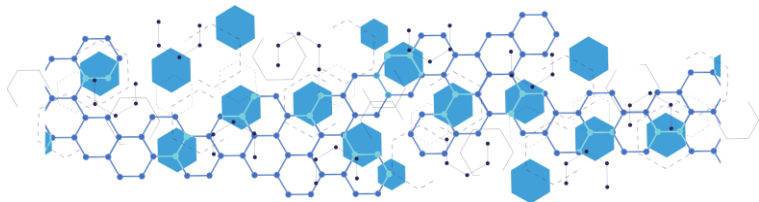|	
OC2 Project Title	DYNAMICON: Dynamic Service Migration Optimization in Unified Network Continuum
beneficiary(s)/Country	E-lighthouse Network Solutions SL – Spain
Project Description	The DYNAMICON project focuses on advancing the orchestration of dynamic service migration and load balancing across the Device/Edge/Cloud continuum. This innovative venture leverages the Edge Computing Optimization Tool (ECOT) to enhance the 5TONIC MEC Orchestrator's capability in managing edge resources for efficient service distribution. It aims to refine network resource utilization and quality of service (QoS) by developing algorithms for computational load balancing, application migration, and network slice selection. Key to DYNAMICON's strategy is its integration with the 5TONIC testbed's existing infrastructure, which allows for real-time, slice-aware service management. DYNAMICON not only aims to enhance the 5TONIC framework's service management but also seeks to explore its application in multi-site environments. The project's success helps to redefine network and service management operations, supporting a variety of high-stakes real-time applications aligned with the 6G-XR goals.
Vertical	5G/6G Network Orchestration
Testbed	5GTONIC
Implementation timeframe	Oct 2024- Mar 2025
Results & Impact	**Results:** The DYNAMICON project achieved significant technical advancements by integrating the ECOT into the 6G-XR South Node infrastructure, validating its core functionalities: load balancing, and predictive migration. The validation process was executed in two phases: • Integration Tests: ECOT was successfully integrated with both the 5GC NEF and MEC orchestrator APIs, confirming its ability to collect the needed data properly. • Execution Tests: Demonstrated ECOT's ability to identify congestion patterns, simulate migration strategies, and recommend actions to the MEC orchestrator related to load balancing and migration operations. **Impact:** DYNAMICON has directly contributed to advancing the orchestration capabilities of the 6GXR South Node by introducing ECOT, a novel optimization tool for real-time service migration and load balancing. By integrating ECOT with the 5TONIC infrastructure, the project demonstrated a practical approach to enhancing resource utilization, ensuring service continuity, and maintaining QoS across distributed edge nodes. The experiment validated the use case showcasing how ECOT can make intelligent decisions based on real-time and predictive analysis. These contributions extend the flexibility and responsiveness of the 6G-XR architecture, particularly for the South node.

EMSEOS

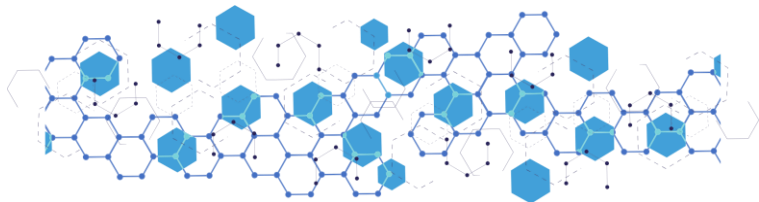|	
OC2 Project Title	EMSEOS: Energy Monitoring System for Energy-Efficiency Optimization and Sustainability of Multimedia VNFs
Beneficiary(s)/Country	IKERLAN - Spain
Project Description	The increasing energy demand of computing edge nodes and cloud services needs the development of energy-aware systems to enhance efficiency, reliability, and cost-effectiveness without degrading performance. The EMSEOS experiment addresses this challenge by implementing an energy monitoring system capable of estimating CPU and GPU power consumption for virtualized network functions (VNFs). Deployed within the 6G-XR project's infrastructure, this system leverages Kubernetes for seamless integration and Prometheus for persistent metric storage and analysis.
Vertical	Energy: energy management and provisioning
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	SEP 2024 – MAR 2025
Results & Impact	**Results:** The system was validated through a series of 15-minute tests, with results averaged over a 3-minute window to ensure consistency and remove initial or final fluctuations Initial tests used a synthetic CPU/GPU stress workload, confirming that energy consumption increased sharply under full load. Subsequent experiments employed a Remote Renderer VNF with varying configurations (resolution, framerate, bitrate, and mode) to analyze how these factors affect power usage. Results showed that energy consumption scales with rendering complexity, with the highest usage observed in the most demanding configuration (T4.1 – stereo 4K, 10 fps, 30 Mbps). These tests demonstrated the system's ability to accurately capture consumption fluctuations across different VNF setups, successfully meeting the experiment's objective. **Impact:** The EMSEOS experiment extends the 6G-XR project's capabilities by integrating a real-time energy monitoring system into its computing infrastructure. EMSEOS results contribute to the broader research community by demonstrating a scalable methodology for power-aware resource management in cloud and edge environments. The collected energy metrics can serve as a foundation for future optimization strategies, helping operators and developers improve energy efficiency without compromising performance. This aligns with the growing need for sustainable computing in next-generation networks, where energy-aware orchestration will play a key role in balancing performance, cost, and environmental impact.

ENORMOUS

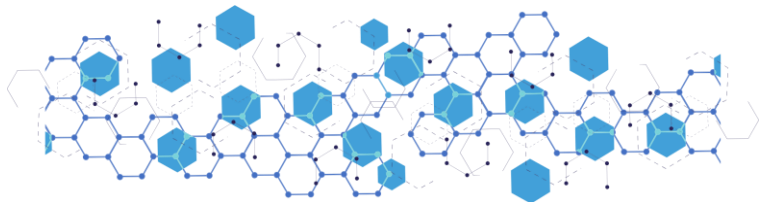|	
OC2 Project Title	ENORMOUS - ENergy Optimization in multimedia tRansMission and 5G netwOrks Unified System
Beneficiary(s)/Country	University of Malaga - Spain
Project Description	ENORMOUS responds to the need for energy efficiency raised in the 6G-XR OC2 initiative, specifically addressing the monitoring and prediction of the energy consumption of the different network elements within virtualized network functions during data transmission. It has developed advanced tools for real-time monitoring and measurement of energy consumption, as well as investigating AI/ML-based techniques for predicting consumption based on the network state. The aim is to enable the dynamic optimization of network resources and configuration parameters to reduce energy consumption. The techniques have been tested on the VTT infrastructure in Oulu provided by the 6G-XR consortium. The results generated are expected to provide important contributions to both operators and the scientific community, facilitating the transition towards more sustainable, resilient and efficient networks, aligned with global sustainability goals and the IMT-2030 framework.
Vertical	Energy: (Residential/industry) energy management and provisioning
Testbed	VTT 5GTN
Implementation timeframe	Sep 2024- Mar 2025
Results & Impact	**Results:** The ENORMOUS project developed an effective solution for monitoring and predicting energy consumption in the Central Unit (CU) and Distributed Unit (DU) within the Open5GS environment. The system combines real-time data collection, feature engineering, and supervised AI/ML models (such as LSTM, linear trees, and MAPIE) to estimate short-term energy usage. Validated through deployment in the Open5GS testbed under multimedia traffic conditions, the tool enables dynamic network adjustments that reduce energy consumption while maintaining Quality of Service (QoS). A continuous optimization feedback loop allows the models to refine predictions and improve performance over time, supporting more sustainable network operations. **Impact:** The project's outcomes, validated monitoring tools and AI/ML prediction models, provide practical mechanisms for energy-efficient network management applicable to operators, researchers, and standardization bodies. From an industrial perspective, the results allow telecom operators to optimize resource utilization, reducing operational costs while maintaining service quality. From an academic viewpoint, the methodologies and findings advance research in AI-driven network management and energy-aware system design. Furthermore, it promotes open collaboration by sharing datasets and models publicly, encouraging benchmarking, reuse, and innovation across the broader scientific and industrial communities. These contributions accelerate progress toward sustainable and efficient 6G technologies.

StreamAnalyzerFor5GSlicing

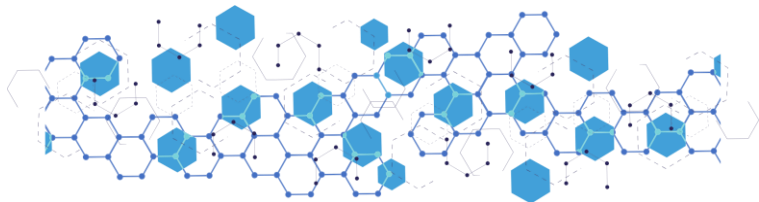|	
OC2 Project Title	StreamAnalyzerFor5GSlicing: Integration and enhancements of Lamda Networks' NWDAF implementation to 6G-XR for providing AI/ML capabilities for slicing
beneficiary(s)/Country	Lamda Networks - Greece
Project Description	This project addressed ML/AI challenge in the sub area AI/ML algorithm for efficient resource optimization in the 5G slicing techniques, focusing on two key objectives:(i) developing a centralized AI-based load balancer that meets UEs' bandwidth requirements, and(ii) implementing a distributed reinforcement learning scheduler to optimize 5GTN RI resource utilization under congestion in Cumucore slices.The resulting open-source codebase constitutes a valuable asset for the 6G-XR project and a significant contribution to the SNS Stream B "System Architecture" initiative.
Vertical	AI/ML for slicing
Testbed	5GBarcelona (now i2CAT testbed)
Implementation timeframe	Sep 2024- Mar 2025
Results & Impact	**Results:** The AI-based centralized use case demonstrated that the admission control agent effectively restricted UE access when more than seven active UEs were connected, as it learned that additional UEs could not achieve the target bandwidth of 5 Mbps. The model also showed a preference for Slice 2 (UPF250) in specific scenarios, optimizing performance based on its training experience.For the AI-based decentralized use case, the deep reinforcement learning (DRL) UE scheduler successfully learned to optimize slice assignment decisions. The agent minimized both waiting time and slice usage time by prioritizing smaller UE requests and assigning them dynamically to the appropriate network slice (Slice 1 or 2). The results confirm that the agents learned effective scheduling policies that balance load and maximize overall system efficiency within the 5GTN testbed. **Impact:** StreamAnalyzerFor5GSlicing yielded promising results serving as the basis for a realistic business plan. The implementation is currently integrated and operational within the 5GTN production network and is available to support other researchers and experimenters throughout the duration of the 6G-XR project. Additionally, the open-source codebase developed during the project constitutes an asset for Stream B "System Architecture" of the SNS program.

TRUSTNET

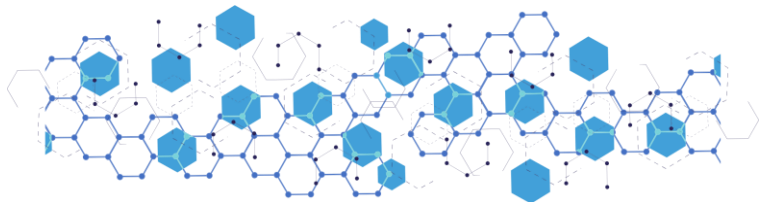| OC2 Project Title	TrustNet - Trust Management Framework for 6G Networks
Benefiaciary(s)/Country	WINGS ICT Solutions S.A. - Greece
Project Description	TrustNet aims to tackle the challenges of ensuring end-to-end trust and reliability in 6G networks, within the compute continuum, which extends computing capabilities from centralised cloud to distributed edge infrastructures, as well as up to end-user devices. This project focuses on the development and validation of a Trust Management Framework (TMF) that quantifies and manages trust. The project aims to enhance trust quantification, optimise data paths, and ensure secure, reliable communication across multi-domain 6G ecosystems, with a particular focus on XR applications. Ultimately, TrustNet contributes to the creation of secure, trustworthy environments for future 6G networks, supporting dynamic, multi-stakeholder service provisioning.
Vertical	Security and trust mechanisms
Testbed	5GTONIC
Implementation timeframe	SEP 2024 – MAR 2025
Results & Impact	**Results:** TrustNet enabled the collection of a diverse set of trust quantification-relevant performance metrics and the evaluation of two available 5TONIC edge domains, leveraging the collected datasets. The 5TONIC-TMF integration (including extended API configurations, related to the exposure of performance KPIs, dynamic traffic load modelling, etc.) was successfully tested, while interesting preliminary results were collected. The potential for further development and commercialization of the TrustNet project lies in its ability to provide a scalable and robust Trust Management Framework (TMF) for dynamic, multi-domain 6G networks and XR applications. The TMF's capability to quantify and optimise trust in real-time can be applied to various industries, including telecommunications, smart cities, and autonomous systems. It offers significant value for service providers, application developers, and infrastructure managers who need to ensure reliable, trust-aware communication across complex networks. Further development could focus on enhancing the framework for specific use cases, such as secure edge computing or resource optimisation. The commercialization potential includes licensing the technology or offering tailored solutions for enterprise applications across a wide range of sectors. **Impact:** TrustNet, leveraging the 5TONIC infrastructure, significantly contributes to the broader community by offering real-world trust quantification experimentation outcomes as well as a novel methodology for evaluating trust at both the device and edge domain levels, addressing a key gap in current technology. This approach enables communication service providers, cloud providers, and application developers to assess the trustworthiness, reliability, and security of their networks and infrastructures, while also providing valuable insights for third-party application developers and 6G stakeholders.

OPTICALRAN

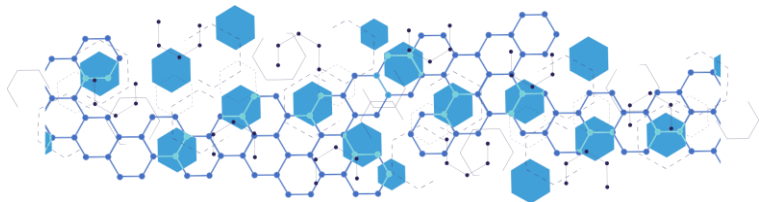| OC2 Project Title	OPTICALRAN: 5G/6G FWA with optical RAN
Benefiaciary(s)/Country	Peta Optik, Spain
Project Description	The project develops a high-capacity Fixed Wireless Access (FWA) Radio Access Network that uses optical frequencies (around 1500 nm) instead of microwaves or millimeter waves. This enables non-interfering, easily reusable optical links between user devices and the gNodeB. Current prototypes already deliver >10 Gbps per user over distances under 2 km, with expectations to exceed 100 Gbps through further design improvements. The system leverages very large optical MIMO channels, supported by Peta Optik's advanced Digital Signal Processors (DSPs) that can handle large MIMO configurations and tolerate link misalignments. These high data rates aim to support demanding 6G applications such as UHD holographic displays, digital twins, and XR/VR for dense user populations.
Vertical	Increased capacity
Testbed	I2CAT testbed
Implementation timeframe	Sep 2024- Oct 2025
Results & Impact	Results: The project successfully demonstrated optical telecommunication links for Fixed Wireless Access (FWA) Radio Access Networks (RAN), using optical frequencies instead of microwaves or millimeter waves for the FWA channel. This approach enables high-speed optical links between User Equipment (UE) and gNodeB.Currently, the system achieves data rates exceeding 2 × 230 Mbps (460 Mbps) per connected FWA UE over distances of several hundred meters, suitable for AR/XR applications. Performance is currently limited by the drivers, which will require further refinement. The optical signals operate at a wavelength of 1500 nm. Optical signal wavelength used is 1500nm. Impact: The impact of these developments is significant: - Future advancements in the technology could achieve data rates exceeding 10 Gbps. The optical spectrum is highly reusable and license-free, offering flexible deployment options. - New business models can be implemented on license-free technologies by companies beyond traditional telecommunications operators. These developments create opportunities to establish new standards supporting such innovative business models.

xDRL-RCS

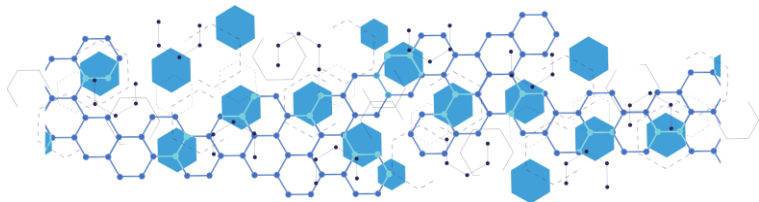|	
OC2 Project Title	xDRL-RCS: eXplainable Deep Reinforcement Learning Assisted 5G/6G RAN and Core Slicing
Beneficiary(s)/Country	iThermAI -Belgium
Project Description	xDRL-RCS develops an explainable deep-reinforcement-learning framework for adaptive RAN slicing in open 5G/6G systems, supporting demanding digital-twin applications. Built on OAI, FlexRIC, and the OAI 5G Core, aligned with the UOULU 5GTN setup, the system enables real-time, closed-loop control through enhanced KPM and RC xApps connected to an xDRL controller via REST and E2SM-RC interfaces. The xDRL algorithm models latency, throughput, and packet loss, evaluates SLA compliance, and incorporates a fairness parameter in its reward function. Two environments were developed: a Python simulator for training and an OAI + FlexRIC testbed for near-real-time validation. Results across both confirm improved resource use, latency, and reliability, with transparent decision-making supported by SHAP explainability. Open-source releases ensure reproducibility and provide a solid base for future AI-driven 6G research.
Vertical	AI/ML for slicing
Testbed	UOULU 5GTN
Implementation timeframe	Feb 2024 – Oct 2025
Results & Impact	**Results:** The xDRL-RCS framework provides an explainable, adaptive solution for RAN inter-slice resource management using three modular xApps: the Enhanced KPM xApp for gNB telemetry collection, the xDRL Controller xApp for DRL-based resource allocation, and the RC Slice Control xApp for applying actions via E2SM-RC to the OAI gNB. Deployed in a Dockerized OAI + FlexRIC testbed, it enables closed-loop control between the AI agent and the RAN.Training combined a Python-based simulator with integrated testbed evaluations. PPO, A2C, and DQN agents enhanced with SHAP-based pruning were tested, with PPO-xDRL achieving the best gains: +18% throughput, −86% delay, −92% packet drops, and +32% SLA compliance over PF and RR baselines. SHAP analysis highlighted latency and throughput as key decision drivers.A full OAI + FlexRIC + OAI Core setup further validated real-time, near-RT RIC interaction and adaptive resource redistribution. Overall, xDRL-RCS delivers dynamic, explainable, and fairness-aware slicing with consistent performance across simulation and testbed environments. **Impact:** Scientifically, the project advances explainable AI-native end-to-end slicing, combining RAN and Core optimization with transparency, fairness, and SLA compliance. Its open-source framework facilitates reproducibility and further research on standard OAI/FlexRIC platforms.Industrially, it demonstrates that AI-driven automation can be effectively deployed in open 5G/6G networks. The integration of RAN and Core slicing supports trustworthy, SLA-aware controllers suited for digital-twin applications, XR, and Industry 4.0 services.

LCEVC-6G-XR

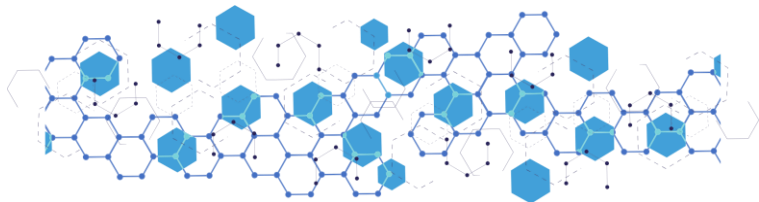| OC3 Project Title	LCEVC-6G-XR: LCEVC for Enhanced 6G-XR Holographic Streaming Services
Beneficiary(s)/Country	Fluendo S.A. / Spain
Project Description	The proposed experiment aims to advance holographic communication platforms by integrating the MPEG-5 Low Complexity Enhancement Video Coding (LCEVC) standard. LCEVC is an innovative enhancement layer that enhances the performance of base codecs without replacing them, thus ensuring backward compatibility. By enhancing widely used codecs such as H.264, LCEVC bridges the gap between legacy solutions and next-generation XR applications. This integration improves encoding and streaming performance for high-resolution, immersive multimedia applications in real-time holographic communication scenarios.
Vertical	Real-Time Holographic Communications
Testbed	i2CAT
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: The project integrated and validated an LCEVC-enhanced streaming pipeline within the 6G-XR infrastructure. On the server side, the "Lynx" GStreamer plugin was developed to add LCEVC to OpenH264, achieving -30.93% BD-Rate (VMAF) versus AVC and approaching HEVC efficiency at far lower CPU cost. On the client side, the LCEVC decoder was successfully compiled to WebAssembly, enabling real-time 1080p/30fps playback in standard browsers. Low-latency transport was achieved using QUIC/WebTransport integrated into the GStreamer pipeline. End-to-end latency tests confirmed stable performance: 720p and 1080p met interactive service thresholds, while 4K remained viable but exposed a system-level bottleneck unrelated to the codec. Impact: Within 6G-XR, the work delivered a new WebTransport-based player, HEVC-level quality at lower bitrates and CPU load, seamless integration with the Remote Renderer, and transport support aligned with ultra-low-latency XR goals. Scientifically and industrially, the project contributed a reusable benchmarking framework, practical encoding presets, and transferable tools relevant to cloud gaming, remote graphics, and other low-latency streaming applications.

AViD-NMP

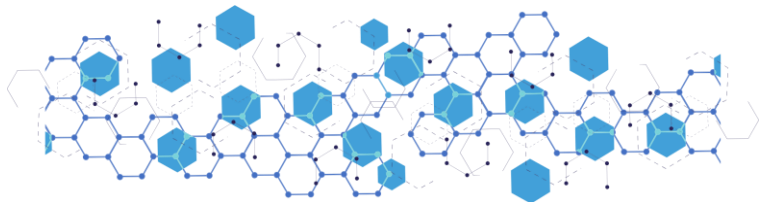| OC3 Project Title	AViD-NMP - Adaptive Video Delivery for Network Music Performance
Beneficiary(s)/Country	AUEB-RC / Greece
Project Description	The AViD-NMP project explores Network Music Performance (NMP) using the 6G-XR infrastructure, focusing on ultra-low latency and high-bandwidth requirements that are only achievable with 5G/6G networks. It integrates audio, video, and volumetric data for immersive, XR-enabled multiparty NMP sessions. To meet performance needs, the project leverages 5G RAN for low-latency communication and MEC (Multi-access Edge Computing) resources for real-time media processing, including volumetric video and SFU/MCU bridging close to end users. The primary goal is to support training and education, evaluating QoS and QoE of XR-enabled NMP across advanced 6G-XR testbeds. The project will showcase a fully operational multiparty NMP setup as a demonstrator of 5G/6G and XR's potential for enhancing real-time, immersive remote collaboration.
Vertical	Immersive Services
Testbed	5TONIC
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: Experiments in the 5TONIC 5G testbed evaluated volumetric video, audio, and 2D video for NMP teaching. Volumetric video maintained 30 FPS with ~48 ms latency in P2P and SFU setups; the MCU added ~40 ms but reduced bandwidth by up to 90%. With two producers, limited MEC resources caused frame loss and latency increases up to 200 ms.Audio delays were 53–60 ms—slightly above the live NMP threshold—while 2D video delays (172–195 ms) were too high for synchronized teaching. A live two-user test confirmed that ~50 ms one-way audio delay impaired synchronization, with moderate QoE ratings (2–3/5) mainly due to latency. Impact: The project validates the potential of 5G for telepresence and NMP but highlights challenges in meeting ultra-low-latency requirements. Volumetric video achieved 30 FPS with <50 ms latency on standard hardware. SFU added negligible delay; MCU added ~40 ms but reduced bandwidth drastically. Audio latency (55–75 ms) was acceptable for music teaching, not for live performance. 2D video latency (>150 ms) made it unsuitable for real-time synchronization. Thus, NMP-based teaching is feasible in two-party P2P or SFU/MCU setups, but multiparty streaming needs more bandwidth and MEC resources.

DREAMS

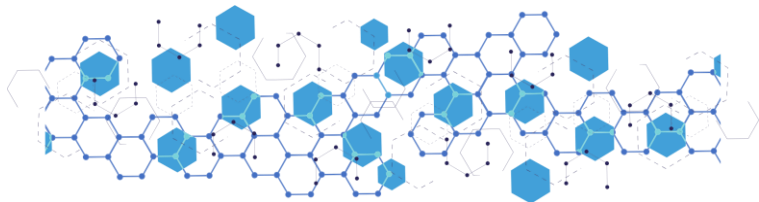|	
OC3 Project Title	DREAMS: Dynamic Radio Access Network (RAN) Energy-Aware Management System
Beneficiary(s)/Country	Future Connections España Soluciones de Conectividad SL / Spain
Project Description	DREAMS integrates microgrid control systems with flexible RAN management to optimize energy use in telecom networks. The system uses DREAMS Agents for distributed, intelligent edge-cloud energy control, incorporating data like renewable energy forecasts, electricity prices, CO_2 emissions, and network load to balance performance, efficiency, and cost. A central DREAMS Controller manages policies and provides real-time monitoring across the network. DREAMS will test a forecast-driven decision algorithm within DREAMS Agents. This algorithm analyzes energy and network data to optimize RAN configurations, with testing planned on an O-RAN deployment within the North Node. It will also develop visual dashboards for real-time monitoring of energy usage, production, and network performance to validate the algorithm's effectiveness.
Vertical	Energy Measurement Framework for Energy Sustainability
Testbed	VTT 5GTN
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: DREAMS delivered a working prototype of a Dynamic RAN Energy-Aware Management System integrated into 6G-XR. By adding external energy parameters (solar forecasts, electricity prices, CO_2 intensity) to the original load-based algorithm, the system can intelligently identify low-traffic periods and adjust or power down RAN elements to save energy. Tests showed solar forecasts increased energy-saving windows by up to 30%, spot prices shifted tasks to cheaper periods, and CO_2 data supported greener decisions. A configurable UI enables instant threshold updates, and validation on the 6G-XR RAN confirmed reliable real-time data collection and control. The prototype demonstrates the feasibility of forecast-driven, energy-aware RAN management for future AI-assisted 6G systems. Impact: The project advances sustainable telecom operations by integrating energy-aware management into adaptive 5G/6G networks. It offers a scalable, cost-effective approach that reduces operational costs, energy use, and environmental impact while maintaining service quality. By combining renewable energy forecasting, microgrid principles, and dynamic RAN optimisation, it supports the development of eco-efficient edge-cloud ecosystems.The results strengthen Future Connections' competitiveness by positioning it as a leader in sustainable telecommunications, opening new market opportunities, and attracting environmentally conscious partners. The approach improves operational efficiency, lowers emissions, and contributes to global decarbonisation efforts. It also provides the 6G-XR project with a validated model for energy-smart RAN management with strong technical and environmental benefits.

EMASS

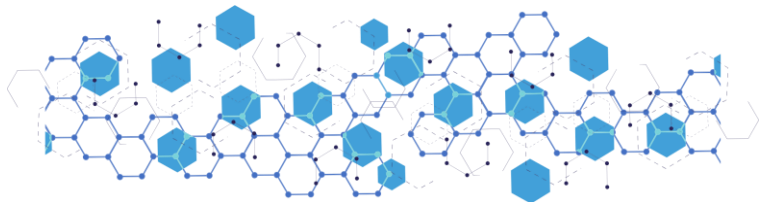|	
OC3 Project Title	EMASS - Energy measurement as a service
Beneficiary(s)/Country	GRIDNET / Greece
Project Description	Energy consumption and carbon footprint are key concerns for O-RAN systems, impacting costs, sustainability, and future 5G/6G scalability. O-RAN's modular, software-driven design enables real-time energy management aligned with climate goals. The project advances this by developing an intelligent energy-measurement framework for O-RAN test sites to optimize energy use in XR applications and support renewable integration. A major challenge is ensuring that energy data truly reflects network behavior, as calibration and validation methods are still lacking. To address this, an experiment on the VTT 5GTN O-RAN testbed will use AI-based energy meters and centralized data systems to ensure accurate validation, reliable verification, and standardized calibration. The modular approach also enables easy scaling to other facilities to support greener telecom networks.
Vertical	Energy Measurement Framework for Energy Sustainability
Testbed	VTT 5GTN
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: The EMAS project developed and validated a real-time AI-driven system for energy calibration and anomaly detection across 5G O-RAN components (CU, DU, RU) on the VTT 5GTN testbed. Power and KPI metrics were collected at 1 Hz and stored in a unified InfluxDB time-series database.Three AI models were implemented:RU Model (XGBoost): Predicts power from aggregated KPIs, recalibrates when deviations exceed 2%. Achieved high accuracy (MAE 0.65 W, R^2 0.83) and 100% anomaly detection.DU Model (Hybrid XGBoost + CatBoost): Handles idle/traffic states with periodic baseline correction. Achieved MAE 1.95 W, R^2 0.74, detecting all injected and additional real anomalies.CU Model (Autoencoder + Regression): Operates on 15 s windows to mitigate co-location noise. Achieved MAE 2.66 W, R^2 0.76, with full anomaly detection and genuine anomaly discovery.An integrated anomaly classification mechanism flags sustained over/underconsumption after 30 consecutive alerts.A React + Grafana dashboard provides real-time visualization of raw, calibrated, and anomaly-labelled metrics.Validation using real 5G datasets with injected +8–12% power anomalies confirmed that all models reliably detected abnormal behaviour, demonstrating the robustness of the EMAS pipeline. Impact EMAS offers a replicable, open-source methodology for energy-aware experimentation in 5G/6G networks.The pipeline enhances measurement reliability, energy calibration, and sustainability insights, aligning with global efforts to reduce telecom carbon footprints.Its open-source release enables adoption and replication in other testbeds, supporting future research and operational energy optimization.

EVIT

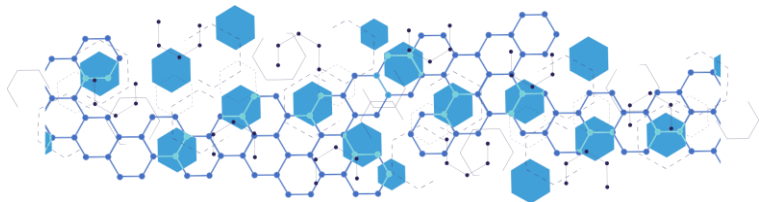| OC3 Project Title	EVIT - Electric Vehicle Infrastructure Twin
Beneficiary(s)/Country	Parity Platform P.C. - Greece
Project Description	EVIT enhances electric vehicle charging station (EVCS) installations by integrating Augmented Reality (AR) with 3D scanning and real-time diagnostics to support electrical engineers. The system improves safety, reduces errors, and boosts efficiency during complex installations. Key features include: live 3D scans using devices like the Creality CR-Scan Ferret Pro or smartphones, real-time feedback and safety alerts via 5G to an edge server, AR-guided instructions for accurate installation. Testing is conducted in the South node, leveraging its private 5G network and edge computing for sub-10ms latency, enabling: Seamless streaming of 3D scans and MR annotations, Synchronization with IoT platforms (e.g., EV Loader) to display charger status, Immediate alerts and system readiness updates within the AR field of view. EVIT combines AR, 3D scanning, and 5G to deliver a safer, smarter, and more efficient EVCS installation process.
Vertical	Immersive Services
Testbed	5TONIC
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: The EVIT experiment on the 5TONIC private 5G network in Madrid tested real-time 3D streaming and AR guidance for electrical installations. Using FR2 (26 GHz) cells, Wi-Fi 6E, and AR devices (Meta Quest 2, Creality Ferret scanners), the setup achieved 8 ms latency, >200 Mbps upload, and 350–400 Mbps download, representing ~90% lower latency and 5–6× higher throughput than 4G/Wi-Fi. This enabled seamless real-time AR overlays, instant feedback, and streaming of large 3D models (>500 MB), validating private 5G for industrial-grade XR applications. Impact: EVIT enhances safety, quality, and inclusivity in industrial electrical work. Real-time AR guidance and 3D scanning reduce errors and accident risk, while accurate digital twins enable documentation, verification, and remote expert review. The system allows experts with mobility or location constraints to contribute remotely, ensuring knowledge retention and workforce inclusivity. Overall, EVIT demonstrates the potential of XR and 5G to improve industrial installation efficiency and safety in alignment with 6G-XR goals.

FSXR

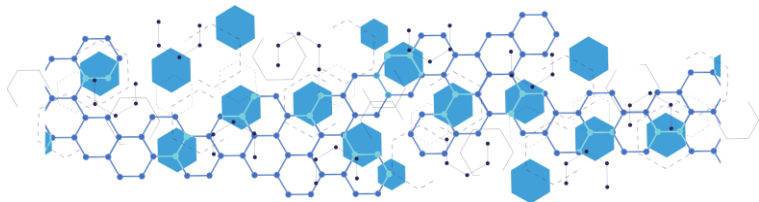| OC3 Project Title	FSXR - Fluid Simulation in eXtended Reality
Beneficiary(s)/Country	Luxembourg Institute of Science and Technology/ Luxembourg
Project Description	Extended Reality (XR) devices face significant limitations in running fluid simulation (FS) algorithms due to their high computational demands and the difficulty of maintaining real-time performance. To address this, we previously proposed offloading the particle position computations of the Position Based Fluids (PBF) method to a remote server, resulting in improved frame rates compared to fully local processing on devices such as the HoloLens v2. However, local rendering continued to constrain performance. The main challenge for remote rendering lies in the large size of rendered frames that must be transmitted to the XR device. To overcome this, FSXR leverages 6G-XR infrastructure, providing low latency and high bandwidth communication between the server and XR devices. This enables seamless, real-time fluid simulation visualisation, paving the way for more advanced and interactive XR applications.
Vertical	Collaborative 3D Digital Twin-like Environment
Testbed	Oulu 5GTN
Implementation timeframe	April 2025- October 2025
Results & Impact	Results Evaluation of Obi fluid simulation over O-RAN 5G SA and 5G Wi-Fi Router networks shows performance depends on architecture and context. The Wi-Fi Router network achieves lower latency and faster MTP locally, while O-RAN 5G SA offers predictable, scalable jitter, suited for real-time XR and outdoor rendering. Frame rates are limited by device decoding rather than network throughput (e.g., iPhone 14 maxes at 1920×885). Overall, Wi-Fi Router excels in local low-latency conditions, whereas O-RAN 5G SA provides more stable, flexible performance for broader deployments. Impact The FSXR project introduces a novel pipeline for visualizing fluid simulations on XR devices over O-RAN-based 5G SA networks, contributing significantly to XR and fluid simulation research. It also offers a comparative analysis of O-RAN 5G SA and 5G Wi-Fi Router performance, yielding insights into network efficiency for compute-intensive XR workloads. The FSXR pipeline generalizes to any remote, high-computation visualization use case, supporting 6G-XR's "Collaborative 3D Digital Twin-like Environment" goals. Strategically, FSXR aligns with Luxembourg's Smart Growth agenda and LIST's priorities—Digital Twin, Smart Space, and Industry 4.0—by enabling complex fluid simulations as integral components of scientific and industrial digital twin systems.

IMMVIEX

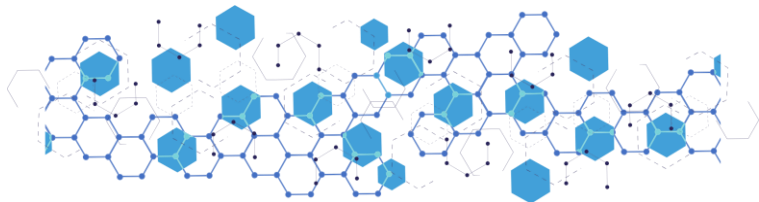| OC3 Project Title	IMMVIEX: 6G-XR-enabled IMMersive VIsiting EXperience
Beneficiary(s)/Country	Universidad Politécnica de Madrid / Spain
Project Description	IMMVIEX aims to showcase and evaluate a multi-user virtual cultural tour experience of a monument. The tour features a 3D model, user avatars, and a live presenter—teleported into the scene via a volumetric video system (FVV). Remote users, wearing VR headsets, navigate the immersive Unity-based environment, with content streamed and processed over 5G/6G networks using edge servers and WebRTC. A gesture recognition module enables presenter interaction and session control. This 6G-XR-enabled setup demonstrates the potential of next-gen networks for delivering real-time, interactive XR applications in culture, education, and training.
Vertical	Immersive Services
Testbed	i2CAT
Implementation timeframe	April 2025- October 2025
Results & Impact	**Results:** Results:Three experiments assessed network, application, and latency performance.Network-level: Using i2CAT's Qosium Probe, uplink throughput reached 300 Mbps, downlink <10 Mbps per user; packet loss occurred during uplink spikes, while delay and jitter remained acceptable. Application-level: Stable networks showed minor errors, while packet loss caused color distortions, depth inconsistencies, and frame rate drops from 30 to 15 fps. Bitrate: color ≈10 Mbps; depth varied with content.E2E latency: Measured on laptops and Meta Quest 3, delays were low, suitable for videoconferencing, with 5G slightly outperforming Wi-Fi. Overall, the system delivers low latency and good video quality under stable conditions, but network congestion or packet loss reduces frame rates and increases artifacts. **Impact:** The completion of the experiment has tested the capabilities of the cutting-edge i2CAT 6G testbed under challenging situations, obtaining outstanding results even in long sessions. To that end, it has improved and consolidated the integration of technologies that enable live XR services, specifically the Free Viewpoint (FVV Live) system, WebRTC, Unity, Kubernetes, and artificial intelligence-based modules, around 5G/6G equipment and infrastructure in a key vertical sector, also providing multi-user interactivity, and scalability. Collectively, these efforts have contributed to the development of an innovative and unique immersive solution for culture, entertainment, tourism, and other verticals.

LEARN-6G

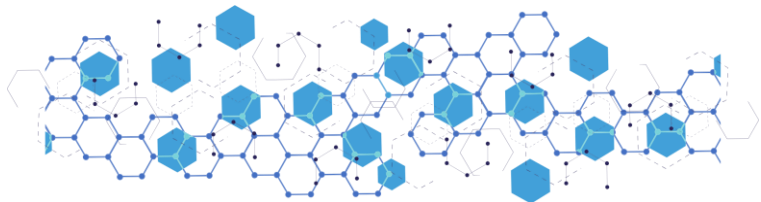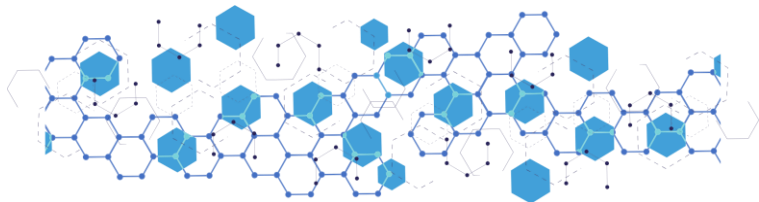|	
OC3 Project Title	LEARN-6G: Learning with Holograms over future 6G networks
Beneficiary(s)/Country	Universitat Politecnica de València / Spain
Project Description	Real-time holographic communication is revolutionizing remote interaction by enabling immersive experiences essential for future collaboration and ""teleportation"" applications. However, deploying these systems at scale poses technical challenges, particularly around performance metrics like bitrate, latency, and reliability. To address these, telecom and standards bodies (e.g., ITU-R IMT-2030, 5G-MAG, 3GPP) are defining requirements for next-gen networks that can support immersive technologies. LEARN-6G involves a cross-site education and training use case between UPV and i2CAT's South Node, using technologies like edge computing, network slicing, and federated networking to enable real-time holographic communication. UPV will provide its immersive communications lab and private 5G network, integrated with i2CAT's infrastructure and commercial off-the-shelf (COTS) hardware. The goal is to demonstrate real-world feasibility, gather insights into quality of service (QoS) and quality of experience (QoE), and validate the 6G-XR platform.
Vertical	Immersive Services
Testbed	i2CAT
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: The project successfully developed and deployed a collaborative XR/hologram application, tested iteratively on lab and real-world networks. In the final trial, the teacher app ran at UPV and the student app at i2CAT, connected via UPV's private VPN. Key KPIs included: - Maximum DL/UL throughput of client PC connected to 5G CPE: 630 Mbps DL, 40 Mbps UL on average (with fast.com) - Iperf3 throughput between client PC connected to 5G CPE and VPN to UPV's iperf3 server: 30 Mbps average (iperf3 server limitation) - Measured real-time hologram bitrate: 35 Mbps average - Measured on-demand hologram bitrate: 13.4 Mbps max peak, no steady bitrate over time - Measured received XR stream bitrate: 5 Mbps average (1280x720p60) - Measured pose update bitrate from client to host and host to client: 31 Kbps peak c-h ,17 Kbps peak h-c Despite some measured throughput limitations the application functioned smoothly, with real-time hologram and XR streams received and pose updates transmitted without stalls. Observed instabilities were likely due to plugin implementation and Unity memory management. Impact: The project provides insights into the requirements of holographic and XR applications for 5G/6G networks. It demonstrates the potential of collaborative XR for remote classrooms, offering both immersive and PC-based accessible modes. The trial confirmed that the 6G-XR platform at i2CAT can deliver the performance needed for smooth, multi-user experiences, informing future XR-enabled educational applications.

MechEye

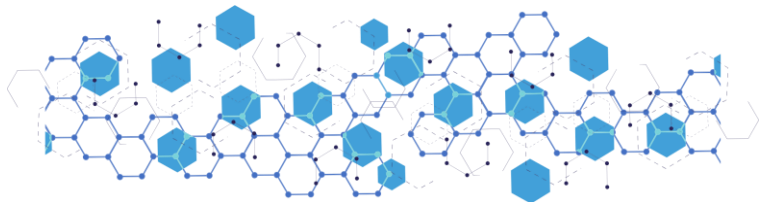|	
OC3 Project Title	MechEye: Industrial Machine Sentinel
Benefiaciary(s)/Country	INESC TEC / Portugal
Project Description	The MechEye project is a proof-of-concept system designed to enhance industrial safety and efficiency by combining video analysis, object detection, and contextual data. It aims to proactively detect manufacturing errors using AI-driven sensor processing. Given the system's high compute and bandwidth demands, the project will benchmark its performance across different edge computing scenarios, exploring trade-offs between compute placement, communication, and latency.MechEye represents a relevant future industrial workload, and its experimentation will be supported by 6G-XR infrastructure, which offers advanced edge computing, high-capacity networks, and ultra-reliable low-latency communication. The results will inform the development of next-gen cloud/edge AI solutions for industrial environments.
Vertical	Artificial Intelligence
Testbed	Oulu 5GTN
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: The MechEye project developed an AI-assisted monitoring system for industrial environments, demonstrating use in safety audits, training evaluation, and incident investigation. The system uses an Edge–Cloud pipeline with NATS publish/subscribe architecture. Model evaluation identified llava-13b for image captioning and deepseek-r1-14b for reasoning, achieving 39–59% accuracy under the Model-as-a-Judge framework. A new industrial IQA dataset (100 triplets, 5 categories) was created. 5G network slicing enabled latency control and synchronization under congestion. Real-time monitoring is limited by GPU-bound captioning (80–95% processing), requiring 2–3 GPUs for multi-camera setups, while network latency remains low (<5% E2E delay). Impact: MechEye advances 6G-XR by showcasing AI-driven industrial workflows with high compute demands, validating hybrid edge–cloud orchestration over static deployments. It demonstrates network slicing, edge ML acceleration, and multi-component integration on the 5GTN testbed, confirming 6G-XR readiness. Key bottlenecks, VLM inference latency, highlight the need for faster models or tiered processing. The project also provides a repeatable framework for orchestrating, monitoring, and benchmarking AI workloads in future 6G-XR environments.

RACE-6G

OC3 Project Title	RACE-6G: Robotic Autonomous agents with Cognitive Enhancements over 6G
Beneficiary(s)/Country	Buontech Solutions srl - Italy
Project Description	RACE-6G addresses modern manufacturing challenges—such as rapid product changes and mass customization—by using LLM-powered multi-agent AI systems to coordinate factory and warehouse robots in real time. Running on GPU-powered edge servers within a 5G network, the system enables dynamic task allocation, HD video streaming, and seamless robot integration, minimizing downtime and supporting scalable, reconfigurable production. Key features include Plug & Produce, self-learning, and centralized multi-step planning. The experiment, to be conducted at VTT 5GTN infrastructure, will demonstrate how 5G/6G connectivity, edge computing, and network slicing enable ultralow latency and high-throughput operations for AI-supervised robotics. RACE-6G contributes to 6G-XR goals by showcasing a replicable model for intelligent, adaptive manufacturing and advancing Europe's leadership in Industry 4.0 innovation.
Vertical	Artificial Intelligence
Testbed	VTT 5GTN
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: Experiments at VTT 5GTN confirmed that modern wireless infrastructure supports both autonomous and human-controlled industrial operations. Latencies of 10–15 ms enabled responsive forklift navigation and precise robotic arm manipulation. HD video streams at 15–20 Mbps sustained multiple simultaneous feeds without quality loss. Human teleoperation trials successfully executed complex tasks—forklift navigation, pallet transfers, and multi-axis assembly—demonstrating practical feasibility. Edge computing processed AI decisions in 150–200 ms, maintaining seamless handoffs between autonomous and manual modes. System stability remained robust under varying loads, coordinating multiple robots and operators. Impact: RACE-6G shows that cable-free, real-time industrial operations are achievable. Wireless networks meet the latency, bandwidth, and reliability needs for immersive teleoperation within 6G-XR. The results enable remote expert assistance, centralized control, and flexible workforce deployment, addressing labor shortages, improving safety, and ensuring operational continuity. The project lays the groundwork for advanced human-AI collaboration and resilient, sustainable industrial systems.

SafeDriveXR

OC3 Project Title	SafeDriveXR: Enhanced Driver Awareness through Cooperative XR Technologies
Beneficiary(s)/Country	AviSense.ai / Greece
Project Description	SafeDriveXR aims to enhance road safety by developing a 5/6G-enabled system that integrates Cooperative Intelligent Transport Systems (C-ITS) with Extended Reality (XR) interfaces for Connected and Automated Vehicles (CAVs). The project leverages real-time XR visualizations of traffic, road conditions, and obstacles to boost driver situational awareness, decision-making, and response times. Using heterogeneous devices, distributed signal processing, and cloud-edge coordination, SafeDriveXR ensures low-latency communication and meets human reaction time requirements. It also focuses on accurate detection of vehicles, road hazards, and Vulnerable Road Users (VRUs), while employing adaptive XR interfaces and QoE evaluation to personalize information delivery based on user context. The solution supports the EU's vision for scalable Cooperative, Connected, and Automated Mobility (CCAM)
Vertical	CCAM
Testbed	5TONIC
Implementation timeframe	April 2025- October 2025
Results & Impact	Results: SafeDriveXR delivers a fully containerized, Kubernetes-managed cooperative perception system deployed across cloud–edge nodes within the 6G-XR platform. Edge devices run initial multimodal sensor processing and local inference, sending preliminary detections over 5G to the cloud for global fusion and multi-object tracking. Synthetic LiDAR, GNSS, and IMU streams validated the end-to-end pipeline, with real-time visualization in VR. Trials at the 5TONIC 5G facility confirmed technical readiness: edge apps and cloud fusion services were orchestrated via the 6G-XR Trial Controller, achieving 17.3% AMOTA and 15.99% AMOTP, outperforming comparable frameworks. A dedicated 5G slice sustained 100 Mbps and 15 ms latency, meeting real-time CCAM perception requirements. Overall, the system proved effective for low-latency, distributed AI perception and cooperative awareness in connected mobility scenarios. Impact: Industrial/Economic: Strengthens AviSense's XR and AI perception portfolio, enabling commercialization of AR-based driver assistance tools and supporting innovation and job creation in Europe's XR and CCAM sectors. Scientific/Technological: Advances 5G/6G cooperative perception through distributed fusion, dynamic cloud–edge orchestration, and explainable XR interfaces aligned with safety-critical 6G-XR objectives. Societal/Environmental: Improves driver awareness and supports Vision Zero safety goals while enabling eco-driving and reduced emissions through smarter, cooperative traffic management.

6G4proQ

OC3 Project Title	6G4proQ: 6G-enabled and AI-based proactive quality control in manufacturing domain: experimentation in the metal cutting processes
Benefiaciary(s)/Country	Nissahub /Serbia
Project Description	The study evaluated an AI-based anomaly detection system in a complex manufacturing environment, focusing on 5G performance and cloud-processing efficiency.Key Findings5G Testing5G supports fast, reliable transfer of large shop-floor datasets, outperforming 4G.RTT stayed consistently under 15 ms with minimal jitter, ensuring stable real-time data flow. Throughput remained high with no congestion, confirming suitability for continuous, high-rate data streaming. Cloud TestingOverall service latency can be reduced by optimising the worker service.System stability improves with better debugging of the change-point detection module. Faster anomaly detection is achievable by optimising the K-means component. Overall, 5G provides the low-latency and high-throughput connectivity needed for real-time anomaly detection, while cloud-side optimisations remain the main improvement area
Vertical	Artificial Intelligence
Testbed	UOULU 5GTN
Implementation timeframe	April 2025- November 2025
Results & Impact	Results: The system enables real-time cloud-based anomaly detection using 5G for fast, reliable data transfer from the shop floor. Two evaluations were performed: 5G network performance and cloud-side processing efficiency.Key FindingsProcessing AnalysisWorker service is the most time-consuming; anomaly detection services have similar load.Combination service is most efficient; mc2pca and worker services can be optimized.Change Point Detection shows potential memory leaks; other services are stable.5G-Based Results5G provides fast, consistent data transfer with RTT < 15 ms, very low jitter, and no congestion.Clearly outperforms 4G for large, continuous industrial data streams.Cloud-Based ResultsTotal detection time can be reduced with worker service improvements.Change Point Detection needs debugging for stability.Optimizing K-means can speed up execution. Impact: The system enhances traditional manufacturing monitoring by adding QoS dimensions such as maximum alarm delays and controlled alarm rates—supporting data observability, a growing trend in advanced monitoring.The solution positions the technology provider as an early mover in proactive 5G-enabled quality control, with market potential across Western Balkans and Central/Eastern Europe.Industry 4.0 benefits include predictive maintenance and up to 50% maintenance cost reduction, making the approach attractive for many manufacturing SMEs