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# 6G-SANDBOX

Supporting Architectural and technological Network evolutions through an intelligent, secureD and twinning enaBled Open eXperimentation facility

Deliverable D6.5

Date: 31/03/2026

Version: 1.0

Grant Agreement 101096328 — 6G-SANDBOX — HORIZON-JU-SNS-2022

| | |
|---|---|
| Grant Agreement | 101096328 |
| Document number | D6.5 |
| Document title | Report on implementation of Open Calls |
| Lead Beneficiary | EURE |
| Editor(s) | Halid Hrasnica (EURE) |
| Author(s) | Anastasius Gavras (EURE), Halid Hrasnica (EURE), Apostolis Salkintzis (LNV), Dimitris Dimopoulos (LNV), Marina Koulaloglou (INF), Georgios Koumaras (INF), Konstantinos Fragkos (INF), Vaios Koumaras (INF), Ioannis Stergiou (INF), Stavros Charismiadis (FOG), Katerina Giannopoulou (FOG), Michael Dieudonne, Laura Bernasconi (KEYB), Filip Ivanovich (KEYD), Alfonso Carrillo Aspiazu, Antonio Álvarez Romero (ON), Harilaos Koumaras (NCSRD), George Makropoulos (NCSRD), Vasilis Pitsilis (NCSRD), Spyros Georgoulas (NCSRD), Ioannis Manolopoulos (NCSRD),Pedro Merino (UMA) |
| Dissemination level | PU |
| Contractual date of delivery | 31 December 2025 (in agreement with PO extended until 31 March 2026) |
| Status | Final |
| Version | 1.0 |
| File name | **6G-SANDBOX-D6.5-v1-0.pdf** |

**Document History**

| Version | |
|---|---|
| V0.1 | Initial draft (December 2025) |
| V0.2 | Complete draft (February 2026) |
| V0.3 | Final draft (March 2026) |
| V1.0 | Final version (31st of March 2026) |

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## ABSTRACT

This document presents a final report on implementation of the open calls in the scope of the 6G-SANDBOX project activities during the entire project life time.



## KEYWORDS

Open Calls, Cascaded funding

# 1 INTRODUCTION

This deliverable summarizes activities on implementation of the 6G-SANDBOX open calls during the entire project life time, where the main goal is to prepare and implement the open calls and to establish and follow-up formal agreements and reporting with the successful third parties – accepted after the open call evaluations. The open calls have been organized for innovative experiments as well as for inclusion of new infrastructures and functionalities in accordance with the schedule presented below.

| Call identifier | Launch/publication date | Submission deadline | Evaluation period | Implementation period |
|---|---|---|---|---|
| OC-1<br>• Functionalities and Infrastructures | 21 April 2023 | 3 July 2023 | July 2023 | September/October 2023 – April/May 2024 |
| OC-2<br>• Experiments<br>• Func. & Infra. | 28 November 2023 | 29 February 2024 | March 2024 | June – November 2024 |
| OC-3<br>• Experiments | 3 July 2024 | 19 September 2024 | October 2024 | January – December 2025 |

The main purposes of the competitive 6G-SANDBOX open calls are to allow experimentation on top of the 6G-SANDBOX infrastructure as well as to extend portfolio of the 6G-SANDBOX experimental facilities in terms of inclusion of new infrastructures and additional functionalities. The overall goal of WP6 and its Task 6.1 is to prepare and implement the open calls and to establish and follow-up formal agreements and reporting with the successful third parties – accepted after the open call evaluations.

The 6G-SANDBOX project established all necessary processes for implementation of competitive open calls, which included the following activities:

- Process for technical and formal definition of the open calls
- Templates for open call proposals
- Wide promotion of the open calls
- Submission tool
- Permanent support for potential proposers
- Evaluation criteria and needed evaluation forms
- Group of independent experts for evaluation of open call proposals
- Evaluation process consisting of remote evaluations and consensus meetings
- Contracting with successful 3rd parties
- Follow-up of implementations.

# 2 Implementation of Open Calls

## 2.1 Definition of open calls

The technical scope of the open calls has been defined through collaboration and with the project consortium, to identify the most relevant topics for each of the Open Calls. The outcomes of these discussions have been used to define each of the open calls in detail.

Furthermore, formal requirements and eligibility criteria have been defined for the open calls along the following principles:

- Proposals will only be accepted from parties eligible for participation in EC Horizon Europe / SNS JU projects.
- Proposers' organizations can submit multiple proposals, but only one proposal per single organization might be selected for funding.
- The proposal must be submitted in English language through the 6G-SANDBOX submission tool by using specific proposal template.

For each of the calls, a full definition of the open call has been created and published within the corresponding public open call information (e.g. project website). Short versions of the open calls' definitions are also provided for various communication purposes. The open call definitions for each of the implemented 6G-SANDBOX open calls are summarized in Sec. 5.2 - 5.4.

To support the potential proposers and make the proposal phase as efficient as possible, for both proposers and evaluators, proposal templates have been created for each type of proposal and published on the open call web page within the project website (templates are provided in Annex 3 and are available on the project website at https://6g-sandbox.eu/opencall/).

## 2.2 Submission phase

In order to receive proposals for the open calls, Eurescom established and maintained a submission tool (Figure 2-1), enabling updates of the submitted proposals until a set deadline, collecting all necessary information from the proposers (proposal title and short names, contact persons, organizations, countries, etc.), and allowing a proper documentation on all relevant proposal and submission processes.

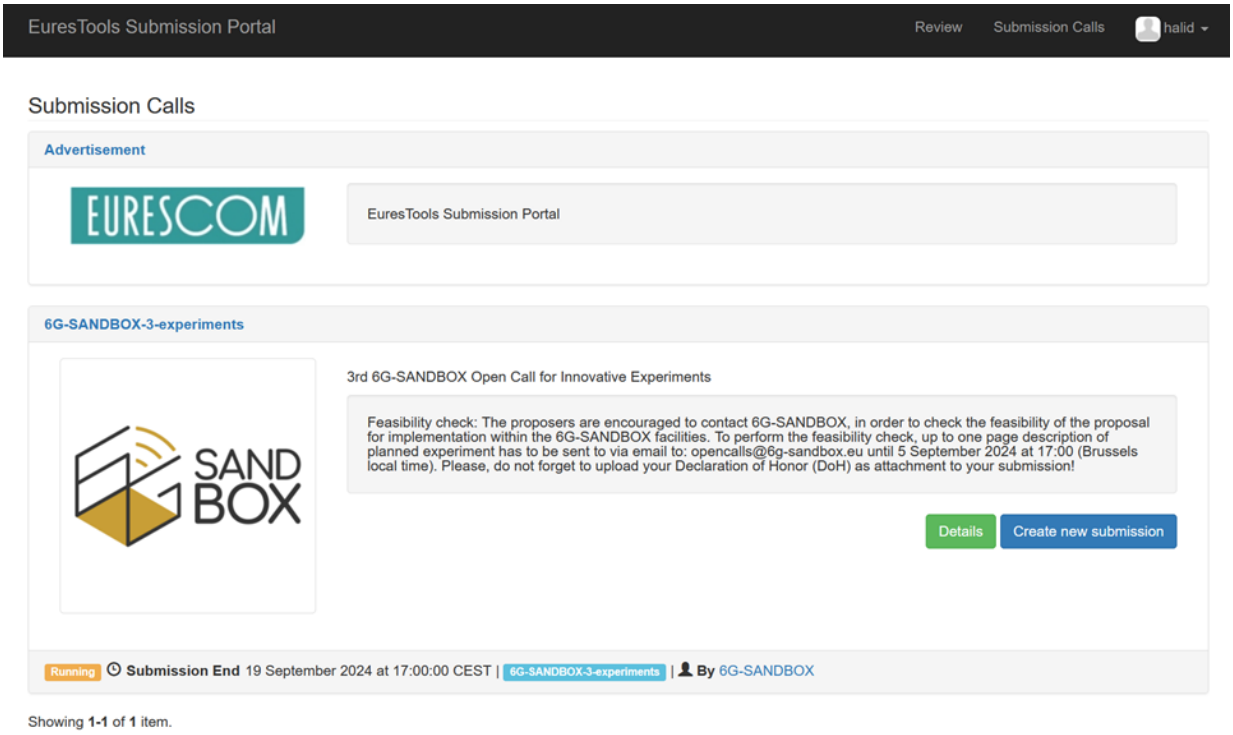


**Figure 2-1: 6G-SANDBOX Submission and evaluation portal**

Another important activity during the submission phase, starting immediately after an open call has been published, is a wide promotion of the open calls through various channels. For this purpose, the short definitions of the calls are used to create corresponding promotional messages (e-mail information, web and twitter posts, presentation slides), which are then disseminated in the scope of 6G-SANDBOX WP6, Task 6.2, activities (Dissemination). The complete information and all related documents about the open calls is consolidated on the project website as well (Example for OC-2 in Figure 2-2).

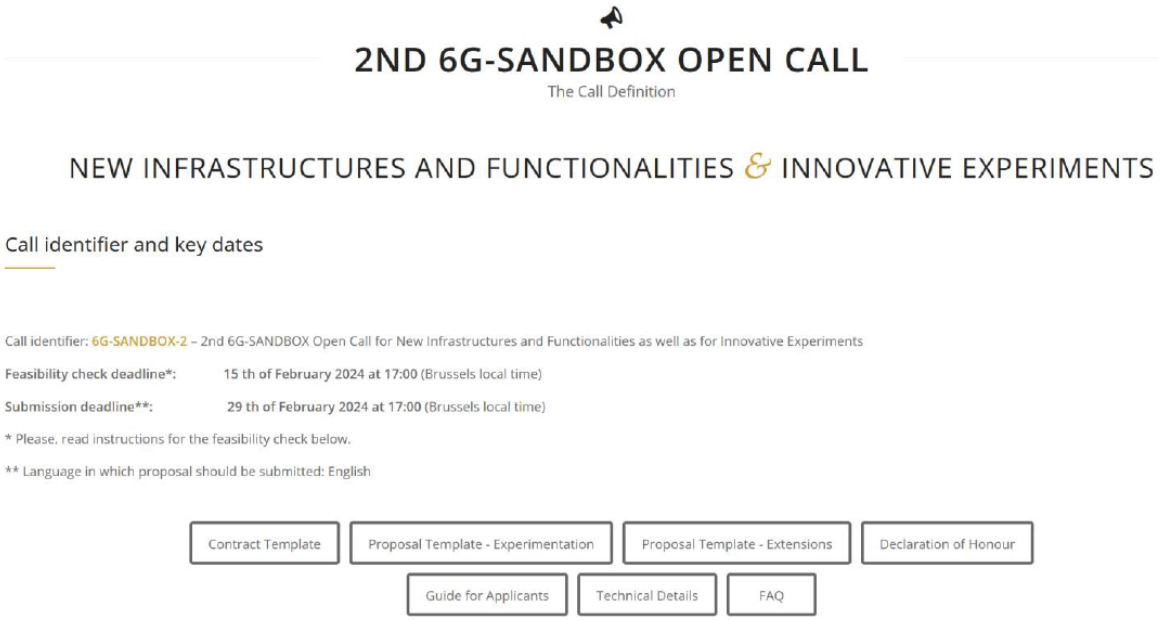


**Figure 2-2: Full Open Call information on the 6G-SANDBOX website**

During the submission phase, it is necessary to ensure permanent support to the proposers and answer questions on the open call objectifies, formal requirements, submission issues etc. Furthermore, as the proposers should perform so-called feasibility check before submitting the proposal to find out if approach to be proposed fits to the overall open call objectives and which infrastructures can support the proposed experiments.

In the open call definition, the 6G-SANDBOX offered an initial feasibility check for the proposals performed by the technical open call team, elaborating basic possibility to technically implement the proposals within the 6G-SANDBOX framework, prior formal submission of the proposal. As the feasibility check is not mandatory, the proposal submitted without the feasibility check were analysed accordingly after the submission deadline and before start of evaluations.

The support to the applicants was ensured by interaction through the 6G-SANDBOX contact e-mail address dedicated to the open calls management (opencalls@6g-sandbox.eu) where all relevant project representatives are included as recipients) and by providing and updating FAQ entries on the project website. The FAQ section is related directly to questions on the project open calls, whereas a dedicated space on the project website (https://6g-sandbox.eu/pilot-6g-sites/) provides detailed information on the 6G-SANDBOX infrastructures, tools, instructions for usage, and further useful information helping to understand the technical 6G-SANDBOX framework and summarizing this information for the proposers and further interested parties.

## 2.3 Open Call Committees

**6G-SANDBOX open call management team**

The open call management team consist of representatives of following organizations from the 6G-SANDBOX consortium:

- Eurescom – responsible for implementation of the open calls as leader of the designated Task 6.1
- Keysight – the project coordinator
- University of Malaga – appointing 6G-SANDBOX project technical manager as well as responsible for the project budget reserved for the third parties and legal management

**Technical open call team**

The technical team consist of representatives of all 6G-SANDBOX experimental Facilities; Athens, Berlin, Oulu, and Malaga.

**Independent experts**

Initial list of independent experts has been established from databases of recognized experts, who participated in similar activities from the past, namely 5GINFIRE and Fed4FIRE projects successfully implementing several open calls for experimentation and provision of new experimental facilities and functionalities in the networking area. The initial list of experts was

extended to around 50 names by receiving proposals received from the project consortium members.

All potential experts have been approached, to estimate their availability and to receive recent update on the experts' expertise (updated CVs) for each of the open calls. The available experts have been also asked to indicate their expertise in respect to the specific open call objectives.

In order to prevent Conflict of Interest (CoI) among the experts and the proposers' organizations, a first check was performed by the 6G-SANDBOX open call management team. To further reduce the CoI probability, it was ensured that the proposals were evaluated by experts who are not from the proposers' counters of origin.

The next CoI check was performed together with the experts while the proposals were allocated and distributed for evaluations, when the experts had opportunity to express conflicts if applicable. Finally, while completing the evaluation forms in the online submission and evaluation portal, the experts had to confirm that no CoI exists in relation to the evaluated proposal.

## 2.4 Evaluation Process

After an open call deadline, the proposals are evaluated remotely by two independent experts, by using pre-defined criteria presented in Table 2-1. Definitions of the open calls also include clear criteria for evaluation and ranking of the proposals in accordance with the specific objectives of the calls.

**Table 2-1: Structure of 6G-SANDBOX evaluation forms, maximum scoring, thresholds, and weight of evaluation categories in the total score.**

| Infrastructures & Extensions | Experiments | maximum threshold weight |
|---|---|---|
| **Excellence / Innovation and technology: innovativeness and technological value of the proposal**<br>How the proposal matches the call objective? If the objectives are not properly addressed – the proposal should be rated below threshold.<br>Novelty and innovation potential of intended experimental infrastructure or functionality when included in 6G-SANDBOX - potential for future experimenters. | **Excellence / Innovation and technology: innovativeness and technological value of the proposal**<br>How the proposal matches the call objective? If the objectives are not properly addressed – the proposal should be rated below threshold.<br>Novelty and innovation potential of intended experimentation and expected results. | 5<br>3<br>2 |
| **Impact: value for extension and readiness of the 6G-SANDBOX facilities for experimentation** | **Impact: exploitation potential of the proposed experiment**<br>Potential for exploiting the experimentation in general from the | |

| | | |
|---|---|---|
| Potential for exploiting the functionality/infrastructure integration in general from the proposer's point of view; both industrial and academic impacts are relevant<br>Added value for 6G-SANDBOX - How will 6G-SANDBOX project/infrastructure will gain from the proposed extensions (functionalities / infrastructures)<br>Must be strong enough to pass the threshold!<br>Functionalities to be included in 6G-SANDBOX portfolio | proposer's point of view; both industrial and academic impacts are relevant<br>- Value of the gained experimentation results for proposer<br>- Value for 6G-SANDBOX - How will 6G-SANDBOX infrastructure be used by experimentation and what is the added value?<br>- Will the experimentation be running on 6G-SANDBOX for future use by other participants? | 5<br>3<br>2 |
| **Implementation: quality of methodology and of proposed participants**<br>Operation and maintenance approach<br>Feasibility – if there are any doubts on feasibility to implement the functionalities/infrastructure in 6G-SANDBOX, please, contact the project representatives and while doing this, please, do not mention proposal title and other information disclosing the proposers.<br>Budget, Background of applicant | **Implementation: quality of methodology and of proposed participants**<br>Implementation methodology and approach<br>Feasibility – if there are any doubts on feasibility to implement the functionalities/infrastructure in 6G-SANDBOX, please, contact the project representatives and while doing this, please, do not mention proposal title and other information disclosing the proposers.<br>Budget, Background of applicant | 5<br>3<br>1 |
| **General Comments:**<br>**Ethical issues:** | **Maximum:**<br>**Threshold:** | 25<br>16 |

Each evaluation criterion is scored on a scale from 0 to 5, as follows:

- 0 – The proposal fails to address the criterion under examination or cannot be judged due to missing or incomplete information
- 1 – Poor. The criterion is addressed in an inadequate manner, or there are serious inherent weaknesses
- 2 – Fair. While the proposal broadly addresses the criterion, there are significant weaknesses
- 3 – Good. The proposal addresses the criterion well, although improvements would be necessary
- 4 – Very good. The proposal addresses the criterion very well, although certain improvements are still possible
- 5 – Excellent. The proposal successfully addresses all relevant aspects of the criterion in question.

When scores are equal, any further prioritization is based on other appropriate characteristics and/or specific call requirements, which will be decided by the panel of evaluators.

If the scores for proposals set by experts during the remote evaluations are significantly distinguishing among individual evaluations, consensus meetings (video calls) are organized for the affected proposals among the involved experts, to build up a common opinion and adapt the scores accordingly. As significant discrepancy among the experts' rating is recognized if:

- Both reviewers differ in one evaluation criterion for at least 1.5 points (maximum score per criteria: 5)
- Total scores differ for at least five points (maximum total score: 25)
- Different opinions (above/below threshold) per criteria or for overall score

If in some cases the consensus is not possible to achieve, additional independent expert is involved to make final decisions.

At the end of the evaluation process, the proposals are ranked in accordance with total scores received and specific call objectives (if any), so that selection of successful proposals is done according to this list and available funding for the open calls. The final ranking is approved by the 6G-SANDBOX project General Assembly after consultations with the Project Officer.

Immediately after end of the evaluations, information about the open call outcome, including corresponding evaluation forms with scores and comments from the experts, is sent to the proposers.

## 2.5 IMPLEMENTATION

In order to formalize participation of the third parties in the project – the third parties which are selected after the open calls – corresponding 3rd party contracts (template available on the open call web page) are concluded among them and UMA, responsible for the 3rd parties' budget in 6G-SANDBOX.

As soon as possible, after open call outcomes are known, a so-called kick-off meeting is organized to ensure direct discussions and interactions among the 3rd parties and representatives of corresponding 6G-SANDBOX facilities, where implementations and experiments are hosted.

To follow up work done by the third parties, a number of deliverables and milestones are defined, along the proposed implementation plans, including final report on work done and usage of resources.

The performance of the third parties in accordance with the concluded contracts is regularly followed-up by the 6G-SANDBOX open call management team and the Technical open call team.

# 3 1ST 6G-SANDBOX OPEN CALL (OC-1)

## 3.1 OC-1 DEFINITION

The first open call (Call identifier: 6G-SANDBOX-1) was dedicated to New Infrastructures and Functionalities. Feasibility check deadline was on 23 June 2023 at 17:00 (always CET / Brussels local time) and the submission deadline on 3 July 2023 at 17:00.

**Call objectives**

The purpose of the open call was to enlarge and make the 6G-SANDBOX experimental infrastructure ready for advanced experimentation in upcoming project open calls for experimentation along the following requirements:

- AI Extensions of the 6G-SANDBOX NEF emulator
- Integrating LoRaWAN in the 6G-SANDBOX connectivity infrastructure
- Adding NWDAF Capabilities 6G-SANDBOX Testbeds
- Adding NEF Capabilities to the 6G-SANDBOX Testbeds
- Inclusion of Release 16 Devices
- Location information capability
- Integrated Sensing & Communication (ISAC or JCAS) to save energy
- Expanding the 6G-SANDBOX testbed capabilities with additional ORAN solutions
- Advanced Channel modelling capabilities for 6G to augment the 6G-SANDBOX testbed
- Multilink backhaul management
- Augmenting 6G-SANDBOX with Terahertz communication capabilities
- RAN extensions towards 6G RAN with new xApps
- Expand the 6G-SANDBOX with validated Digital twin performance for realistic deployments
- Technology for use cases in Internet of Sense
- Expanding the 6G-Sandbox testbed With Content Distribution Networks for Quality of Experience
- Expanding 6G capabilities and/or experimenting with the 6G capabilities

  … as well as further topics of community interest.

**Funding**

- Maximum amount of financial support for each third party: 60,000€ (if justified, the proposer can request higher amounts)
- Consortium can request up to 180,000€ when composed of 3 or more participants.
- The project contribution to the third parties will be 90% (for-profit organization) or 100% (not-for-profit organization) of the declared costs, in accordance with the corresponding rules for participation in the SNS JU programme
- Total of 540,000€ is available for this Open Call

- The proposals (ranked above threshold) will be selected for funding to cover as many identified call topics (see above) as possible. Further priority will be given to close to equal utilization of the 6G-SANDBOX facilities (see below).
- Expected duration of the implementation is Six months. The technology needs to be supported for the rest of the project duration.

**Eligibility**

- As regards eligibility rules for participation and funding in the Open Calls, the General Annexes to Horizon Europe for the Work Programme 2023-2024 apply.
- Implementing the Decision (EU) 2022/2506 on measures for the protection of the Union budget against breaches of the principles of the rule of law in Hungary, that took effect on 16 December 2022, some of the Hungarian entities are not eligible for funding (link for more information provided on the website).
- Please, note that organizations from United Kingdom and Switzerland are not eligible for the EC funding in this open call. UK and Swiss organizations can apply for the open call, as a single organization or as part of a consortium, but the funding if requested must be provided by UK or Swiss authorities.
- Proposers' organizations can submit multiple proposals; however, total available funding for the organization in this call is 60,000€, expect in case of duly justification of a larger funding amount in which case only one proposal per organization might be selected for funding.
- Beneficiaries of the 6G-SANDBOX project are not eligible to participate in this open call.

## 3.2 OC-1 EVALUATIONS

The table below present anonymously proposals submitted to the 6G-SANDBOX OC-1 (information on proposals titles and involved organizations as well as list of involved external experts and their allocations to proposals are provided directly to Project Officer).

**Table 3-1: OC-1 Overview**

| Submission nr. | Comment | Score after individual evaluations | Score after consensus meeting (if applicable) | Involved experts | |
|---|---|---|---|---|---|
| 1 | * | | | | |
| 2 | Not eligible | | | | |
| 3 | | 17.00 | 20.00 | 2 | 5 |
| 4 | | 16.75 | 17.25 | 1 | 3 |
| 5 | * | 13.50 | 15.00 | 5 | 6 |
| 6 | **Selected** | **22.25** | | 2 | 8 |
| 7 | | 13.25 | | 1 | 9 |
| 8 | **Selected** | **20.25** | **23.50** | 2 | 4 |
| 9 | **Selected** | **23.75** | | 6 | 8 |
| 10 | | 21.25 | | 7 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | | 17.25 | 17.25 | 7 | 8 |
| 12 | | 15.50 | 17.50 | 4 | 6 |
| 13 | | 20.25 | 20.00 | 1 | 9 |
| 14 | | 12.75 | 13.00 | 2 | 3 |
| 15 | | 17.50 | 19.25 | 2 | 8 |
| 16 | Not eligible | | | | |
| 17 | | 19.75 | 19.50 | 3 | 4 |
| 18 | **Selected** | **22.50** | **24.50** | 3 | 4 |
| 19 | **Selected** | **24.00** | | 5 | 7 |
| 20 | | 12.25 | | 3 | 4 |
| 21 | | 18.50 | 18.50 | 1 | 5 |
| 22 | | 19.25 | 18.50 | 5 | 6 |
| 23 | | 21.25 | | 7 | 9 |
| 24 | | 20.75 | 20.75 | 4 | 7 |
| 25 | **Selected** | **21.50** | | 1 | 2 |
| 26 | | 18.25 | 17.75 | 1 | 9 |
| 27 | | 20.75 | | 3 | 4 |
| 28 | | 15.00 | 13.00 | 3 | 4 |
| 29 | | 12.50 | | 5 | 8 |
| 30 | | 17.25 | 17.25 | 5 | 7 |
| 31 | | 20.75 | 20.75 | 6 | 7 |
| 32 | | 14.50 | 15.00 | 3 | 4 |
| 33 | | 14.00 | | 6 | 9 |
| 34 | **Selected** | **24.25** | | 8 | 9 |
| 35 | | 9.75 | | 6 | 9 |
| 36 | | 19.50 | | 1 | 2 |

**Eligibility**

All received proposals were check for their eligibility to participate in the open call (country of origin, compliance with the open call rules, etc.). No automatic eligibility check was performed.

It was found out that the proposals nr. 2 and 16, submitted from a same organization, were not eligible because the mandatory proposal template was not followed and the submitted documents did not include enough relevant information for evaluations.

Also, the proposals nr. 1* and 5* are the same, submitted from a same organization, thus the proposal version submitted as the last one was evaluated, as also communicated to the proposer.

**Feasibility**

As the feasibility check is not mandatory, the proposal submitted without the feasibility check were analysed accordingly before evaluations. None of the submitted proposal was rejected because of the feasibility check performed after the submission.

**Remote and consensus evaluations**

Remote evaluations by nine independent experts (information about involved experts is provided directly to Project Officer) have been performed between 7 – 17 July 2023 through the online submission and evaluation portal. At this stage, the experts provided their opinion on the allocated proposals without interaction with another expert assigned to the same proposal.

The consensus (online) meetings have been organized between 20-25 July 2023 with participation of the involved experts and members of the 6G-SANDBOX open call management team for proposals where individual evaluations differ from each other significantly (Sec. 2.4).

During the consensus meetings, the involved experts discussed their opinions on the proposals and in all cases agreed on final scores (Table 3-1).

**Ranking**

Based on the complete evaluation results, the project open call management team established a ranking among the proposal, strictly based on the final ranking concluded by the independent experts. Accordingly, and based on the available funding budget for the open call, seven proposals have been selected for the implementation in the 6G-SANDBOX project.

The decision on the final ranking was confirmed at the 6G-SANDBOX General Assembly audio conference, held on 27 July 2023. The entire ranking process was communicated in parallel to EC.

## 3.3 OC-1 STATISTICS

36 proposals have been received and 33 of them were eligible for evaluations (Figure 3-1 and Figure 3-2).

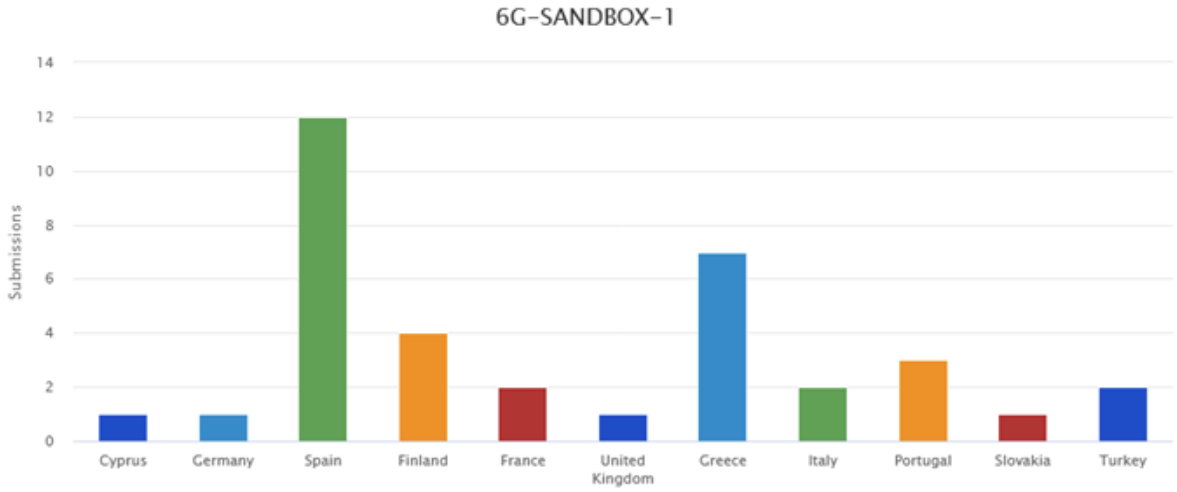


**Figure 3-1: Statistics on submitted proposals per country of origin**

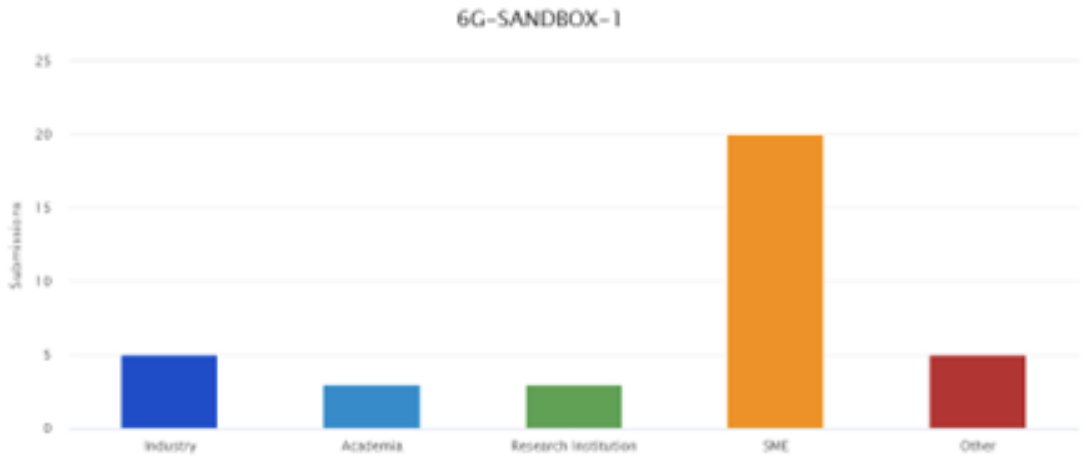


**Figure 3-2: OC-1 Statistics on submitted proposals per type of organization**

7 proposals have been accepted, amounting to success rate of 21%, as follows:

- Cyprus, France, Greece, Italy, Portugal, Spain (two accepted)
- Academia, Industry, Research institution, SME (four accepted)

## 3.4 OC-1 IMPLEMENTATION

The process of contracting the selected proposers was carried out during August and early September 2023, so that all selected implementations started latest in October 2023. Accordingly, the third parties involved in the implementations received pre-payments after concluding the contracts. An overview on the accepted proposals and status of their implementation is presented in the Table 3-2 below.

**Table 3-2: Accepted proposals in OC1**

| Title | Short Title | Organization | 6G-SANDBOX contribution | Status |
|---|---|---|---|---|
| O-RAN research prototype for the 6G-SANDBOX platform | ASTRAL | Eight Bells Ltd. | 60,000€ | Finished |
| ReleAse-16 Device IntegrAtioN and Trialing in open experimentation facilities | RADIANT | 5G communications for future industry verticals SL | 54,000€ | Finished |
| AI-driveN multi-link bAckhauL management through network data analYticS and locAlizaTion | ANALYSAT | Nextworks, CNIT, RomARS | 179,462€ | Finished |
| Integration of the University of Granada's LoRaWAN network in the 6G SANDBOX connectivity infrastructure | 6G-LoRaGRAN | University of Granada | 60,000€ | Finished |

| | | | | |
|---|---|---|---|---|
| ONEmNEF: OneSource's Microservice-based Network Exposure Function | ONEmNEF | OneSource | 59,906€ | Finished |
| RAY-tracing based Physical Layer Inside 6G digital AccuraTE twin | RAYPLICATE | SIRADEL | 60,000€ | Finished |
| AI-powered Digital Security Processes over Cloud-native 5G and Beyond Networks | ARROW | CERTH / INFORMATION TECHNOLOGIES INSTITUTE | 60,000€ | Finished |
| | | Total: | 533,369€ | |

# 4 2ND 6G-SANDBOX OPEN CALL (OC-2)

## 4.1 OC-2 DEFINITION

The second open call (Call identifier: 6G-SANDBOX-2) was dedicated to New Infrastructures and Functionalities as well as for Innovative Experiments. Feasibility check deadline was on 15 February 2024 at 17:00 (always CET / Brussels local time) and the submission deadline on 29 February 2024 at 17:00.

**Call objectives**

The purpose of the open call is twofold:

**OPTION 1** – New infrastructures and functionalities (extensions): Enlarge and make the 6G-SANDBOX experimental infrastructure ready for advanced experimentation in upcoming project open calls for experimentation. New 6G features and functionalities should be integrated into the 6G-SANDBOX infrastructure. Below, the specific requirements for the option 1 are listed:

- Integrated Sensing & Communication (ISAC or JCAS) to save energy
- Technology for use cases in Internet of Sense
- RIS infrastructure to expand the 6G-SANDBOX capabilities in FR1 and or FR2
- Expanding the 6G-Sandbox testbed With Content Distribution Networks for Quality of Experience
- Portable data center / smart furniture for 6G AI/ML workloads
- Self-learning, evolving Digital Twin. Based on real time data
- Testbed network operation center //Experimentation / "experimental load balancer" front end for optimal experimentation (PORTAL)
- Stand-alone mmWave early modules & infrastructure
- Dynamic slice allocation, entitlement server
- 5GPPP final results integration in 6G-SANDBOX

- 5G Multicast-Broadcast Services (MBS)
- Use explainable AI (XAI) to improve O-RAN functionality in 6G networks
- provision system for eSIM
- AI techniques for autonomous network management / Zero touch
- Support of Ambient IoT devices
- Expanding 6G capabilities

  … as well as further topics of community interest.

**OPTION 2** – Innovative experiments: Initiate first funded innovative experiments on the 6G-SANDBOX infrastructure. Innovative 6G use cases and KPI measurements are expected to use the 6G-SANDBOX infrastructure.
In alignment with the overall project objectives 6G-SANDBOX is organizing a competitive open call targeting external organizations, including industry, SMEs, research institutions, and academia, interested in performing experiments on the top of the infrastructure provided by the 6G-SANDBOX. This open call invites experimenters to use the 6G-SANDBOX experimental facilities, by taking advantage of the provided testbed features, in order to deploy and test broad scope of applications, e.g., coming from various vertical sectors, tailored for the future 6G communications networks (e.g., use cases described in ITU FG-NET2030). The main scope is to provide values/scores for application and network KPIs and also quantify the added value for their target vertical sector.

**Funding**

Maximum amount of financial support for each third party:

- OPTION 1: New infrastructures and functionalities: 60,000€ (if justified, the proposer can request higher amounts). Consortium can request up to 180,000€ when composed of 3 or more participants.
- OPTION 2: Innovative experiments: 20,000€ + maximum of 10,000€ reserved budget for equipment or software purchase. A consortium of two organizations can request up to 40,000€ + 10,000€ for equipment, if it is composed of a technology provider and a vertical/customer

A total of 540,000€ is available for this Open Call:

- 270,000€ for OPTION 1 – Extensions (new infrastructures and functionalities)
- 270,000€ for OPTION 2 – Experiments

**Eligibility**

- As regards eligibility rules for participation and funding in the Open Calls, the General Annexes to Horizon Europe for the Work Programme 2023-2024 apply. UK entities are allowed to participate subject to the UK/EU agreement being effective in January 2024.

- Implementing the Decision (EU) 2022/2506 on measures for the protection of the Union budget against breaches of the principles of the rule of law in Hungary, that took effect on 16 December 2022, some of the Hungarian entities are not eligible for funding (link for more information provided on the website).
- Organizations from Switzerland are not eligible for the EC funding in this open call. Swiss organizations can apply for the open call, as a single organization or as part of a consortium, but the funding if requested must be provided by Swiss authorities).
- Proposers' organizations can submit multiple proposals; however, total available funding for the organization in this call is limited to the maximum amounts defined in the funding section.
- Beneficiaries of the 6G-SANDBOX project and organizations funded from 6G-SANDBOX OC1 are not eligible to participate in this open call.

## 4.2 OC-2 EVALUATIONS

The Table 4-1 below present anonymously proposals submitted to the 6G-SANDBOX OC-2, Option 1 New Infrastructures and Functionalities (information on proposals titles and involved organizations as well as list of involved external experts and their allocations to proposals are provided directly to Project Officer).

**Table 4-1: OC-2 Overview – Option 1 – New Infrastructures and Functionalities**

| Submission nr. | Comment | Score after individual evaluations | Score after consensus meeting (if applicable) | Involved experts | |
|---|---|---|---|---|---|
| 1 | Not eligible | | | | |
| 2 | | 21.50 | | 11 | 12 |
| 3 | | 20.50 | | 14 | 15 |
| 4 | | 15.00 | 15.50 | 11 | 15 |
| 5 | | 15.25 | 15.50 | 12 | 15 |
| 6 | **Selected** | **22.25** | | 11 | 12 |
| 7 | | 18.50 | 18.00 | 12 | 15 |
| 8 | | 21.75 | 20.00 | 13 | 15 |
| 9 | | 20.00 | | 11 | 12 |
| 10 | **Selected*** | **17.75** | | 11 | 12 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | | 20.25 | 20.75 | 12 | 13 |
| 12 | | 17.75 | 17.50 | 11 | 13 |
| 13 | | 21.00 | 21.00 | 13 | 14 |
| 14 | | 19.75 | 20.75 | 14 | 15 |
| 15 | | 19.50 | | 11 | 13 |
| 16 | | 15.00 | 15.50 | 11 | 14 |
| 17 | | 20.25 | | 13 | 14 |
| 18 | | 15.50 | 19.25 | 13 | 14 |
| 19 | **Selected** | 22.50 | | 13 | 14 |
| 20 | | 14.25 | 14.50 | 14 | 15 |
| 21 | | 21.00 | 21.50 | 12 | 15 |

All received proposals were checked for their eligibility to participate in the open call (country of origin, compliance with the open call rules, etc.). No automatic eligibility check was performed.

Proposal nr. 1 was not eligible because instead of using the mandatory proposal template, just a marketing information has been uploaded.

Even the proposal nr. 10 was not ranked among the best proposals, since it passed the evaluation threshold and is not requiring funding from 6G-SANDBOX, it was accepted.

The Table 4-2 below present anonymously proposals submitted to the 6G-SANDBOX OC-2, Option 2 Innovative Experiments.

**Table 4-2: OC-2 Overview – Option 2 – Innovative Experiments**

| **Submission nr.** | **Comment** | **Score after individual evaluations** | **Score after consensus meeting (if applicable)** | **Involved experts** | |
|---|---|---|---|---|---|
| E-1 | * | 20.25 | 18.00 | 21 | 22 |
| E-2 | Not selected | 23.00 | 23.00 | 21 | 22 |
| E-3 | **Selected** | **20.75** | | 22 | 23 |
| E-4 | **Selected** | **22.50** | | 21 | 23 |

| | | | | | |
|---|---|---|---|---|---|
| E-5 | **Selected** | **21.75** | **20.75** | 21 | 22 |
| E-6 | **Selected** | **24.25** | | 22 | 23 |
| E-7 | | 19.00 | 17.50 | 21 | 22 |
| E-8 | **Selected** | **21.00** | | 21 | 23 |
| E-9 | **Selected** | **24.00** | | 22 | 23 |
| E-10 | **Selected** | **23.75** | | 21 | 23 |
| E-11 | **Selected** | **18.50** | **17.75** | 22 | 23 |
| E-12 | **Selected** | **23.50** | | 21 | 23 |

All received proposals were checked for their eligibility to participate in the open call (country of origin, compliance with the open call rules, etc.). No automatic eligibility check was performed.

Proposal nr. E-1* was not selected because it was rated in one of the evaluation categories below the threshold.

Even the proposal nr. E-2 was ranked high enough to be funded, it was not selected for the funding because the same proposing organization was selected under the option 1 within the OC-2.

**Feasibility**

As the feasibility check is not mandatory, the proposal submitted without the feasibility check were analysed accordingly before evaluations. None of the submitted proposal was rejected because of the feasibility check performed after the submission.

**Remote and consensus evaluations**

Remote evaluations by nine independent experts (information about involved experts is provided directly to Project Officer) have been performed between 5 – 11 March 2024 through the online submission and evaluation portal. At this stage, the experts provided their opinion on the allocated proposals without interaction with another expert assigned to the same proposal.

The consensus (online) meetings have been organized between 13 – 15 March 2024 with participation of the involved experts and members of the 6G-SANDBOX open call management team for proposals where individual evaluations differ from each other significantly (Sec. 2.4).

During the consensus meetings, the involved experts discussed their opinions on the proposals and in all cases agreed on final scores (Table 4-1 and Table 4-2).

**Ranking**

Based on the complete evaluation results, the project open call management team established a ranking among the proposal, strictly based on the final ranking concluded by the independent experts. Accordingly, and based on the available funding budget for the open call, three proposals have been selected for the implementation in the 6G-SANDBOX project under option 1 and 9 proposals under option 2.

The decision on the final ranking was confirmed at the 6G-SANDBOX General Assembly audio conference, held on 26 March 2024. The entire ranking process was communicated in parallel to EC.

## 4.3 OC-2 STATISTICS

21 proposals have been received for option 1 (New Infrastructures and Functionalities) and 20 of them were eligible for evaluations (Figure 4-1 and Figure 4-2).

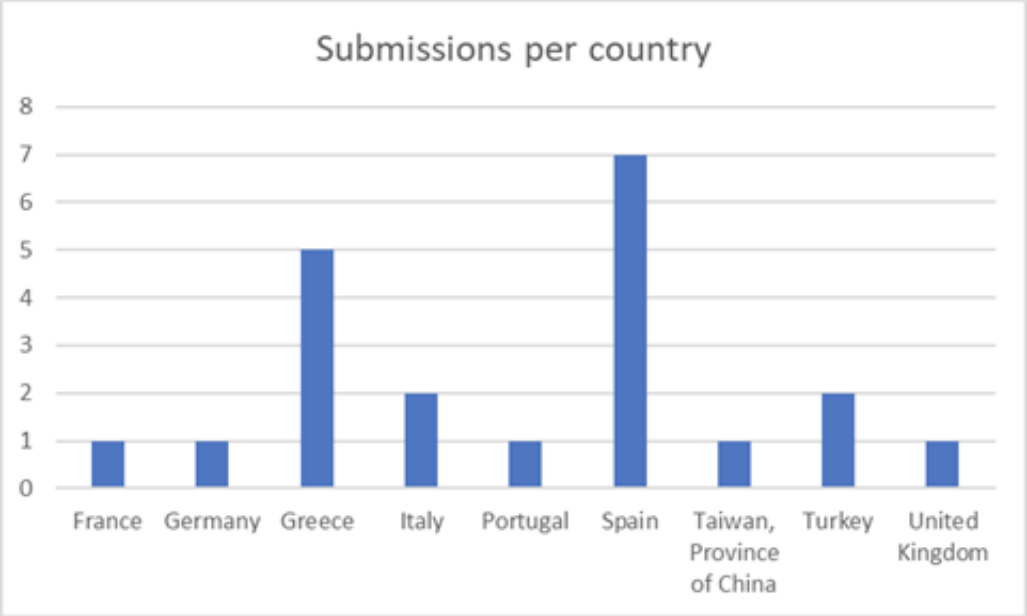


**Figure 4-1: OC-2 Statistics on submitted proposals per country of origin – option 1**

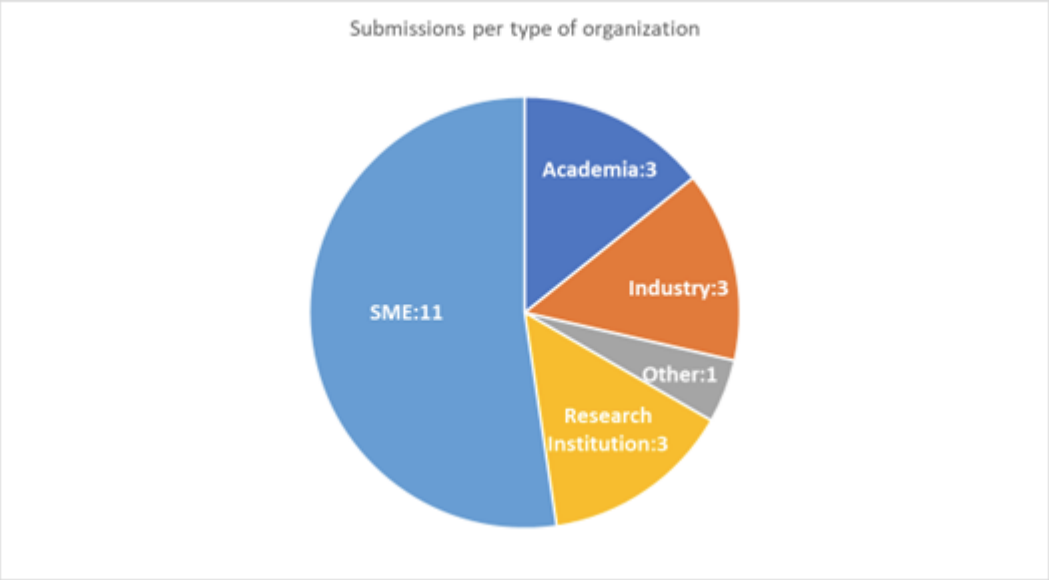


**Figure 4-2: OC-2 Statistics on submitted proposals per type of organization – option 1**

Three proposals were accepted under option 1 (success rate 15%):

- Greece (2), Taiwan (1)
- SME (2), Research institution (1)

12 proposals have been received for option 2 (Innovative Experiments), where proposals have been accepted (success rate 75%, Figure 4-3).

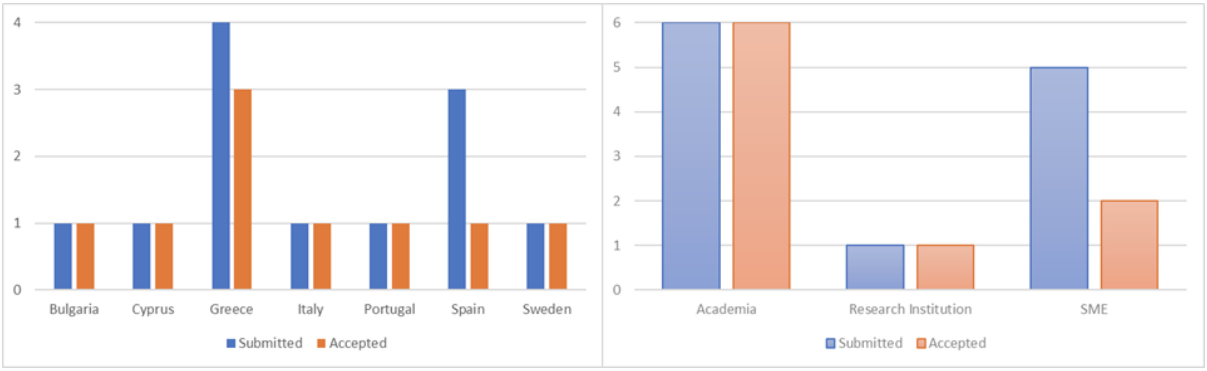


**Figure 4-3: OC-2 Statistics – option 2**

## 4.4 OC-2 Implementation

The process of contracting the selected proposers was carried out during April – May 2024, so that all selected implementations started in June 2024. Accordingly, the third parties involved in the implementations received pre-payments after concluding the contracts. An overview on the accepted proposals and status of their implementation is presented in Table 4-3 and Table 4-4 below.

**Table 4-3: OC-2 accepted proposals – new infrastructures and functionalities (Option 1)**

| Title | Short Title | Organization | 6G-SANDBOX contribution | Status |
|---|---|---|---|---|
| RAN IntElligent Automation and Control via xApps Towards 6G. | REACT-6G | Four Dot Infinity, Accelleran NV, Software Radio Systems | 180,000€ | Finished |
| Integration of Lamda Networks' StreamAnalyzer to 6G-SANDBOX for offering NWDAF capabilities | NDWAF_ Stream Analyzer | Lamda Networks | 59,850€ | Finished |
| FR2-RIS connectivity reinFORCEment for Malaga platform | RISFORCE | ITRI | 0€ | Finished |
| | | Total: | 239,850€ | |

**Table 4-4: OC-2 accepted proposals – innovative experiments (Option 2)**

| Title | Short Title | Organization | 6G-SANDBOX contribution | Status |
|---|---|---|---|---|
| Replicable Cellular Networking Experiments using ns-3 | REPLICA | INESC TEC | 20,000€ | Finished |
| 6G-MOBKPI: KPI measurement in 6G networks under mobility scenarios | 6G-MOBKPI | Universidad de Vigo | 25,000€ | Finished |
| Experimentation: Smart Contract-based Digital Twins for the IoT | Experimentation: SCDT | Athens University of Economics and Business - Research Center | 20,000€ | Finished |
| MeAsuring 5G anD sAteLlite nEtwork iNtegrAtion | MAGDALENA | Karlstad University | 20,000€ | Finished |
| Experimentation: Remote mEdical Support and Communication Utility in Emergency scenarios | RESCUE | Scuola Superiore Sant'Anna | 30,000€ | Finished |
| Customer dispute resolutions for metaverse/augmented reality goods and services. | Prosperancy | Alis Grave Nil | 21,600€ | Finished |
| PowerStorm – Energy-Aware Streaming Analytics Job Scheduling for 5G/6G Deployments | PowerStrom | University of Cyprus | 29,700€ | Finished |

| | | | | |
|---|---|---|---|---|
| Remote Earthquake Area Management through real-time immersive MR streaming to monitor and guide first responder's field operations | MR@REAM | MSc 'Global Health - Disaster Medicine', Medical School NKUA, Pi P.C. | 47,500€ | Finished |
| Experimentation: 6G-EARN (6G-Energy leARNing) | 6G-EARN | ENERGY COMMUNITY BESSARION LIMITED LIABILITY COOPERATIVE | 30,000€ | Finished |
| | | Total: | 483,650€ | |

# 5 3RD 6G-SANDBOX OPEN CALL (OC-3)

## 5.1 OC-3 DEFINITION

The third open call (Call identifier: 6G-SANDBOX-3) will be dedicated to Innovative Experiments. Feasibility check deadline is set for 5 September 2024 at 17:00 (always CET / Brussels local time) and the submission deadline for 19 September 2024 at 17:00.

**Call Objectives**

Deployment and experimentation over the 6G-SANDBOX experimentation infrastructure. Innovative 6G use cases and KPI measurements shall use the features and capabilities of the 6G-SANDBOX experimentation infrastructure.

The objective is to demonstrate future 6G communications networks in the context of use cases described in FG-NET2030-Sub-G1 and in the scope of the ITU IMT-2030 framework. The main scope is to deliver values and ratings for application and network KPIs, as well as to quantify the added value for their target vertical sector.

The experiments are estimated to start on 1. January 2025 and the duration of each experiment should not exceed 6 months.

**Funding**

The maximum amount of financial support for each innovative experiment is 60,000€ for eligible costs and considering the funding rate.

A consortium of up to two organizations can apply for funding. The total aggregated funding shall not exceed 60,000€.

In accordance with the funding rules of the SNS JU work programme, the financial support to the third parties will be 90% (for-profit organization) or 100% (not-for-profit organization) of the declared costs.

A total of 772,980€ is available for this Open Call for innovative experiments

**Eligibility**

- As regards eligibility rules for participation and funding in the Open Calls, the General Annexes to Horizon Europe for the Work Programme 2023-2024 apply. UK entities are allowed to participate subject to the UK/EU agreement being effective in January 2024.
- Implementing the Decision (EU) 2022/2506 on measures for the protection of the Union budget against breaches of the principles of the rule of law in Hungary, that took effect on 16 December 2022, certain Hungarian entities are not eligible for funding (more information is available on the 6G-SANDBOX website).
- Please, note that organizations from Switzerland are not eligible for EC funding in this open call. Swiss organizations can apply for the open call, as a single organization or

as part of a consortium, but the funding, if requested, must be provided by Swiss authorities).

- Proposers' organizations can submit multiple proposals; however, the total available granted funding for the organization in this call is limited to the maximum amount defined in the funding section.
- Young organizations with less than three years of commercial operations are encouraged to apply, however the funding conditions in the agreement will be defined for "payment after delivery", i.e. no advance payment will be paid.
- Beneficiaries of the 6G-SANDBOX project and organizations funded by 6G-SANDBOX OC-1 and OC-2 are not eligible to participate in this open call.

## 5.2 OC-3 EVALUATIONS

The Table 5 5 below present anonymously proposals submitted to the 6G-SANDBOX OC-3.

**Table 5-1: OC-3 Overview**

| Submission nr. | Comment | Score after individual evaluations | Score after consensus meeting (if applicable) | Involved experts | |
|---|---|---|---|---|---|
| E-1 | Selected | 20.75 | | 32 | 34 |
| E-2 | Selected**** | 18 | 18.50 | 33 | 36 |
| E-3 | | 18.5 | 17.25 | 35 | 37 |
| E-4 | Selected | 20.5 | 22.00 | 32 | 39 |
| E-5 | Selected | 22.75 | 22.75 | 34 | 39 |
| E-6 | Selected | 21.25 | 20.25 | 33 | 39 |
| E-7 | Not selected* | 21.75 | | 31 | 37 |
| E-8 | | 16 | 16.50 | 35 | 39 |
| E-9 | | 12.5 | | 31 | 34 |
| E-10 | | 14.25 | 14.25 | 32 | 33 |
| E-11 | | 16.25 | 15.50 | 36 | 37 |
| E-12 | | 17.5 | | 31 | 35 |
| E-13 | Reserve** | 19.5 | | 32 | 34 |
| E-14 | | 16.75 | | 31 | 33 |
| E-15 | Selected | 22 | | 36 | 37 |

| | | | | | |
|---|---|---|---|---|---|
| E-16 | Selected* | 22 | | 31 | 35 |
| E-17 | | 13.75 | 13.25 | 32 | 34 |
| E-18 | Selected | 19.25 | 19.75 | 31 | 33 |
| E-19 | Selected | 22 | 21.50 | 31 | 36 |
| E-20 | | 13.75 | | 32 | 35 |
| E-21 | Reserve | 21.25 | 19.25 | 31 | 34 |
| E-22 | Selected** | 19.25 | 19.50 | 33 | 37 |
| E-23 | Selected | 21 | 22.00 | 32 | 36 |
| E-24 | Selected | 23.5 | | 35 | 38 |
| E-25 | Not feasible*** | n/a | n/a | n/a | n/a |
| E-26 | Reserve | 18.25 | 18.50 | 32 | 33 |
| E-27 | Selected | 23 | | 34 | 36 |
| E-28 | | 12 | | 37 | 38 |
| E-29 | Reserve | 18.5 | | 35 | 38 |
| E-30 | | 13.25 | | 33 | 38 |
| E-31 | Threshold***** | 16.5 | 16.50 | 34 | 36 |
| E-32 | | 17.5 | 17.50 | 38 | 39 |
| E-33 | Threshold***** | 16.25 | | 35 | 39 |
| E-34 | | 16.75 | 15.75 | 36 | 38 |
| E-35 | | 13.5 | | 38 | 39 |
| E-36 | Selected | 21 | | 37 | 39 |

All received proposals were checked for their eligibility to participate in the open call (country of origin, compliance with the open call rules, etc.). No automatic eligibility check was performed.

* Proposal number E-7 was not accepted even it was better scored than others, because the proposal number E-16, which was better ranked than the E-7 and was accepted, involves one of the partners from E-7, which is against the formal requirement of the call text, where 6G-SANDBOX can fund a single organization only once.

** Proposals E-22 and E-13 have the same overall score, but E-22 was better ranked in evaluation categories a and 2 and therefore was selected.

*** Proposal E-25 was identified as not feasible

- The proposal is not feasible, because the solution proposed to implement and test is very demanding in terms of resources available in 6G-SANDBOX facilities. Your

solution involves using 10 GW servers and 7 Matching machines, as stated in your proposal ("It is planned to migrate and deploy the software, including CLLM, in the 6G-SANDBOX environment in Athens."). Moreover, the overall concept describes that the GWs are essential components for the functionality of the software.

- Upon request from the proposer, the 6G-SANDBOX consortium performed also an additional feasibility check

**** Proposal E-2 was in the reserve list and was accepted as the requested costs fitted into the available budget for the OC-3

***** Proposals E-31 and E-33, having the overall score above corresponding threshold, did not mee the threshold in the 1st evaluation criteria.

**Feasibility**

As the feasibility check is not mandatory, the proposal submitted without the feasibility check were analysed accordingly before evaluations.

**Remote and consensus evaluations**

Remote evaluations by nine independent experts (information about involved experts is provided directly to Project Officer) have been performed between in October 2024 through the online submission and evaluation portal. At this stage, the experts provided their opinion on the allocated proposals without interaction with another expert assigned to the same proposal.

The consensus (online) meetings have been organized also in October 2024 with participation of the involved experts and members of the 6G-SANDBOX open call management team for proposals where individual evaluations differ from each other significantly (Sec. 2.4).

During the consensus meetings, the involved experts discussed their opinions on the proposals and in all cases agreed on final scores (Table 5-1).

**Ranking**

Based on the complete evaluation results, the project open call management team established a ranking among the proposal, strictly based on the final ranking concluded by the independent experts. Accordingly, and based on the available funding budget for the open call, 14 proposals have been selected for the implementation in the 6G-SANDBOX project.

The decision on the final ranking was confirmed at the 6G-SANDBOX General Assembly audio conference, held on 12 November 2024. The entire ranking process was communicated in parallel to EC.

## 5.3 OC-3 STATISTICS

36 proposals have been received, whereas one of the was not feasible for evaluations, and 14 of them were selected for implementation (Figure 5-1 and Figure 5-2).

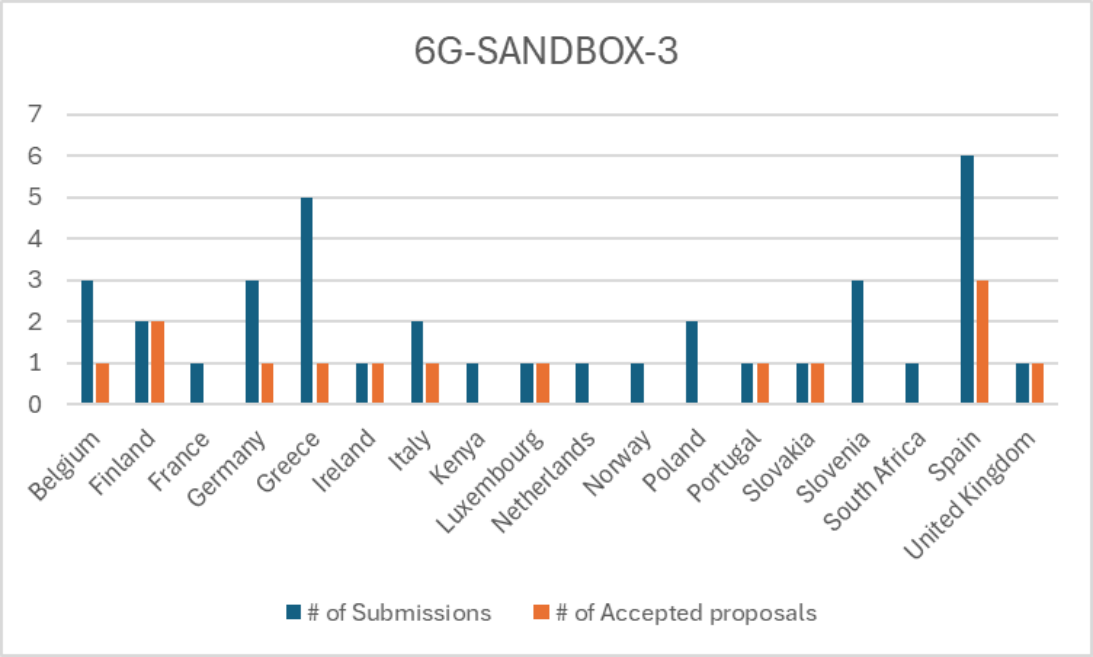


**Figure 5-1: OC-3 Statistics on submitted and accepted proposals per country of origin**

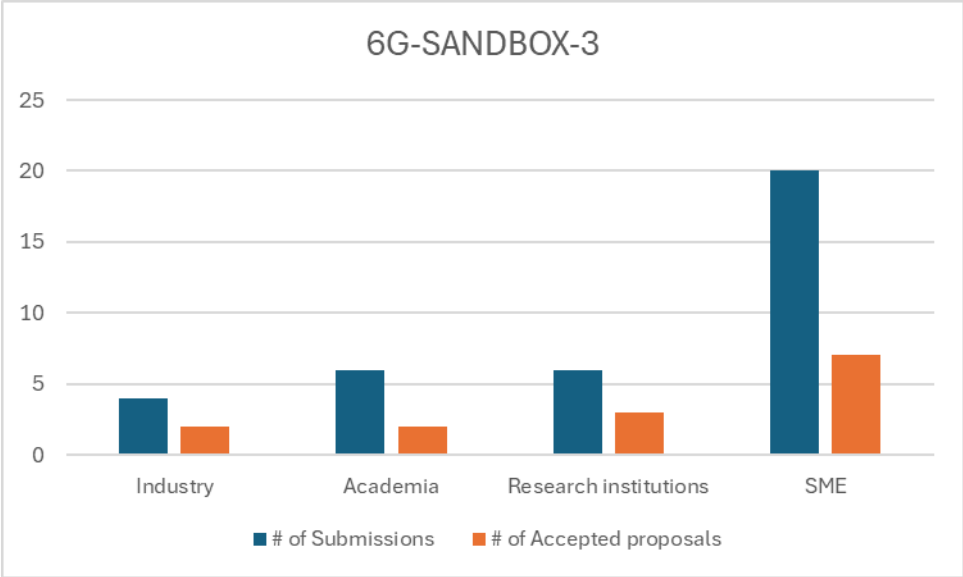


**Figure 5-2: OC-3 Statistics on submitted and accepted proposals per type of organization**

## 5.4 OC-3 IMPLEMENTATION

**Table 5-2: OC-3 accepted proposals**

| Title | Short Title | Organization | 6G-SANDBOX contribution | Status |
|---|---|---|---|---|
| Testing the integration of an open-source 5G FR2 gNB with the 6G-SANDBOX Reconfigurable Intelligent Surface | OAIBOX+RIS | Allbesmart Lda | 60,000 € | Finished |

| | | | | |
|---|---|---|---|---|
| Innovate your connectivity (glass-related connectivity solutions): Hidden antennas for urban environments | Camouflage antenna | AGC GLASS EUROPE | 20,052 € | Finished |
| Next cell prediction using Graph Neural Networks | NEXT-CELL-GNN | The Laude Technology Company, S.L. | 54,591 € | Finished |
| Scalable applications with point-to-multipoint communication towards 6G/IMT-2030 technologies | 6G-VLCBOX | iTEAM-UPV | 60,000 € | Finished |
| Energy Consumption Optimization in O-RAN | ECO-RAN | Fundació Privada i2CAT, Internet i Innovació Digital a Catalunya | 60,000 € | Finished |
| 6G Measurement and QoS Predictability Operations | 6GMeasur-Ops | Maliatsos | 54,000 € | Finished |
| Health Awareness via Radio Technology | HART | Sykno GmbH Huawei GmbH | 55,800 € | Finished |
| Blockchain Enabled end-to-end Network Slicing for Manufacturing | BENSM | Advanced Manufacturing Research Centre, University of Sheffield | 59,997 € | Finished |
| Remote robotic handling of delicate artifacts enabled by 6G networks | 6G4Artifacts | Stam S.r.l. | 59,794 € | Finished |
| PQC-6G: Implementing NIST PQC Standards in Next-Gen Networks | PQC-6G | Decent Cybersecurity s.r.o. | 60,000 € | Terminated* |
| Orchestration of Virtualized Passive QoS Measurement | OVQOS | Kaitotek Oy | 59,874 € | Finished |
| NTN Waveform Performance Analysis | NTN WAVE | Luxembourg Institute of Science and Technology (LIST) | 53,647 € | Finished |
| 6G Real-Time Visualization and Digital Twin Platform | 6G-VIZ | Finwe Ltd. | 60,000 € | Finished |
| Adversarial Resistance and Model Optimization for Robustness for 6G Open Radio Access Networks | ARMOR | University College Dublin | 60,000 € | Finished |
| | | Total: | 777,755 € | |

*This project was terminated as progress was not in line with plan. A procedure to recuperate the advance payment has been started but is not completed by the time of submission of this deliverable.

# 6 CONCLUSIONS

The 6G-SANDBOX has successfully organized and implanted its three Competitive Open Calls in accordance with the project planning. The open calls were targeting new infrastructures and functionalities, for inclusion in the 6G-SANDBOX experimental facilities, as well as innovative experiments, using the 6G-SANDBOX facilities to test new approaches and providing valuable feedback to 6G-SANDBOX, for further improvement of its facilities.

Altogether, during its life time the 6G-SANDBOX received **105 proposals**, where after the evaluations **33 open call projects were selected** for implementation and 32 of them were successfully implemented.

Results achieved by the open calls projects, funded by 6G-SANDBOX, are summarized within a SNS publication, available on the SNS website (https://smart-networks.europa.eu/sns-ju-projects-open-calls-results/) along contributions from other SNS projects implementing the open calls. The information related to 6G-SANDBOX implementations and experiments is also provided in the Annex 2: 6G-SANDBOX Open Call Projects – Summary of Results.

Overall statistics, for all three 6G-SANDBOX open calls is presented below on the next page.

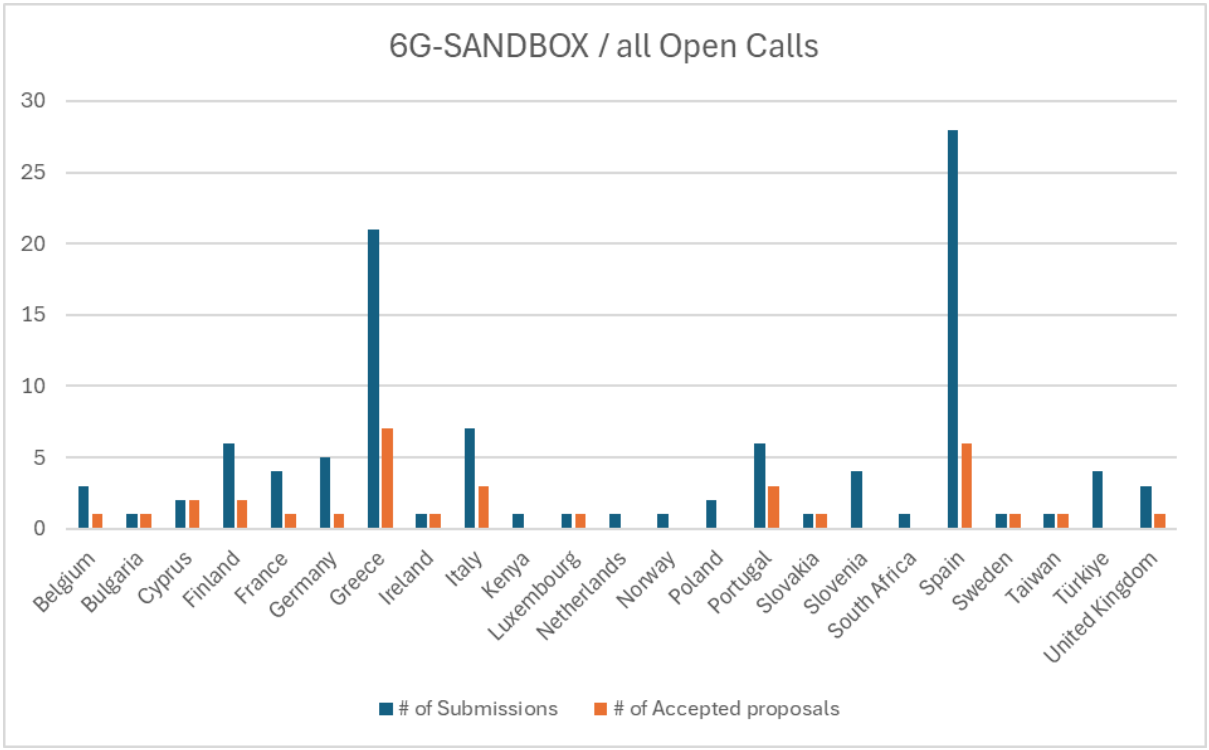


**Figure 6-1: Submitted and accepted proposals per country of origin**

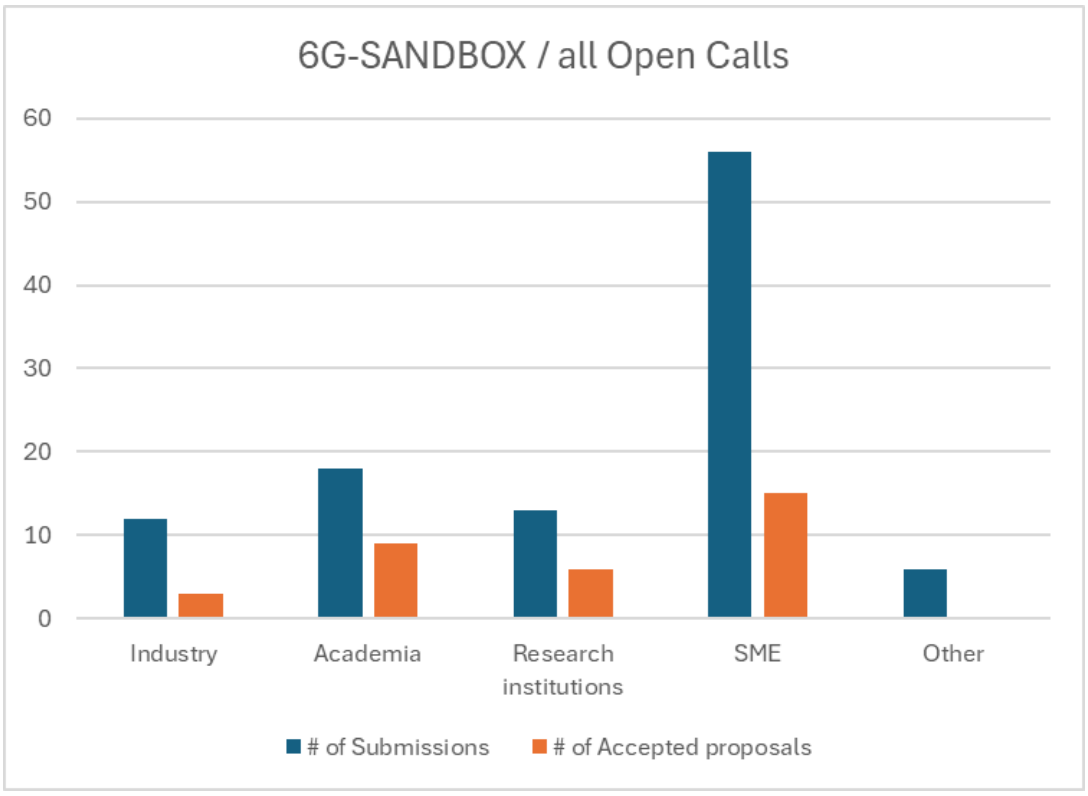


**Figure 6-2: Submitted and accepted proposals per type of organization**

# ANNEX 1: PROPOSAL TEMPLATES

## New Infrastructures and Functionalities

*Maximum number of pages: 10 plus cover and table of content pages (12).*

***The COVER PAGE has to include the following details:***

- Short and full title of the proposal: Extension: XXXXyour titleXXXX
- (List of) participating organization(s), including PIC number(s) (if available), type of organization (Industry, SME, Academia, Research Institute) and country
- Contact person(s) - per organization: name and e-mail
- Tables indicating addressed call objectives and 6G-SANDBOX facilities planned to use (see below)

*Please, REMOVE the topics which are NOT ADDRESSED by the proposal*

| | |
|---|---|
| 1 | Integrated Sensing & Communication (ISAC or JCAS) to save energy |
| 2 | Technology for use cases in Internet of Sense |
| 3 | RIS infrastructure to expand the 6G-SANDBOX capabilities in FR1 and or FR2 |
| 4 | Expanding the 6G-Sandbox testbed With Content Distribution Networks for QoE |
| 5 | Portable data center / smart furniture for 6G AI/ML workloads |
| 6 | Self-learning, evolving Digital Twin. Based on real time data |
| 7 | Testbed network operation center (PORTAL) |
| 8 | Stand-alone mmWave early modules & infrastructure |
| 9 | Dynamic slice allocation, entitlement server |
| 10 | 5GPPP final results integration in 6GSANDBOX |
| 11 | 5G Multicast-Broadcast Services (MBS) |
| 12 | Use explainable AI (XAI) to improve O-RAN functionality in 6G networks |
| 13 | provision system for eSIM |
| 14 | AI techniques for autonomous network management / Zero touch |
| 15 | Support of Ambient IoT devices |
| 16 | Expanding 6G capabilities |
| 17 | … as well as further topics of community interest<br>please, provide further details in brief if applicable |

*Please, indicate (by 'X') the 6G-SANDBOX facilities you plan to work with (* mandatory)*

| *Facility* | *Primary** | *Secondary, …* | *Comment/explanation* |
|---|---|---|---|
| Athens | | | |
| Berlin | | | |
| Malaga | | | |
| Oulu | | | |

*Please, follow the section structure presented below and* adapt the sub-section titles below as needed.

# 1) Excellence

## 1.1 Description of additional functionalities and/or infrastructures

## 1.2 Main objectives/purpose of the proposed functionalities/infrastructures

## 1.3 Novelty of the proposed functionalities and/or infrastructures

# 2) Impact

## 2.1 Exploitation potential of the proposed functionalities and/or infrastructures

## 2.2 Added value for 6G-SANDBOX

How will 6G-SANDBOX project gain from the proposed extensions (functionalities / infrastructures)?
From perspective of proposer; maturity of solution, readiness for experimenters, support until end of 6G-SANDBOX project

## 2.3 Functionalities to be included in 6G-SANDBOX portfolio

Functionalities to be included in 6G-SANDBOX will need to remain in the portfolio until project end.

# 3) Methodology, Work plan, and Budget

## 3.1 Implementation and operation/maintenance methodology

## 3.2 Description of activities to implement and operate the proposed functionalities and/or infrastructures

- List and brief description of the needed activities (no WP descriptions or similar)
- Milestones and time plan for achieving them – Proposed functionalities and infrastructures must be operational (ready to serve 6GSANDBOX experimenters) after six (6) months. Furthermore, the milestones should present the expected results and be aligned with portion of the planned resources to achieve them.
- Reporting – deliverables (mandatory):
    - Detailed functionalities/infrastructure description and implementation plan latest at M2 (Confidential)
    - Implementation report and operation plan at M6 (Project internal – to be disclosed upon consortium decision)
    - Description of functionalities/infrastructures and user manual at M6 (Public), including a summary of information for publication on the6GSANDBOX website
- Further reports (optional)

### 3.3 Budget

- Presentation of personnel resources to be involved in experiment implementation and execution in Person Months (PM) per activity / Milestone described above

a) Total personnel costs in Euros
b) Other costs (equipment, travel, etc.)
c) Indirect costs (if applicable) – please, note that in Horizon Europe program maximum of 25% of the indirect costs (on both personnel and other costs) can be funded

- Total costs: a + b + c (also to be directly provided in the submission portal!)

# 4) Background of applicant

- Brief information about the applicant organization
- Motivation to respond the Open Call
- Background specific to the call objectives and particular related capabilities of the applicant
- Short CVs of personnel to be involved in the experiment implementation

Maximum one page is allowed for this section.

# 5) Remarks

Any further remarks regarding the proposal – maximum one additional page – will be not considered during the evaluation process.

# 6) Ethics

Please, consider the potential ethical issues listed below related to your proposal and provide further details if applicable. Please, specify any further potential ethical issue not mentioned in the list if applicable.

1) Does your research involve human participants or human embryos and/or cells?

2) Does your research involve animals?

3) Does your research include collection and/or processing of personal data?

4) Does your research include work on Artificial Intelligence?

5) Relation to third countries in respect to the ethical issues mentioned above?

6) Does your research can harm environment, animals, or plants?

7) Any further potential issue?

# Innovative Experiments

*Maximum number of pages: 10 plus cover and table of content pages (12).*

***The COVER PAGE has to include the following details:***

- Short and full title of the proposal: Experimentation: XXXXyour titleXXXX
- (List of) participating organization(s), including PIC number(s) (if available), type of organization (Industry, SME, Academia, Research Institute) and country
- Contact person(s) - per organization: name and e-mail
- Tables indicating your role as experimenter and 6G-SANDBOX facilities planned to use (see below)

**Please select one experimenter role *(by 'X')* and provide clarification if needed.**

| | |
|---|---|
| | 6G-SANDBOX Experimenter |
| | 6G-SANDBOX Trial Network User (TNU) |
| | 6G-SANDBOX Trial Network Operator (TNO) |
| | Third party Technology Provider for the 6G-SANDBOX facility |
| | Third party host for the 6G-SANDBOX framework |

*Please, indicate (by 'X') the 6G-SANDBOX facilities you plan to use (* mandatory)*

| ***Facility*** | ***Primary**** | ***Secondary, ...*** | ***Comment/explanation*** |
|---|---|---|---|
| Athens | | | |
| Berlin | | | |
| Malaga | | | |
| Oulu | | | |

**Can your experiment run in an agnostic environment (pure virtual system): yes / no.**

*Please, follow the section structure presented below.*

# 1) Excellence

Please, adapt the sub-section titles below and provide the corresponding descriptions/explanations.

### 1.1 Description of your experiment

### 1.2 Main objectives/purpose and expected results of the experiment

### 1.3 Novelty of the proposed experiment

# 2) Impact

### 2.1 Exploitation potential of the proposed experiment

### 2.2 Added value for 6G-SANDBOX

How will 6G-SANDBOX infrastructure be used by your experimentation?

Are you willing to leave your experimentation running on 6G-SANDBOX for future use by other participants?

# 3) Methodology, Work plan, and Budget

### 3.1 Experimentation methodology

### 3.2 Description of activities to implement and operate the proposed functionalities and/or infrastructures

- List and brief description of the needed activities (no WP descriptions or similar)
- Milestones and time plan for achieving them – Experimentation must be completed after six (6) months, check the availability of the components you need. Furthermore, the milestones should present the expected results and be aligned with portion of the planned resources to achieve them.
- Reporting – deliverables (mandatory):
    - Detailed experimentation plan latest at M2 (Confidential)
    - Experimentation implementation report and results at M6 (Project internal)
    - Summary of experimentation report at M6 for publication on the 6G-SANDBOX website (Public)
- Further reports (optional)

### 3.3 Budget

- Presentation of personnel resources to be involved in experiment implementation and execution in Person Months (PM) per activity / Milestone described above

a) Total personnel costs in Euros
b) Other costs (equipment, travel, etc.)

c) Indirect costs (if applicable) – please, note that in Horizon Europe program maximum of 25% of the indirect costs (on both personnel and other costs) can be funded
- Total costs: a + b + c (also to be directly provided in the submission portal!)

# 4) Background of applicant

- Brief information about the applicant organization
- Motivation to respond the Open Call
- Background specific to the call objectives and particular related capabilities of the applicant
- Short CVs of personnel to be involved in the experiment implementation

Maximum one page is allowed for this section.

# 5) Remarks

Any further remarks regarding the proposal – maximum one additional page – will be not considered during the evaluation process.

# 6) Ethics

Please, consider the potential ethical issues listed below related to your proposal and provide further details if applicable. Please, specify any further potential ethical issue not mentioned in the list if applicable.

1) Does your research involve human participants or human embryos and/or cells?

2) Does your research involve animals?

3) Does your research include collection and/or processing of personal data?

4) Does your research include work on Artificial Intelligence?

5) Relation to third countries in respect to the ethical issues mentioned above?

6) Does your research can harm environment, animals, or plants?

7) Any further potential issue?

# ANNEX 2: 6G-SANDBOX OPEN CALL PROJECTS – SUMMARY OF RESULTS

# 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-SANDBOX Project

Supporting Architectural and technological Network evolutions through an intelligent, secureD and twinning enaBled Open eXperimentation facility

### Overview

The 6G-SANDBOX project - Supporting Architectural and technological Network evolutions through an intelligent, secureD and twinning enaBled Open eXperimentation facility - brings a complete and modular facility for the European experimentation ecosystem, which is expected to support for the next decade technology and research validation processes needed in the pathway towards 6G. The target is at technologies and research advances, that span over the entire service provisioning chain, and refer to user/data, control and management planes. In this direction, 6G-SANDBOX introduces the concept of Trial Networks, which refers to fully configurable, manageable and controlled end-to-end networks, composed of both digital and physical nodes.

The 6G-SANDBOX Trial Networks incorporate infrastructures distributed in EU and offer to third parties automated experimentation capabilities through a rich and extensible toolbox. Meant to create tangible and long-term impact, the 6G KPIs and KVIs that will be quantified with the facility, will be released to any interested party; while the set of developments and APIs that will be produced, will feed an open repository as an initial step to move the contributions and the lessons learned beyond the project boarders and define a European 6G library.

### THE 6G-SANDBOX TESTSITES

**Athens**, Greece - The Athens platform is an advanced large-scale experimental facility for 5G SA networks located in two different locations in Athens, namely the Cosmote/OTE Academy campus and the NCSR Demokritos campus, which are interconnected with a dedicated 10G dark fiber. The network at the NCSR Demokritos campus includes two radio access networks connected to different 5G cores, enabling research in inter-PLMN handover and roaming scenarios. The platform also features a satellite/NTN-emulator that allows for multi-operator

and multi-access scenarios with low cost and agility. ATSSS enables efficient use of multiple RATs in a multi-connectivity scenario, and MPTCP is used to combine multiple network paths in a single TCP connection, potentially improving QoS for users with hybrid access.

**Berlin**, Germany - The Berlin Platform is located at Fraunhofer FOKUS premises in Berlin, Germany. It provides the Technology and services to develop and run experiments using the latest 5G and 6G technologies. The Berlin Site is being enhanced with all the software components developed in 6G-SANDBOX to create the trial networks and network digital twins, including integration of 6G components at the physical infrastructure layer that are related to: (i) Open RAN radio technology, including RU/DU splits, (ii) Extension of the testbed with additional nomadic nodes for field tests, and (iii) Extension by developing a platform for edge-based data acquisition, exchange, and analysis.

**Malaga**, Spain - Victoria Network (Malaga Platform) includes a wide variety of mobile networks and other technologies situated across various physical locations, but with a clear centralized control post in the Ada Byron building on the University of Malaga (UMA) campus. Victoria Network is being enhanced with all the software components developed in 6G-SANDBOX to create the trial networks and extend current network digital twins, including integration of 6G components at the physical infrastructure layer that are related to: University campus RAN extension and new RAN locations, Reconfigurable Intelligence Surfaces, More disaggregated RAN solutions (O-RAN) with the related SW and HW emulation components of Keysight, Fixed/RAN and NTN with EDGE/MEC, and use of OneWeb satellite mobile backhaul, in addition to the existing Starlink, Improved Deterministic networking using P4 language with Intel Tofino 2 switches, and Features to support extended reality and haptic communications.

**Oulu**, Finland - CWC research unit at Oulu has a campus wide 5G Test Network (5GTN) with small cell, macro-cell and distributed antenna based cellular network to be complemented by NFV based EPC and 5G backhauling solution (http://5gtn.fi/). 5GTN is a full-scale 5G test network with its own SIM cards, and it supports using 5G devices, higher frequency bands, cognitive management functionalities, and system testing tools for new solutions. The Oulu Site is being enhanced with all the software components developed in 6G-SANDBOX to create the trial networks and network digital twins, including integration of 6G components at the physical infrastructure layer that are related to: Enhanced autonomous programmability features of the 5GTN, Incorporated within 5GTN an AI-based closed loop that can protect the network against Application-Layer (D)DoS Attack and protect the edge cloud against economic denial of sustainability attacks, and APIs exposure to some of its cloud nodes where external users can deploy their services to be delivered as an edge cloud service and tested over the 5GTN.

### 6G-SANDBOX Open Calls

In order to further enrich the capabilities of its overall experimental infrastructure, upgrade and extend specific experimental features of ist four test sites, and finally open its infrastructure for wide experimentation and gathering experience from concrete tests and

trials, the 6G-SANDBOX involved the 3rd parties in these activities through organization of three competitive open calls, dedicated to the following main activities:

- Establishing new infrastructures and functionalities (extensions): Enlarge and make the 6G-SANDBOX experimental infrastructure ready for advanced experimentation, where the new 6G features and functionalities should be integrated into the 6G-SANDBOX infrastructure.
- Innovative experiments: To initiate first funded innovative experiments on the 6G-SANDBOX infrastructure

In the scope of the 6G-SANDBOX Open Calls, all together 31 Open Call / 3rd Parties projects have been implemented (last ones are being completed); 9 related to establishing new infrastructures and functionalities and 22 experiments.

# Establishing new infrastructures and functionalities in 6G-SANDBOX

## ARROW

| OC Project Title | AI-powered Digital Security Processes over Cloud-native 5G and Beyond Networks |
|---|---|
| Benefiaciary(s)/Country | • Centre of Research and Technology Hellas – CERTH<br>• Information Technologies Institute – ITI<br>• Visual analytics Lab – VALab: https://valab.iti.gr/ |
| Project Description | An end-to-end security architecture in 5G and B5G that incorporates Artificial Intelligence (AI) approaches is required to autonomously identify and respond to possible attacks based on network abnormalities rather than traditional authentication and authorization methods. ARROW targets systematic experiments with an SDN-based platform that provides AI-powered Digital Security mechanisms to generate, detect, and prevent attacks over 5G and B5G networks. The ARROW solution includes: (i) end-to-end AI-enabled threat detection and prevention techniques; and (ii) attack configuration tools for AI-powered attack generation on multiple threat vectors. The experiments involve various attacks and 5G protocols, while AI-enabled mechanisms are examined to generate the attacks and enable AI-based penetration testing of the facilities. A detailed data collection procedure is adopted for every conducted experiment to formulate tailored datasets that can further accelerate research on 5G/6G cybersecurity and derive updated AI models tailored to testbed intrusion detection capabilities. A validation procedure is performed to enable the ARROW Cybersecurity Module to be added to 6G-SANDBOX infrastructure for further experimentation. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga |
| Implementation timeframe | September 2023 – March 2024 |
| Results & Impact | To thoroughly evaluate the proposed method's effectiveness within the ARROW project framework, extensive experimentation was conducted utilizing AI models trained and tested on the captured traffic data. This approach allowed the performance of the models in a controlled environment and their real-time applicability to be established. |

## ANALYSAT

| OC Project Title | AI-driveN multi-link bAckhauL management through network data analYticS and localization |
|---|---|
| Benefiaciary(s)/Country | • Nextworks<br>• RomARS<br>• CNIT |
| Project Description | ANALYSAT delivers a technical solution for the 6G-SANDBOX facilities through the implementation of three new functionalities: Network Data Analytics Function (NWDAF) capability, Location Management Function (LMF) capability, multi-link backhaul management in hybrid terrestrial-satellite networks. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | Demokritos, Athens |
| Implementation timeframe | September 2023 – March 2024 |
| Results & Impact | ANALYSAT implemented three new functionalities (NWDAF, location information capability, multi-link backhaul management) by integrating and enhancing results from previous H2020 and ESA ARTES projects to extend the capabilities of 6G-SANDBOX testbeds. Moreover, ANALYSAT demonstrated how the new proposed functionalities can jointly support the introduction of novel management features for network automation in satellite enabled mobile networks. This is achieved through the implementation of a use case application that exploits the information data from the new Network Data Analytics exposed by the mobile network to automatically select between satellite and terrestrial backhaul link technologies based on aggregated mobility and traffic load analytics data as well as on the basis of predictions built via ML techniques.<br>Integrating the solutions proposed in ANALYSAT, 6G-SANDBOX experimenters will be able to retrieve network KPIs and information of UEs' localization in Athens and Malaga testbeds, which can be used to develop new network-aware applications or service management solutions, possibly based on data analytics and ML techniques. Moreover, the possibility to programme dynamically the multi-link transport network will allow to experiment with new end-to-end resource allocation schemas, placement algorithms, and strategies for network planning and automated optimization.<br>The solutions delivered in ANALYSAT derive from existing software assets already demonstrated in relevant environments (around TRL 6). They have been extended and adapted for integration in the 6G-SANDBOX NCSRD testbed during the project, making them ready to be used and exploited by 3rd party experimenters. |

## 6G-LoRaGRAN

| OC Project Title | **Integration of the University of Granada's LoRaWAN network in the 6G SANDBOX connectivity infrastructure** |
|---|---|
| **Benefiaciary(s)/Country** | Universidad de Granada, SPain |
| **Project Description** | The 6G-LoRaGRAN project was presented by the WiMuNet research group (code TIC-235 of the Scientific Information System of Andalusia) of the University of Granada (UGR), Spain. The main functionality that the project adds to the current 6G-SANDBOX infrastructure is the integration of the University of Granada's LoRaWAN network in the 6G-SANDBOX connectivity infrastructure. To facilitate its use, our LoRaWAN testbed will be integrated with the 6G-SANDBOX sites, aiming to transmit LoRaWAN traffic through the 5G core networks of the 6G-SANDBOX sites. This integration allows for remote LoRaWAN experimentation using UGR's LoRaWAN motes and infrastructure. Additionally, a network slicing solution will be implemented in the LoRaWAN radio access network, enabling research on radio resource allocation algorithms to efficiently share resources among motes belonging to different verticals. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | Fraunhofer FOKUS, Germany |
| **Implementation timeframe** | September 2023 – March 2024 |
| **Results & Impact** | The 6G-LoRaGRAN project serves as a proof-of-concept illustrating how a mobile network operator could integrate a LoRaWAN network into its own 5G network infrastructure. LoRaWAN, a prominent technology for massive IoT, operates within unlicensed frequency bands, allowing private companies to leverage it for their deployments. By integrating LoRaWAN, MNOs can offer comprehensive solutions that encompass LoRaWAN, NB-IoT, and other cellular-based technologies, each tailored to different use cases. This integrated approach is poised to attract various verticals. Consequently, we anticipate that this project will facilitate knowledge transfer not only to MNOs but also to network equipment manufacturers.<br>Moreover, given that the 6G-LoRaGRAN platform is open to researchers interested in exploring LoRaWAN and 5G integration, along with developing radio resource management algorithms to enhance network slicing in LoRaWAN, the project will foster collaboration opportunities with research teams from companies, research centers, and universities across Europe and beyond. This expanded collaboration network has the potential to extend the reach of the 6G-SANDBOX project. |

## ASTRAL

| OC Project Title | O-RAN research prototype for the 6G-SANDBOX platform |
|---|---|
| Benefiaciary(s)/Country | EIGHT BELLS LTD, Cyprus |
| Project Description | ASTRAL is in position to adopt popular open-source libraries (i.e., srsRAN) and to integrate them with the latest O-RAN near-RT RIC software. This will be achieved through the establishment of the standardized E2 interface and the development of an E2 Agent integrated in srsRAN. Such a deployment will enable the data exchange between RAN and near-RT RIC, and the control and optimization of RAN functions and resources in (near) real-time through proper software tools, called xApps. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga, Spain |
| Implementation timeframe | September 2023 – March 2024 |
| Results & Impact | ASTRAL extension adopted popular open-source libraries (i.e., srsRAN) and integrated them with the latest O-RAN near-RT RIC software through the establishment of the standardized E2 interface and the development of an E2 Agent integrated in srsRAN.<br>Such a deployment enabled the data exchange between RAN and near-RT RIC, and the control and optimization of RAN functions and resources in (near) real-time through proper software tools, collectively called “xApps”. Potential xApps include handover optimization, radio link monitoring, mobility management, load balancing, slicing policy updates, traffic steering, and interference management. Moreover, additional software applications that may leverage on AI/ML based algorithms to optimize RAN functions will be enabled. |

## RADIANT

| OC Project Title | ReleAse-16 Device IntegrAtioN and Trialing in open experimentation facilities |
|---|---|
| Benefiaciary(s)/Country | Fivecomm, Spain |
| Project Description | Fivecomm will provide to the 6G-SANDBOX project a set of 8 Release (Rel)-16 5G modems, developed by the company, that will allow consortium members to experiment on the four different infrastructures with Rel-16. Such modems represent a natural evolution of our 5G Release-15 modems, which were developed, integrated and validated in a wide range of test-bed infrastructures and Horizon 2020 5G-PPP previous projects including: FUDGE-5G, 5G-RECORDS, iNGENIOUS, 5G-IANA and 5G-INDUCE. The Rel-16 modems integrate a Quectel RG520N-EU module that, in turn, employs a Qualcomm radio chipset (Snapdragon x62). Our Rel-16 modems have been already tested and validated in the Rel-16 network of the Universitat Politècnica de València (UPV), in Spain. The 5G modems provided by Fivecomm are a solution that connects any user device (e.g., cameras, drones, robots, etc.) to the 5G network. The 5G modem has simplified electronics while minimized power consumption and cost. It is versatile enough to adapt to the different requirements and scenarios specified by industrial verticals in the context of the 6G-SANDBOX project. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Oulu (additional implementation in Malaga) |
| Implementation timeframe | September 2023 – March 2024 |
| Results & Impact | Thanks to the RADIANT project, Fivecomm was able to take their 5G Rel-15 device as a basis and design a new complete model with a much more reduced form factor and additional functionalities, such as the use of USB for direct connection of the module to testing software. The 5G modems provided by Fivecomm are a solution that connects any user device to the network. They integrate a 5G Rel-16 module, i.e., a Quectel RG520N-EU module with a Qualcomm radio chipset Snapdragon x62. Eight 5G modems were developed, classified into three categories:<br>• Small-size modems: light version of our prototype, so-called 5G BROAD, to be used in simple scenarios where only 5G connectivity is needed in a particular device.<br>• Medium-size modems: full version of the 5G BROAD consisting of a 5G hat and a Raspberry Pi 4, to be used in moving devices and more complex scenarios.<br>• Fixed modems: different version using an outdoor case with IP protection for outdoor scenarios. |

## ONEmNEF

| OC Project Title | OneSource's Microservicebased Network Exposure Function |
|---|---|
| **Benefiaciary(s)/Country** | One Source, Consultoria Informática Lda, Portugal |
| **Project Description** | This proposal outlines OneSource's proposal to integrate its innovative Microservice-based NEF into the 6G-SANDBOX platform, thus enhancing its capabilities and providing users with a range of essential features specified by the 3GPP NEF framework. Furthermore, OneSource intends to include its own state-of-the art security solution to further enhance security for NEF APIs.<br>The integration of ONEmNEF into three of the 6G-SANDBOX testbeds and their corresponding 5GCs aims to leverage the solution's flexibility and scalability, enabling an extended set of capabilities for the platform users. The NEF acts as a pivotal component in the network, facilitating secure and controlled exposure of network services and data to authorized third-party applications. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | Demokritos (Athens), Fraunhofer FOKUS (Berlin), University of Malaga |
| **Implementation timeframe** | September 2023 – March 2024 |
| **Results & Impact** | To evaluate the detection performance of the HSPF detection module, a comprehensive evaluation scenario has been outlined as follows:<br>1 Collection of Normal Traffic: The initial step involved collecting normal network traffic. This process was conducted concurrently with one of the testing rounds designed to evaluate the NEF performance. While the characteristics of different validation tests for the NEF varied in terms of the number of simultaneous requests and respective intervals, the variability in data among these tests was minimal.<br>2 Federated Training of ML Model: Following the collection of normal traffic, the HSPF Agent initiated a federated training round orchestrated by the HSPF Orchestrator. This process resulted in a trained ML model capable of accurately identifying normal traffic patterns similar to those observed during the network traffic collection phase.<br>3 Simulation of Malicious Flows: To simulate malicious flows, a script originally used for validating the integration between the NEF and the 5G Core was adapted. This adaptation involved the simulation of SQL injection commands and malformed URLs, using the create<br>A set of three experiments were conducted for each of the scenarios resulting in the generation of 60 malicious requests. |

## RAYPLICATE

| OC Project Title | RAY-tracing based Physical Layer Inside 6G digital AccuraTE twin |
|---|---|
| Benefiaciary(s)/Country | SIRADEL (Engie group, France) |
| Project Description | SIRADEL contributes to the elaboration of an accurate digital twin (DT) for the Malaga platform. The radio physical layer can be simulated from a precise 3D digital representation of the deployed infrastructure (environment, base-stations, antennas) and deterministic ray-tracing emulation of the MIMO channel properties. The ray-tracing outputs are exploited by the Keysight's digital twin solution, such that the performance of the real testbed can be reproduced in the virtual world, or new network scenarios (in terms of deployment, antenna system, resource management, etc) can be precisely assessed. This DT solution will be operational for several physical deployments implemented in the Malaga platform, including: FR1/FR2 small-cells installed on the rooftop or inside the Ada Byron building (University campus); and FR1 small-cells deployed in Malaga downtown. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga |
| Implementation timeframe | September 2023 – March 2024 |
| Results & Impact | It should be noted that the outdoor FR2 measurements on the campus and FR1 ones in Malaga downtown<br>will be exploited after completion of the RAYPLICATE project to perform the calibration of SIRADEL's<br>Volcano Urban propagation model dedicated for outdoor environments. The same applies for the FR1<br>indoor measurements on the ground floor and 1st floor of Ada Byron building, which will be used to<br>calibrate SIRADEL's Volcano Flex propagation model specifically intended for indoor environments. |

## NDWAF – StreamAnalyzer

| OC Project Title | NDWAF – StreamAnalyzer |
|---|---|
| **Benefiaciary(s)/Country** | Lamda Networks P.C, Greece |
| **Project Description** | Within the scope of this project, we will enhance our commercial software product, StreamAnalyzer so that it offers certain 3GPP NWDAF functionalities to the 6G-SANDBOX project. Specifically, leveraging telemetry data from the Athens site (Open5GS, NEF and Amarisoft), we will implement and validate: (I) selected functionalities from 3GPP TS 23.288 NWDAF APIs Events Subscription, Analytics Info, Data Management & ML Model Provision and (II) the NWDAF use cases network conditions and performance, device behavior, and service experience. Furthermore, we will support the CAPIF/NEF integration framework. Our NWDAF validated functionalities shall be maintained and supported throughout the full duration of the 6G-SANDBOX project. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | Demokritos, Greece |
| **Implementation timeframe** | June 2024 – December 2024 |
| **Results & Impact** | his project implemented NWDAF_StreamAnalyzer, a Proof-of-Concept prototype of an NWDAF Event Subcription Service providing predictions for the 3GPP TS29.520 Events 'UE_COMMUNICATION' and 'NUM_OF_UE'.<br>We managed to achieve quite satisfactory predictions' accuracy when we validated our experimentally-driven<br>configuration of the LSTM prediction model in Demokritos' 5G environment in a real-life experiment involving a 5G smartphone accessing the Internet to receive a video file. Therefore, we could state that we have a Proof of Concept (PoC) of an NWDAF with accurate prediction mechanisms for the Events 'UE_COMMUNICATION' and 'NUM_OF_UE'.<br>The above results are encouraging us to pursue the continuation of the implementation of NWDAF_StreamAnalyzer in order to reach the maturity of an MVP. |

## REACT-6G

| OC Project Title | RAN IntElligent Automation and Control via xApps Towards 6G |
|---|---|
| **Benefiaciary(s)/Country** | • Four Dot Infinity, Greece<br>• Accelleran N.V., Belgium<br>• Software Radio Systems Limited, Ireland |
| **Project Description** | The main objective of REACT-6G was to deploy additional RAN components in facility at University of Malaga as well as to develop and integrate xApps and CM functionalities, further enhancing the capabilities provided by 6G-SANDBOX, to maximise the project's uptake by interested 6G stakeholders and application developers. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | University of Malaga |
| **Implementation timeframe** | June 2024 – December 2024 |
| **Results & Impact** | Outcomes:<br>• A disaggregated RAN architecture has been delivered and tested across two servers with RIC/CU/DU and Open5GS components to ensure modularity and scalability. The delivered RAN architecture leverages full 10G connectivity between CU and DU, with front-haul links carefully monitored for packet loss. The configuration supports flexible deployment, making it a robust foundation for performance benchmarking and future beyond 5G innovations.<br>• Two xApps for power control of the RUs in a multi-cell environment have been developed. The ML models have been tested in an NDT simulated environment and integrated in the RI, along with the prototype reference CM. The CM functionality has been validated, showcasing its capability to detect direct conflicts across different power control actions and resolve them based on UE-centric or EE-centric policy.<br>Impact of the results:<br>• For the 6G-SANDBOX consortium: the delivered architecture enables the collection of measurements and data from the radio (RU/DU) that can be exploited by diverse 6G scenarios, thereby facilitating experimenters to conduct testing on 6G services towards future innovations.<br>• For the REACT-6G consortium partners: the involved partners are planning to be commercially active in 6G technologies, developing and integrating additional RAN equipment and components, as well as ML algorithms residing in xApps in the framework of O-RAN architecture.<br>• Environmental Impact is implicitly achieved through the objectives of the delivered ML algorithms for power control. The ML-assisted energy efficiency operation of the radio units was evaluated through the intelligent ML-assisted xApps in the simulated environment. |

## 6G-EARN

| OC Project Title | 6G-Energy leARNing |
|---|---|
| **Benefiaciary(s)/Country** | ENERGY COMMUNITY BESSARION LIMITED LIABILITY COOPERATIVE, Greece |
| **Project Description** | 6G-EARN aims to develop i) a 5G-based variant of its monitoring solution and ii) a Federated Learning (FL) mechanism for accurate forecasting of energy consumption/production with the integration of external data sources. In particular, historical energy data along with data collected from locally deployed weather stations will be used. The proposed FL approach will ensure that the data of the end-user are not disclosed and hence its privacy is preserved. |
| **Vertical** | Energy |
| **Testbed** | OTE / Demokritos |
| **Implementation timeframe** | May 2024 – December 2024 |
| **Results & Impact** | 1. Aggregation of data from multiple sources as per Federated learning and with integration of external resources improves prediction accuracy by more than 100% (in cases of limited available data per client).<br>2. Forecasting the daily consumption of a household can be sufficiently accurate, with mean absolute percentage error MAPE <20%<br>3. Aggregating consumption data from too diverse data sources may have the opposite effect, and hence careful grouping of the users is necessary.<br>4. 6G-EARN training can be completed in less than 10 minutes even without GPU availability at end-clients<br>Regarding the 6G-SANDBOX experimentation platform, our main findings are:<br>1. 6G-SANDBOX supports the deployment of any properly-designed cloud service and experiment with a diverse set of simulated Trial Networks scenarios.<br>2. The connectivity and computation requirements of Energy communities are adequately captured by 6G-SANDBOX and 5G.<br>3. Clear separation of the control and user planesin a 5GS deployment is necessary.<br>4. With the cloudification of the 5G system, competition for computing resources between 5G and the hosted services should be considered and avoided.<br>5. For compute-intensive services (such as the training phase of 6G-EARN), monitoring of the cloud infrastructure and flexible allocation of compute resources are critical |

## 6G-MOBKPI

| OC Project Title | KPI measurement in 6G networks under mobility scenarios |
|---|---|
| **Benefiaciary(s)/Country** | Universidade de Vigo, Spain |
| **Project Description** | The aim of the 6G-MOBKPI experiment is to analyse the different key performance indicators (KPIs) for mobility scenarios of 6G networks. To this end, we propose to use a mobile user equipment (UE) mounted on top of an autonomous mobile robot with accurate localization, navigation and autonomous driving capabilities. The robot will be physically placed inside the 6G-SANDBOX testbed facilities in a location with coverage from different cells. In particular we plan to use the Malaga platform for our experiment leveraging its resources. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | University of Malaga |
| **Implementation timeframe** | May 2024 – December 2024 |
| **Results & Impact** | The main result is the design, development and validation of the automated KPI measurement tool for mobility scenarios. The generated datasets with KPI measurements and location information are also a valuable result, which we have used to analyse the suitability of specific 5G setups to support IIoT use case applications. Moreover, we used the proposed tool to study the impact of handover on<br>network KPIs, and identified some limitations of current handover algorithms to guarantee low latency and ensure network availability, which are critical for IIoT scenarios. |

## SCDT

| OC Project Title | Smart Contract-based Digital Twins for the IoT |
|---|---|
| Benefiaciary(s)/Country | Athens University of Economics and Business |
| Contact point (Name,email) | n/a |
| Project Description | The SCDT experiments will assess the feasibility and evaluate the performance of a novel form of decentralized, transparent, auditable, interoperable, and secure digital twins for Internet of Things (IoT) devices, such as sensors and actuators. The IoT is envisioned to be an ecosystem of interconnected devices merging the cyber with the physical world, to provide a multitude of services. The IoT has been on the spotlight of many research efforts in the past few years, and it has already been used in a variety of use cases, such as smart cities, smart homes, healthcare, etc. However, there are still some IoT challenges that need to be addressed. First, IoT systems are fragmented, since there is a plethora of IoT devices from different manufacturers, using different protocols and standards. Second, securing IoT services requires complex security solutions, usually relying on advanced cryptographic techniques and algorithms, which have not been designed for the IoT, where many devices are limited in processing, memory and energy resources. We argue that digital twins, with the right design, can address both these challenges, enhancing the interoperability, auditability, and security of IoT systems. |
| Vertical | IoT |
| Testbed | University of Oulu, Finland |
| Implementation timeframe | May 2024 – December 2024 |
| Results & Impact | In our experimentation, we conducted a variety of experiments to evaluate the performance of smart contractbased digital twins, e.g., latency, throughput, and to fine tune some of the blockchain's parameters, e.g., batch configuration. |

## MAGDALENA

| OC Project Title | MeAsuring 5G anD sAteLlite nEtwork iNtegrAtion |
|---|---|
| Benefiaciary(s)/Country | Karlstad University, Sweden |
| Project Description | The convergence between terrestrial and non-terrestrial networks (TN and NTN) is an important trend within 5G/6G systems, where the integration of satellite components, either for mobile backhauling or as (part of) the access network is being standardized by 3GPP. Still, there is a limited understanding of the performance implications of such integration and experimental results are limited. With MAGDALENA, we aim to address this shortcoming by taking advantage of the 6G-SANDBOX Malaga platform, and in particular its integrated 5G and Starlink deployments. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga, Spain |
| Implementation timeframe | May 2024 – December 2024 |
| Results & Impact | The MAGDALENA project provided several key technical insights into TN-NTN integration, particularly regarding satellite-based connectivity and congestion control mechanisms. One of the most significant findings is that the satellite exit point location (i.e., the point where traffic re-enters the terrestrial network) has a greater impact on round-trip time (RTT) than the physical proximity of the server.<br>Additionally, our experiments revealed that while ICMP PING is useful for basic connectivity checks, it does not reliably reflect the RTT characteristics experienced by real services. Our TN-NTN integration evaluation showed that the system supports bandwidth-intensive services such as IoT data transmission and video surveillance effectively. However, it falls short for latency- and jitter sensitive applications like real-time e-Gaming, primarily due to increased packet loss and higher RTT variability. In contrast, the 5G baseline can deliver satisfactory performance if the server is not too far.<br>Furthermore, we compared different congestion control algorithms, with results showing that BBR consistently outperforms CUBIC in maintaining higher throughput, particularly in lossy environments. CUBIC, by contrast, is more conservative in response to packet loss and tends to underutilize available bandwidth under dynamic network conditions.<br>Overall, our experimental results suggest that TN-NTN integration can effectively extend 5G connectivity to remote areas but presents performance limitations for latency-sensitive applications. |

## MR@REAM

| OC Project Title | MR@REAM |
|---|---|
| Benefiaciary(s)/Country | Crisis Med UoA, Greece |
| Project Description | MR@REAM (Mixed Reality for Remote Earthquake Area Management) is a real-time mixed reality platform designed to enhance emergency response operations by bridging on-site first responders with remote management teams. The system leverages immersive MR technology, WebSocket-based communication, and 5G connectivity to enable bidirectional exchange of audiovisual and interaction data during high-pressure scenarios.<br>Through the use of 5G Standalone (SA) deployment and cloud infrastructure provided by 6G-SANDBOX Athens testbed, and a 5G CPE router for Wi-Fi 6 bridging, MR@REAM delivered a fully connected, hybrid MR workflow. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | Demokritos, Greece |
| Implementation timeframe | May 2024 – December 2024 |
| Results & Impact | • Reliable real-time communication between MR and PC, maintaining low-latency video/audio streaming at optimized configurations (60–70% quality, 1920x1080 resolution, ~20 Mbps).<br>• High responsiveness of the control system, with scenario updates and UI changes reflected instantly on both sides.<br>• Bi-directional voice communication remained stable and clear when bandwidth demands were controlled, especially with prioritization of audio in lower bitrate settings.<br>• Flexible encoder controls allowed fine-tuning of stream settings (FPS, resolution, quality), enabling adaptive performance testing.<br>• PC operator tools, such as network monitoring, timers, and UI interactions, empowered remote participants to supervise and assist effectively.<br>• Infrastructure readiness, thanks to the integration with 6G-SANDBOX testbed, 5G CPE devices, and the Amarisoft-based SA core, which provided a robust and modern networking layer.<br>Despite the high performance, limitations appeared when pushing video quality beyond 80%, resulting in audio packet loss and slight UI desynchronization. These limitations were valuable for identifying future optimization paths such as adaptive streaming, bandwidth-aware prioritization, and further MR-side performance tuning. |

**POWERSTORM**

| OC Project Title | **Energy-Aware Streaming Analytics Job Scheduling for 5G/6G Deployments** |
|---|---|
| **Benefiaciary(s)/Country** | University of Cyprus |
| **Project Description** | Energy profiling and optimization are expected to play a crucial role in realizing the 5G/6G-enabled Internet of Things (IoT), as deploying intelligence closer to the network edges ensures better response times where data are generated. Despite this, research evaluating the energy performance of such deployments on next-generation networks remains scarce. In our experiments, we assessed various schedulers in the Apache Storm framework, including a round-robin scheduler, a resource-aware scheduler, and PowerStorm—a scheduler designed to balance performance and energy consumption for streaming analytics in geo-distributed edge computing scenarios. |
| **Vertical** | Energy |
| **Testbed** | Fraunhofer FOKUS, Berlin |
| **Implementation timeframe** | May 2024 – December 2024 |
| **Results & Impact** | In terms of energy consumption within the local network (ethernet), both PowerStorm and Resource-aware execution demonstrated a reduction in energy use, with decreases of approximately 15% and 5.9% respectively.<br>Next, we analyzed energy consumption during the Edge Cluster execution, involving 5G data generation. In this scenario, PowerStorm resulted in a 13.2% increase in energy consumption, while the Resource-aware scheduler exhibited a substantial rise of 135.9%. This difference is due to the way scheduling nodes were selected. The Resource-Aware Scheduler distributed tasks across all available resources, leading to energy usage from both servers. In contrast, PowerStorm scheduled tasks on only two VMs hosted on the same server, resulting in lower energy consumption. Despite the increased energy demands, both approaches provided superior performance in latency reduction and overall tuples processed, illustrating the trade-off between energy efficiency and performance gains in this setting. Finally, we compared the energy consumption across three configurations, namely, the default execution of Apache Storm, the PowerStorm-enabled deployment, and the resource-aware deployment, in the 5G RAN network. In this comparison, PowerStorm showed a minimal energy increase of just 0.43%, whereas the Resource-aware scheduler nearly doubled the system's energy consumption, with an increase of 93.7%. |

**PROSPERANCY**

| **OC Project Title** | **Transparency protocol for performance on composite digital services** |
|---|---|
| **Benefiaciary(s)/Country** | Alis Grave Nil, Bulgaria |
| **Project Description** | In the digital future shaped by augmented reality, the Metaverse, and high-speed internet interconnectivity, a wide range of online services will rely on multiple layers, each provided by different companies—creating a composite service. However, such a structure inherently poses a challenge: when performance issues arise, consumers may find themselves trapped in a cycle of uncertainty, unsure which provider is responsible for the substandard experience.<br>We aim to merge technical and legal parameters in the outcome, therefore the experiment we are conducting is aimed at establishing acceptable deviation in the speed or latency of a composite service. On top of that we aim to create a clear-cut parameters for dispute resolution, as well as sufficient and cost sensitive methods for storage of large quantities of data to be used in the potential dispute resolution. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | Fraunhofer FOKUS, Berlin |
| **Implementation timeframe** | May 2024 – December 2024 |
| **Results & Impact** | The experiment allowed us to advance the technical, legal, and business aspects of Prosperancy in parallel, creating a seamless integration that strengthens the foundation of our future service. This multi-faceted approach provided the invaluable ability to make real-time adjustments across all dimensions, ensuring a more robust and user-centered service.<br>One of the key milestones achieved was reaching Technology Readiness Level (TRL) 6, a testament to the maturity and readiness of our solution for broader application. This achievement reflects our commitment to delivering a high-quality service capable of addressing complex challenges in next-generation connectivity.<br>In alignment with our mission to promote inclusivity and accessibility, we adopted an open-access business model. This decision ensures that our developments can be widely utilized, fostering a collaborative environment where innovation thrives.<br>As part of our contribution to dispute resolution, we developed comprehensive guidelines that provide clarity and consistency for mediators and adjudicators. These guidelines are designed to streamline processes, increase speed, extend transparency and improve outcomes for all parties involved. |

## REPLICA

| OC Project Title | Replicable Cellular Networking Experiments using ns-3 |
|---|---|
| **Benefiaciary(s)/Country** | INESCTEC, Portugal |
| **Project Description** | Wireless networking R&D depends on experimentation to make realistic evaluations of networking solutions, as simulation is inherently a simplification of the real-world. However, despite more realistic, experimentation is limited in aspects where simulation excels, such as repeatability, reproducibility, and scalability.<br>Motivated by our hands-on experience with testbeds operating in emerging scenarios such as aerial and maritime, and with a track record of more than 10 years and multiple scientific publications on simulation-experimentation synergy, as well as a recognized position in the ns-3 community, INESC TEC has been developing a Trace-based Simulation (TS) approach that enables the recording and reproduction of past physical layer traces, such as received signal strength (RSS), on ns-3 network simulator. Until now, this approach has been validated on Wi-Fi. 6G-SANDBOX provides, now, the perfect opportunity to run experiments and validate this innovative approach for 5G/6G. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | University of Malaga, Spain |
| **Results & Impact** | The REPLICA project successfully collected and analyzed a comprehensive dataset from physical 5G SA experiments and complementary simulation activities. The comparison between real-world and simulated throughput results demonstrated that pure 3GPP-based simulations provided the closest match to experimental observations. This was largely due to the inclusion of features such as Time Division Duplex (TDD) partitioning, which were absent from the other models.<br>The machine learning–based path loss model showed potential for adaptive prediction across different scenarios but still requires refinement to improve accuracy under more variable conditions. Meanwhile, the trace-based simulation approach enabled realistic replay of test conditions but was inherently limited to specific test traces.<br>Across all configurations, higher variance in throughput was consistently observed at greater distances or under attenuated conditions, validating the strong impact of environmental factors on 5G NR performance, as expected. These results provide valuable insight for refining simulation models and enhancing the design and operational robustness of testbeds like 6G-SANDBOX, particularly in the context of trace-driven and reproducible experimentation. |

## RESCUE

| OC Project Title | Remote mEdical Support and Communication Utility in Emergency scenarios |
|---|---|
| **Benefiaciary(s)/Country** | University of Sant'Anna, Italy |
| **Project Description** | RESCUE project proposal aims to conduct an experimental field trial leveraging 5G connectivity where an innovative tele-assistance system is deployed and assessed with the focus to improve emergency and disaster response efforts. The tele-assistance system consists in a set of helmets (worn by the operators) that are equipped with a camera sending real-time audio/video streams of the scene of action (e.g., injured person) through the mobile network; and by a web application hosted in a server that allows doctors in an Operations Center to directly access the front view of the operators and communicate with them to assess the patient situation and guide their intervention. Thanks to the 6G-SANDBOX project, the proposed system will leverage on the attributes proposed by the 5GTN network in the Oulu testbed to integrate with the 5G network features provided by it and test its performance under different conditions. |
| **Vertical** | Emergency and disaster response / Tele-assistance |
| **Testbed** | University of Oulu |
| **Implementation timeframe** | May 2024 – December 2024 |
| **Results & Impact** | The system's performance was evaluated during experimentation across various network scenarios,<br>focusing on the transition from 4G connectivity, currently used by the system, to 5G connectivity provided by the 5GTN (at Oulu University), including both 5G Non-Standalone (NSA) and Standalone (SA) networks. A hybrid configuration combining Wi-Fi and 5G was also tested. The results demonstrated significant performance improvements in bandwidth (bit rate increased up to a factor 5) and round-trip time, highlighting 5G's capability to enhance the tele-assistance system's Quality of Service (QoS) in terms of responsiveness and Quality of Experience (QoE) in terms of video stream quality as perceived by the remote doctor. Additionally, tests with different hardware platforms (i.e., Raspberry Pi 3, 4, and 5) revealed that greater computational power positively impacts overall system performance. |

## NTN WAVE

| OC Project Title | NTN Waveform Performance Analysis |
|---|---|
| Benefiaciary(s)/Country | Luxembourg Institute of Science and Technology, Luxembourg |
| Project Description | This project presents a comparative experimental study of 5G New Radio (5G NR) and DVB-RCS2 waveforms for their suitability in non-terrestrial networks (NTN) operating in geostationary (GEO) satellite scenarios. Using open-source platforms such as the OpenAirInterface5G NTN suite for 5G NR and openSAND for DVB-RCS2, the experiment evaluates each technology's performance under realistic traffic conditions including video streaming, file transfers, and interactive applications. Performance is assessed across key metrics such as throughput, latency, jitter, and error rates, under various system configurations and channel conditions including large GEO delays and different signal-to-noise ratios. The novelty of this work lies in its cross-layer, end-to-end emulation using publicly available tools. It addresses key limitations in prior research that either focused solely on physical layer simulations or relied on proprietary platforms. This is one of the first experiments to directly compare DVB-RCS2 and 5G NR using open tools under realistic conditions, offering practical and reproducible insights into their respective strengths, weaknesses, and potential synergies. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | Demokritos, Greece |
| Results & Impact | This work successfully implemented and validated a comparative experimentation framework for evaluating the performance of 5G-NR and DVB-S2/RCS2 technologies under a unified simulation environment using the 6G-SANDBOX testbed. The experiments revealed that 5G-NTN offers consistently lower jitter and higher throughput compared to DVB-S2/RCS2, owing to its flexible scheduling, leaner protocol stack, and grant-based uplink access. In contrast, DVB-S2/RCS2 showed longer startup delays and lower throughput but performed comparably well in delay-tolerant use cases such as webpage loading.<br>Importantly, all experiments were designed to be repeatable, and the developed tools and test scenarios can be reused for future validation efforts. Beyond performance data, the work highlighted key limitations of non-real-time simulation environments, such as timing imprecision and lack of hardware-driven synchronization, offering valuable feedback for testbed improvement. |

## 6G-VIZ

| OC Project Title | Real-Time Visualization and Digital Twin Platform |
|---|---|
| Benefiaciary(s)/Country | FINWE, Finland |
| Project Description | Next-generation 6G networks aim to revolutionize wireless communication by enabling advanced use cases such as holographic communication, tactile Internet, digital twins, and extended reality (XR). However, developing and validating networks for these applications is challenging due to uncertainties in future technological developments and the difficulty of visualizing complex radio behaviors and network performance. To address these challenges, we propose a modular, open-source, real-time 3D visualization platform that integrates real or simulated use cases into a digital twin of a 6G laboratory environment. This system allows researchers to observe and interact with network KPIs—such as latency, throughput, and signal strength—through immersive simulations that reflect their real-world impact on perceived Quality of Service (QoS). The platform features a 3D globe UI for multi-site collaboration, XR headset support via WebXR, and interactive plug-in-based use case simulations (e.g., robot control, media streaming). It also supports multi-user interaction, live experimentation, and replay capabilities using ROS2 and OpenVidu frameworks. By making invisible network phenomena visible and tangible, this solution enhances research collaboration, stakeholder communication, and training in future network technologies |
| Vertical | Media / extended reality (XR) |
| Testbed | University of Oulu, Finland |
| Results & Impact | Summary of Results:<br>• Dynamic Digital Twin (3D model) of a 6G-SANDBOX laboratory site<br>• Multi-Site Support: a 3D globe-like user interface was for navigating between 6G-SANDBOX laboratory sites<br>• Real-Time 3D graphical visualization of selected network KPIs<br>• Use Case Simulations for Perceived QoS<br>The results were demonstrated at EuCNC 6G-SANDBOX booth. Oulu lab digital twin was also used in co-operation in EU-Converge project booth, whose live experiments could be observed from the 6G-SANDBOX booth via the digital twin. |

## 6G-VLCBOX

| OC Project Title | Scalable applications with point-to-multipoint communication towards 6G/IMT-2030 technologies |
|---|---|
| Benefiaciary(s)/Country | Universitat Politècnica de València, Spain |
| Project Description | 6G-VLCBOX will on-board, experiment with and validate an end-to-end 3GPP Rel-18 system incorporating, for the first time and in an open-source environment, 5G Multicast-Broadcast Services (MBS) features for reliable, low latency, and scalable communication. The open-source software components for MBS contribute towards the SNS Stream C goals of advancing on open architectures and APIs while providing full customization and control for 6G-SANDBOX members and the community. The ability to customize code and configuration is of particular relevance given that MBS spans the UE, RAN (gNB), 5G Core (5GC) and User Services architecture. The project will develop the necessary 3GPP features to enable MBS by extending existing open-source initiatives: For the MBS RAN and UE, the srsRAN platform will be further developed to integrate point-to-multipoint NR features; while for the MBS functions in the 5GC, the relevant control and user plane network functions will be extended from the Open5GS core implementation. This means to update both segments of the solution to Rel-17 and Rel-18 functionalities. The solutions will be integrated into the Malaga's platform, which already features SDR (software defined radio) equipment and Open5GS, with the objective to create a new type of Broadcast-enabled Trial Network. The developments of the project will be aligned with the efforts of the 5G-MAG Reference Tools development programme, which fills the gaps between the development of specifications for multimedia applications and their conformance testing, validation and prototyping. Moreover, the project will contribute feedback to 3GPP as part of 5G-MAG's activities as 3GPP Market Representative Partner. Additionally, 6G-VLCBOX will also provide insight into MBS applications for media, public safety and its potential integration with Non-Terrestrial Networks. |
| Vertical | Media / 5G Multicast-Broadcast Services |
| Testbed | University of Malaga, Spain |
| Results & Impact | The project is being implemented. |

## NEXT-CELL-GNN

| OC Project Title | Next cell prediction using Graph Neural Networks |
|---|---|
| Benefiaciary(s)/Country | The Laude Technology Company, Spain |
| Project Description | The main objective of the project is to train, evaluate and optimize advanced Graph Neural Network (GNN) models for predicting which base station a user will connect<br>to in mobile networks. This will enable improved handover management, identification of congested cells, and optimization of network performance and energy consumption. The project cover creating graph-structured data from network simulations, developing different GNN models adapted to this problem, and their integration, testing, and validation on an open experimental platform. Thus, it seeks to demonstrate the feasibility and real benefits of these techniques for intelligent connectivity management in telecommunications operators, overcoming the limitations of closed solutions and proposing an open and scalable approach for the sector. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | Demokritos, Greece |
| Results & Impact | Our model achieved high prediction accuracy in two different scenarios. In Scenario 1, it reached a Mean Reciprocal Rank of 0.8866, Hits@1 of 84.3%, and overall<br>accuracy of 95.2%, with precision at 74.3%, recall of 87.1%, F1 score of 78.3%, and Matthews Correlation Coefficient of 0.7746. Scenario 2 showed further improvement, with a Mean Reciprocal Rank of 0.8992, Hits@1 of 85.5%, accuracy of 95.7%, precision of 76.2%, recall of 90.1%, F1 score of 80.6%, and Matthews Correlation Coefficient of 0.8012. Stable inference with temporal filtering was developed, achieving an average prediction latency of 0.607 seconds suitable for near real-time applications. The solution was fully integrated with CAPIF APIs and validated in a 6G-SANDBOX laboratory environment, demonstrating practical deployment readiness.<br>These results have significant impact by validating GNN technology as a viable solution for next-generation network management and establishing expertise in AI-driven telecommunications while creating publicly available large-scale emulation datasets that fill important research gaps. The improved handover prediction with sub-second latency enables more reliable mobile connectivity, reducing dropped calls and service interruptions. Additionally, the optimized handover management significantly reduces energy consumption in mobile networks by preventing unnecessary base station activations and enabling more efficient resource utilization. |

**6GMEASUROPS**

| OC Project Title | 6G Measurement and QoS Predictability Operations |
|---|---|
| **Benefiaciary(s)/Country** | Feron Technologies, Greece |
| **Project Description** | 6GMeasurOps introduced a dual-agent measurement and prediction framework to assess and forecast 5G/6G network performance under real-world conditions. The solution combines a portable Golden Unit (mini-PC with 5G modem and Dockerized measurement suite) with a Server at the UPF breakout, enabling synchronized active and passive monitoring – from PHY to the application. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | Demokritos, Greece |
| **Results & Impact** | 6GMeasurOps conducted >3,000 experiment runs at the 6G-SANDBOX Athens/OTE Academy site, covering diverse packet sizes, intervals, durations, and load conditions in three different layers. In the physical layer, RSRP, RSRQ and SINR remained stable with minimal fluctuations, showing reliable mid-band 5G coverage. Measurements confirmed strong radio stability even under stress traffic. In the transport layer, TCP uplink throughput was consistently ~80 Mbps, while TCP downlink throughput was ~15–18% lower than uplink. UDP flows showed larger variance, confirming sensitivity to congestion/load and aggregated RTTs were in line with commercial thresholds; retransmission rates were measurable but within acceptable ranges. Regarding application layer results, MQTT outperformed video streaming in latency and jitter — ideal for IoT, URLLC, and low-power services.<br>Application-level RTT evolutions over hours confirmed stable MQTT but variable video flows behavior. Finally, regarding AI prediction, the LSTM predictor achieved high accuracy (SMAPE>90%) for uplink throughput and RTT.<br>Overall, the dual-agent architecture proved robust and reproducible. By combining PHY, transport, and application measurements with AI forecasting, the platform went beyond benchmarking — it delivered predictive QoS intelligence.<br>6GMeasurOps can have significant technical and scientific impact, since: a) it demonstrated a portable, extensible measurement and prediction platform that works in real 5G NSA and SA networks; b) it Introduced a benchmarking + predictive QoS framework, bridging reactive and proactive network management. c) it created open-source software (QoSCOPE) for reproducible experiments; d) it provides validated datasets for future 6G research and contributions to 3GPP/ETSI standardization. |

## HART

| OC Project Title | Health Awareness via Radio Technology |
|---|---|
| Benefiaciary(s)/Country | Sykno GmbH, Germany<br>Huawei Technologies Duesseldorf GmbH, Germany |
| Project Description | The HART project is advancing future 6G-enabled eHealth through the integration of AI-driven, contactless health monitoring and advanced wireless networks. Led by<br>Sykno GmbH and the Huawei Munich Research Center, it focuses on vertical experimentation using Wireless Radio Sensing (WRS) via Sykno's ViRa24 vital sign radar system. This non-invasive technology uses mmWave signals to measure human vital signs – such as heart rate, respiration, heart rate variability, inter-beat intervals, and heart sounds – without physical contact, even through clothing. In scenarios like hospital waiting rooms or patient homes, WRS nodes anonymously monitor multiple patients, with data transmitted in real time over 5G/6G networks to a centralized computing platform. AI algorithms analyze the data to detect abnormalities and trigger timely medical alerts. The system supports scalable monitoring with high reliability and ultra-low latency – crucial for emergency response. Compared to traditional ECG, HART's approach reduces staff workload<br>and improves hygiene by eliminating electrodes. It also enhances privacy by avoiding cameras and personal data collection, aligning with 6G trust and security standards. |
| Vertical | Health |
| Testbed | Fraunhofer FOKUS, Berlin |
| Results & Impact | The HART project advanced eHealth by developing and evaluating wireless radar sensors for contactless monitoring of vital signs like heart rate and respiration. In a<br>lab trial, these sensors delivered accurate data through AI-powered signal processing, capturing detailed cardiac and respiratory patterns. The performance of the 5G network used to connect sensor, processing and display nodes was<br>evaluated using KPIs and KVIs, showing reliable traffic patterns, strong clustering (Silhouette score up to 0.6515), and high peak similarity (up to 0.9631). Techniques like Dynamic Time Warping and K-Means Clustering modeled traffic behaviors effectively, though clustering robustness showed room for improvement. Data privacy was ensured via end-to-end encryption, secure protocols, and GDPR compliance using encrypted dummy data. HART will showcase its results in future events and plans further innovations, including predictive models and pilot programs for broader healthcare scalability. |

## OVQOS

| OC Project Title | Orchestration of Virtualized Passive QoS Measurement |
|---|---|
| Benefiaciary(s)/Country | Kaitotek, Finland |
| Project Description | The OVQOS project targeted to extend the measurement capabilities of the 6G-SANDBOX experimentation platform with Kaitotek's Qosium solution. The 6G-SANDBOX testbed platforms were already equipped with many high-quality measurement solutions to evaluate the performance of the networks and new techniques developed upon them. The experiment did not overlap with the current capabilities but aimed at introducing measurement capabilities for measuring Quality of Service (QoS) and Quality of Experience (QoE) experienced by applications beyond those supported by the current toolset that were mainly active, basing the measurement on synthetic test traffic. Qosium, as a passive solution, tells in real-time exactly the QoS the real ongoing applications get from the network with unmatched accuracy. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Oulu, Finland |
| Results & Impact | The main result of the project is the successful integration of Qosium into the 6G-SANDBOX experimentation platform as a new TN Component. Qosium extends the range of measurement capabilities available for experimenters, bringing unique aspects to measure the QoS passively for real applications in real-time without synthetic test traffic. A study for different means regarding results federation and multi-site measurements for a comparative performance analysis of measurements carried out over different platforms was also carried out. The study result introduces multiple different alternatives to integrate results federation into the 6G-SANDBOX architecture. A part of the project outcome was demonstrated at the 2025 EuCNC & 6G Summit, being the final, public showcase of OVQOS. The demonstration was carried out in close cooperation with the University of Oulu and two other Open Call projects, 6G-VIZ and OAIBOX+RIS.<br>Real-time monitoring of network quality for applications is a game-changer in critical network infrastructures and R&D, enabling immediate identification and resolution of performance bottlenecks, service disruptions, and resource allocation issues. This not only leads to an improved user experience and minimized downtimes in operative networks but also provides researchers with valuable data and information for technology validation. |

**6G4ARTIFACTS**

| OC Project Title | 6G4Artifacts |
|---|---|
| Benefiaciary(s)/Country | STAM, Italy |
| Project Description | The 6G4Artifacts project introduces an innovative remote-controlled robotic system designed for the safe handling and movement of ancient artifacts with precision and without damaging them. By leveraging 5G-enabled teleoperation, robotics, and immersive VR interfaces, the system ensures precise and delicate manipulation, minimizing the risk of damage to fragile cultural artifacts. The project sets the foundation for future applications, including automated artifact restoration and conservation, expanding the role of robotics in cultural heritage management. |
| Vertical | Robotics |
| Testbed | Fraunhofer FOKUS, Berlin |
| Results & Impact | The first preliminary tests performed on blocks of different shapes showed that, after initial issues that have been solved with the support of our mentor from 6G-SANDBOX, the system provided optimal network performance and the user were able to execute the required tasks with precision. The network showed low latency (RTT of 76ms), 100% uptime, 4% packet loss, a jitter of 1.38ms and a stable 15 FPS at HD quality. Thanks to the good network performance, the users were able to maneuver the blocks precisely, always grasping them correctly and positioning inside their bases with high precision (2.5mm) and a low error rate (3%). Initial feedback on the system usability also provided a positive insight on its simplicity of use and overall usability.<br>Also for the full validation tests, where users were asked to manipulate artifacts replica of different shape and materials, network performances confirmed the previous good values, with low latency (76ms), 100% uptime, low jitter (14ms) and a constant 15 FPS at HD quality. Concerning the functional capabilities of the remotely-controlled robotic system, users were able to perform the required manipulation tasks with precision both in terms of gripper positioning and force applied. Users caused no damage to the artifacts, only needing to restart the task 1 out of 10 times to correct it. An average of 1 minute per artifact manipulation was registered, and the users confirmed the positive feedback regarding the system usability.<br>Overall, the 6G4Artifacts system provides a robust and scalable foundation for teleoperation in sensitive environments, leveraging next-generation connectivity and immersive user interfaces to empower safe and effective human-robot collaboration at a distance. |

## ARMOR

| OC Project Title | Adversarial Resistance and Model Optimization for Robustness for 6G Open Radio Access Network |
|---|---|
| Benefiaciary(s)/Country | University College Dublin, Ireland |
| Project Description | The ARMOR project aimed to strengthen the robustness of Artificial Intelligence (AI) models in Open Radio Access Networks (O-RAN) against adversarial threats, which pose risks to performance, privacy, and trust. The main goal was to develop and validate an adversarial testing framework capable of systematically evaluating AI model vulnerabilities across evasion, inference, inversion, and poisoning attack vectors. The targeted use case was AI-based Intrusion Detection Systems (IDS) trained on radio telemetry data for anomaly detection in O-RAN environments. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Oulu, Finland |
| Results & Impact | Testing revealed critical weaknesses in IDS models, including a complete drop in detection accuracy under small evasion attacks, significant privacy leakage through membership inference, and class collapse under targeted poisoning. The results confirmed the necessity of adversarial testing before deployment and demonstrated reproducibility across both UCD and Oulu testbeds. The impact is twofold: An essential security testing extension for 6G applications such as AI-enabled xApps that strengthens 6G AI security and robustness, while the ARMOR team gained technical expertise, visibility, and potential avenues for commercial exploitation in AI security. |

## QAIBOX+RIS

| OC Project Title | **Testing the integration of an open-source 5G FR2 gNB with the 6G-SANDBOX Reconfigurable Intelligent Surface** |
|---|---|
| **Benefiaciary(s)/Country** | Allbesmart, Portugal |
| **Project Description** | The main objective of the 6G-SANDBOX OC3 project is to test and validate the 6G-SANDBOX Reconfigurable Intelligent Surface (RIS) technology, developed by Queen's University Belfast (QUB) and available at the University of Malaga. We will test the integration of the QUB's RIS with the OAIBOX mmWave and commercial UEs in several propagation scenarios. |
| **Vertical** | n/a (networking related experiment/implementation) |
| **Testbed** | University of Malaga, Spain |
| **Results & Impact** | This trial has demonstrated that a 5G FR2 cellular system requires a clear line-of-sight (LoS) between the gNB and the UE to ensure a stable end-to-end connection. The use of the RIS prototype, developed by QUB, demonstrated a 3 dB gain in RSRP and SINR measured in shadowed areas. 5G FR2 radio coverage assessment at 28 GHz with 200 MHz bandwidth showed a stable 5G connection with 245 Mbps downlink (DL), 64 Mbps uplink (UL), and 15 ms latency measured at 5 meters (LOS) from the gNB.<br>This project marked the first successful integration of a third party RIS with the OAIBOX mmWave 5G system developed and commercialized by Allbesmart. Driven by increasing interest from OAIBOX customers in advanced 5G mmWave experimentation, this integration demonstrates the feasibility of real-time RIS control and monitoring through the OAIBOX dashboard. This new capability significantly expands the potential use cases and opens new business opportunities for the OAIBOX product line (www.oaibox.com) in the evolving 5G and 6G research landscape.<br>The experiment also highlighted important technical requirements for successful RIS integration, such as the need for a well-defined API and comprehensive documentation from RIS manufacturers. During the project, several Merge Requests submitted by Allbesmart were approved by the OAI Software Alliance, enhancing 5G FR2 gNB stability. These contributions have been integrated into the official OAI open-source codebase, which serves a global community of thousands of developers and 5G/6G researchers. This represents a significant large-scale project impact. |

## ECO-RAN

| OC Project Title | Energy Consumption Optimization in O-RAN |
|---|---|
| Benefiaciary(s)/Country | i2CAT Foundation, Spain |
| Project Description | ECO-RAN focuses on reducing the energy consumption of 5G networks through the selective deactivation of 5G cells. Using a realistic dataset from a European MNO, we<br>developed AI-based strategies to determine cell on/off switching based on the load of cells in a specific sector and site, while evaluating the impact on UE Quality of<br>Service. This approach faces two key challenges.<br>• First, ensuring that energy-saving policies do not compromise the quality of service provided by operators, according to their specific policies or constraints.<br>• Second, validating and refining these methods through the application of Digital Twins before deployment in real networks.<br>To address these challenges, ECO-RAN leveraged the 6G-SANDBOX Keysight RIC Tester to generate realistic synthetic data and implement practical O-RAN-based<br>control-loop operations. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga, Spain |
| Results & Impact | First, the validation of the use case and energy-saving strategy demonstrates how AI-driven and O-RAN-based programmability can help MNOs reduce $CO_2$ emissions<br>and associated OPEX, contributing to societal and environmental sustainability in line with global SDG goals. For instance, results show that, for an average<br>throughput of 15 Mbps per UE and a maximum outage probability of 5%, the targeted cells could be switched off for approximately 40% of a week. When considering 5 Mbps and 10% outage, this value could increase to around 70%. These policies, managing the energy-QoS trade-off could be defined by the operator and considered by our developed solution during inference. Second, we have advanced the implementation of our O-RAN framework (AI Engine plus RICs), developing and validating its compatibility with RAN emulators such as the Keysight RIC Tester. This progress will increase the TRL of the infrastructure by demonstrating scalability and conformance with O-RAN standards, while enabling the development of novel and innovative use cases in future projects. |

## BENSM

| OC Project Title | Blockchain Enabled End-to-End Network Slicing for Manufacturing |
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| Benefiaciary(s)/Country | University of Sheffield / AMRC, United Kingdom |
| Project Description | The manufacturing sector demands end-to-end network slicing (E2ENS) to meet diverse operational requirements such as high availability, guaranteed bandwidth, and ultra-low latency. However, current private 5G networks lack clearly defined service-level agreements (SLAs) to support transparent, traceable, secure, and efficient automation of E2ENS. This research introduces a blockchain-enabled approach to automate E2ENS through the use of smart contracts. These contracts establish tamper-proof, transparent agreements among key stakeholders – including mobile network operators, telecom regulators, and end users – tailored to specific manufacturing needs. The project will develop and implement smart contracts for two E2ENS scenarios, each governed by pre-defined SLAs. Upon fulfilment of the contractual conditions, the network slices will be instantiated automatically to meet the required use case parameters. This approach enables dynamic, demand-driven allocation of network resources over shared infrastructure, allowing rapid adaptation to evolving industrial requirements. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Oulu, Finland |
| Results & Impact | he BENSM experimentation validated the seamless integration of a permissioned blockchain with 5G network<br>slicing to meet industrial SLAs. By exercising both control-plane and data-plane workflows, we confirmed that<br>distributed ledger anchoring, and modular orchestration can co-exist to deliver transparent, auditable, and reliable network services.<br>BENSM contributed significant new functionality to the 6G-SANDBOX platform by integrating blockchainenabled SLA tracking, decentralized orchestration, and on-chain KPI anchoring. These extensions support auditability and trust in multi-tenant slicing environments key for industrial and enterprise applications. The project validated not just the technical feasibility of on-chain SLA enforcement, but also the usability of the system via the 6G-SANDBOX portal, demonstrating end-to-end orchestration, real-time monitoring, and compliance verification. These capabilities expand the 6G-SANDBOX experimentation scope to include security and trust as core metrics, enabling future research into secure and autonomous network operations. |

**CAMOUFLAGEANTENNA**

| OC Project Title | Hidden antennas for urban environments |
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| Benefiaciary(s)/Country | AGC GLASS EUROPE, Belgium |
| Project Description | Everyday connectivity is essential, with antennas playing a vital role in delivering reliable signals from the moment we wake up to the moment we go back to sleep, for work, leisure, and daily tasks. This places greater pressure on the delivery of stable, reliable, and accessible signals for an ever-growing number of connected devices. Added to the mix is the fact that delivering greater connectivity requires more antenna in many more places. This can quickly create an unsightly view particularly in historic cities and buildings. And with that, several challenges arise that require innovative technologies taking into consideration the visual impact of the solutions. To answer these deployment challenges, we developed "WAVEATTOCH" solution. This solution consist of using the glass facades of the buildings by installing transparent glass antenna developed by AGC installed "inside building" to radiate through the glazing "outside the building". This solution allow to avoid the traditional challenges of the actual solutions (such as: installation on utility poles, traffic light, bus stops, lampposts…etc): - Expensive: high cost to put 5G cell on utility poles for example - Slow approval: 18 to 24 months for authorities' approval - Complex supply: 6 to 18 months for procurement process - Expensive works: providing power and backhaul to each site - Vandalism risks - Camouflage effort needed And offer several advantages: - Use the façade as new place to provide coverage - Faster Simplified Permit - Plug and Play (Power & Fiber: indoor antenna and electronics) - Transparent antenna allow high densification with low power - Better Esthetics - No vandalism risks As a results, and taking into account the advantages mentioned above, the telecom players can more easily and quickly provide reliable and good connectivity for their customers. |
| Vertical | n/a (networking related experiment/implementation) |
| Testbed | University of Malaga, Spain |
| Results & Impact | The project is being implemented. |