D6.6 Call Announcement and Guide for Applicants - Second Open Call

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List of Acronyms

Abbreviation / acronym	Description
D6.6	Deliverable number 6.6 belonging to WP6
FSTP	Financial Support to Third Parties
GfA	Guide for Applicants

Executive Summary

This document is the deliverable D6.6 Call Announcement and Guide for Applicants - Second Open Call and it defines the Open Call package of documents for the management of the second Open Call in order to initiate Cascade funding of the project and engage in the Financial Support to Third Parties (FSTP) part of the project.

This document is based on FundingBox Accelerator (FBA) FSTP Management Procedures for Horizon Europe projects and built upon the FBA Quality Procedures.

This deliverable will include all the documents needed for the 2nd ICOS Open Call, namely:

1. Open Call Announcement for the 2nd ICOS Open Call: contains an overview of the open call structure, main evaluation criteria, summary of the evaluation process and support for the applicants. As required, the call announcement was published in the Funding & Tender Opportunities Portal via the link: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/competitive-calls.
2. Guide for Applicants for the 2nd ICOS Open Call: our step-by-step guide containing all the necessary information on the application process, available on the call website. The applicants are provided with detailed information about the scope of the Open Call, main eligibility criteria, evaluation criteria,

1 Introduction

1.1 Purpose of the document

The project has two Open Calls (OC) in order to select, fund and support 20 projects (5 in the first OC and 15 in the second) with 1.9M€ distributed as FSTP. In the 1st Open Call, 5 projects were selected and are currently participating in the ICOS 12-month Support Programme. In the 2nd Open Call, 15 projects will be selected in order to deliver 'uptake projects

This deliverable contains guidance documents that are targeting potential applicants for the ICOS 2nd Open Call to participate and join the 6 month-long ICOS Support Programme, namely the:

1. Open Call Announcement for the 2nd ICOS Open Call
2. Guide for Applicants for the 2nd ICOS Open Call

1.2 Relation to other project work

This deliverable contains guidance documents that are targeting potential applicants for the ICOS 2nd Open Call to participate and join the 6 month-long ICOS Support Programme.

The applicants interested in the 2nd ICOS Open Call are expected to apply through the dedicated open call platform at https://icos2.fundingbox.com/ between 10th July 2024 and 30th September 2024.

1.3 Structure of the document

This deliverable is part of WP6, Task 6.2 Open Call Management, where FundingBox is the task leader, supported by partners from ATOS, FBC and SUITE5 who bring their contributions. Together, these partners support the execution and management of Open Calls and the Financial Support provided in the form of lump sum to the third parties selected through the Open calls and coherency of the application process within the documentation. This deliverable is the first step towards accomplishing the objective of launching and managing the second of the two Open Calls expected in the ICOS project.

The results of the application and selection process, as detailed in the Guide for Applicants, part of this deliverable, will be reported in the Deliverable D6.7 Public Summary Report - Second Open Call, after the Open Call is concluded. The 20 selected projects are key to ensuring the relevance of the ICOS platform as a result of the selected projects' development of solutions/services and the testing of the ICOS technologies in several domains.

The Open Call Announcement included in this deliverable has been posted on the Participant Portal at: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/competitive-calls-cs/3761.

2 Call announcement

Announcement of an open call for recipients of financial support

Call title:	ICOS 2nd Open Call
Full name of the EU funded project:	Towards a functional continuum operating system
Project acronym:	ICOS
Grant agreement number:	101070177
Call publication date:	10th July 2024 at 09:00 CEST
Call deadline:	30th of September 2024 at 17:00 CET
Expected duration of participation:	Up to 6 months
Total EU funding available:	Up to900,000.00
Submission & evaluation process:	Detailed information about the ICOS 2nd Open Call submission and evaluation process can be found on the ICOS website: https://www.icos-project.eu/second-open-call and ICOS 2nd Open Call microsite: https://icos2.fundingbox.com/.
Further information:	A more complete overview of the Open Call and proposal guidelines can be found on the official Open Call website here https://icos2.fundingbox.com/. Email address for further information: icos@fundingbox.com. Project website: https://www.icos-project.eu/

Task description:	ICOS (https://www.icos-project.eu/) is a project funded by the European Commission (under the topic: HORIZON-CL4-2021-DATA-01-05 and Grant Agreement number: 10107017) covering a set of challenges emerging from the continuum paradigm. ICOS project will embed a well-defined set of functionalities, ending up in the definition of an IoT2cloud Operating System (ICOS). The main objective of the project ICOS is to design, develop and validate a meta operating system for a continuum, by addressing the challenges of: i) devices volatility and heterogeneity, continuum infrastructure virtualization and diverse network connectivity; ii) optimized and scalable service execution and performance, as well as resources consumptions, including power consumption; iii) guaranteed trust, security and privacy, and; iv) reduction of integration costs and effective mitigation of cloud provider lock-in effects, in a data-driven system built upon the principles of openness, adaptability, data sharing and a future edge market scenario for services and data. **ICOS uptake projects (2nd Open Call)**: is oriented to technology providers (mainly SME/midcap) working as service providers in the sectors of the pilot use cases and the projects from the 1st Open Call. They will test their applications and services through the ICOS infrastructure to improve them. The unstoppable proliferation of novel computing and sensing device technologies, and the ever-growing demand for data-intensive applications in the edge and cloud, are driving the next wave of transformation in computing systems architecture. The resulting paradigm shift in computing is centered around dynamic, intelligent and yet seamless interconnection of IoT, edge and cloud resources in one computing system, to form a continuum. A continuum (cloud continuum, IoT continuum, edge-to-cloud or fog-to-cloud) is expected to provide the means for data processing both in the edge and cloud, while inferring and persisting important information for post-mortem and offline analysis. We envision a holistic approach towards the solutioning of this technology trend in future systems, by architecting, designing and implementing the continuum as extensible, open, secure, adaptable, AI-powered as well as well highly performant and technology agnostic, managed through a meta-OS, i.e., IoT2Cloud Operating System (ICOS). **From GfA** T6.2. Open Call Management: This task oversees the management of 2 Open Calls and the Financial Support (a total of 1.9M€) provided in the form of lump sum to the third parties selected through the Open calls (covering O6.2). The Open Calls are: 1) Solutions Development projects open call, to be launched in M12 to fund up 5 consortia (tech provider and sectoral end-user), to develop ICOS implementation in 5 verticals (different to the pilot cases), and

	2) ICOS uptake projects, launched at M21, to fund 15 SMEs aimed to use ICOS platform in one of the 9 verticals (from pilot cases plus those from 1st Open Call). The management of the Open Calls and FSTP entails the following subtasks: (i) Open Call preparation, which will start 3 months before launching the Open Calls to prepare the Open Call package of Documents and the Communication Toolkit; (ii) Open Call launch and dissemination which will last 2 months to properly disseminate the Call among potential beneficiaries; (iii) Selection process and SGA signature where the FSTP beneficiaries will be selected through an exhaustive selection process, overseen by the Selection Committee, which guarantee transparency, equal treatment, conflict of interest and confidentiality (see Annex 1 for detail). The formal check and the ethics assessment of the beneficiaries will be done and the SubGrant Agreements (SGA) signed; (iv) Third parties projects execution where the 3rd parties projects will be executed according to the specifications included in the Individual Mentoring Plan (IMP) annexed to their SGA. A Mentoring Committee will be assembled to provide technical support to the 3rd parties in their interaction with ICOS and to evaluate the deliverables produced by the third parties according to their IMP; (v) 3rd parties follow-up and payment, where the Milestones Reviews to assess the performance of the FSTP projects and to validate the payments will be organized (see Annex 1 for detail on the Milestone review process). FBA will lead all the subtasks, except subtask (iv) for 3rd parties execution, led by ATOS, and FBA will chair and moderate the Mentoring Committee to ensure the alignment with the Milestone Review process implemented for the 3rd parties follow-up and payment. Output: 2 OC published, 5&15 selected finalists, 20 SGAs signed, 20 funded projects using ICOS platform, 1.9M€ distributed as FSTP.

3 Guide for Applicants (GfA)

Guide for Applicants

2nd Open Call

Submission starts on **10th of July 2024 at 9:00** (CEST)

Deadline is on the **30th of September 2024 at 17:00** (CEST)

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Commission. Neither the European Union nor the granting authority can be held responsible for them. ICOS has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101070177.

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1 Basic Info about ICOS

ICOS (https://www.icos-project.eu/) is a project funded by the European Commission covering a set of challenges emerging from the continuum paradigm. A continuum, today also referred to as Cloud Continuum, IoT Continuum, Edge-to-Cloud or Fog-to- Cloud, is expected to provide the means for data processing both in the Edge and Cloud, while inferring and persisting valuable information for post-mortem and offline analysis. The ICOS project will embed a well-defined set of functionalities, ending up in the definition of an IoT2Cloud Operating System (ICOS).

The main objective of the project ICOS is to design, develop and validate a meta-operating system for a continuum, by addressing the challenges of:

i. devices volatility and heterogeneity, continuum infrastructure virtualization and diverse network connectivity;
ii. optimised and scalable service execution and performance, as well as resources consumptions, including power consumption;
iii. guaranteed trust, security and privacy, and
iv. reduction of integration costs and effective mitigation of cloud provider lock-in effects, in a data-driven system built upon the principles of openness, adaptability, data sharing and a future edge market scenario for services and data.

To achieve its goals ICOS project is looking for:

1. **[CLOSED] Solutions development projects (**1st Open Call**)**: consortia of 2 organisations (SME/midcap; technology provider, and an end-user to validate the developed project) to develop a use case within a specific sector, using ICOS technology.
2. **ICOS uptake projects (**2nd Open Call**)**: technology providers (SME/midcap) developing services/ products in the sectors of the ICOS PILOT use cases and the use cases proposed by the projects from the 1st Open Call (see Annex B on the Guide of Applicant). The 2nd Open Call winners must address the uptake of ICOS platform. The services/products must be onboarded to the ICOS system and should address the possibility to test the ICOS functionalities and performance allowing the ICOS team to improve the ICOS final product.

The ICOS use cases play an important role in the project: they will provide functional and non-functional requirements for the ICOS System and they will be early adopters of the system providing essential feedback on how to improve it. At the same time, the adoption of ICOS will enhance the use cases with unique application deployment and runtime management features implemented by ICOS.

[See more: Annex A: ICOS Architecture/infrastructure and Annex B: List of use cases on this guide, Deliverable 2.3 covering the ICOS technologies and ICOS data repository on Github].

2 What do we offer?

In the 2nd ICOS Open Call, up to 15 uptake projects will be developed based on the sectors of the 9 already existing use cases listed in Annex B. Selected uptake projects will deploy their technology into the ICOS system to test its functionalities and provide feedback to the ICOS team.

The selected projects will receive:

1. 6 month support from ICOS partners to integrate their solution into the ICOS system
2. up to **60,000 €** per project,

Applications are welcome from **10th of July 2024 at 9:00 (Brussels time)** until **30th of September 2024 at 17:00 (Brussels time)** on https://icos2.fundingbox.com/.

3 Eligibility Criteria

To participate in ICOS 2nd Open Call programme you have to meet all the criteria described in Section 3 of this Guide, positively pass our evaluation process and finally sign the Subgrant Agreement with ICOS Consortium.

The projects that do not comply with the criteria described in this section will be excluded. We will check the eligibility criteria during the whole evaluation process.

3.1 Who are we looking for?

Through the 2nd Open Call, we are looking for:

- An individual entity (SME[1] or Midcap[2]) registered as legal entity before the 30th of Sept 2024 in.

One of the following countries[3]:

- The Member States of the European Union and its Overseas Countries and Territories (OCT)[4] or

[1] An **SME** will be considered as such if it complies with the European Commission's Recommendation 2003/361/EC. As a summary, the criteria defining an SME are:

- Headcount in Annual Work Unit (AWU) less than 250.
- Annual turnover less or equal to €50 million OR annual balance sheet total less or equal to €43 million.

Note that the figures of partners and linked enterprises should also be considered as stated in the SME user guide. For detailed information check EU recommendation: https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

[2] **Middle-capitalization company' or 'Midcap**' means an enterprise that is not a SME and that has up to 3 000 employees, knowing that the staff headcount is calculated in accordance with Articles 3 to 6 of the Annex to Commission Recommendation 2003/361/EC:

https://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:124:0036:0041:EN:PDF

[3] The applicants who are subject to EU restrictive measures under Article 29 of the Treaty on the European Union (TEU) and Article 215 of the Treaty on the Functioning of the EU (TFEU) are not eligible to participate in this open call. Please note that the EU Official Journal contains the official list, and, in case of conflict, its content prevails over that of the EU Sanctions Map.

[4] Following the Council Implementing Decision (EU) 2022/2506, as of 16th December 2022, no legal commitments can be signed with Hungarian public interest trusts established under Hungarian Act IX of 2021 or any entity they maintain. Affected entities may continue to apply to calls for proposals. However, in case the Council measures are not lifted, such entities are not eligible to participate in the ICOS 2nd open call. In case of consortium, co-applicants will be invited to remove or replace that entity. Tasks and budget may be redistributed accordingly.

- Horizon Europe Associated Country[5] .

Each applicant must act as a technology-provider who will develop an application in one of the indicated sectors below: (see the Annex B for more details).

1. agriculture robotics,
2. railway monitoring,
3. automotive multimedia management,
4. energy management at domestic uses,
5. structural health monitoring,
6. smart cities,
7. energy management - smart grids,
8. climate and space weather,
9. occupational safety.

The ICOS partners (or their affiliate entities or employees, including persons working under employment contract or contract or similar to employment contract and board members) are not eligible to act as applicants.

The applicants who are subject to EU restrictive measures under Article 29 of the Treaty on the European Union (TEU) and Article 215 of the Treaty on the Functioning of the EU (TFEU)[6] are not eligible to participate in this open call.

3.2 What types of activities can be funded?

The activities that qualify for financial support have to fall within the scope of the ICOS project, which means that applicants, acting as technology providers, must address the **uptake of ICOS platform** in different sectors of application, defined through 9 existing sectors linked to the Use Cases (Annex B).

Activities will range from general applications to specific services that could be applied in one of the 9 pre-defined sectors (described below). Those applications must be onboarded to the ICOS system and should address the possibility to test the ICOS functionalities and performance allowing the ICOS team to improve the ICOS final product.

As referenced in Section 3.1, applicants must address one of the following sectors:

1. agriculture robotics,
2. railway monitoring,
3. automotive multimedia management,
4. energy management at domestic uses,
5. structural health monitoring,
6. smart cities,
7. energy management - smart grids,
8. climate and space weather,
9. occupational safety.

[5] (AC up to 10.07.2024.): Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Iceland, Israel, Kosovo, Moldova, Montenegro, North Macedonia, Norway, Serbia, Türkiye, Tunisia, and Ukraine, for the most up-to-date list please first part of this document.

[6] Please note that the EU Official Journal contains the official list, and, in case of conflict, its content prevails over that of the EU Sanctions Map.

The usage of the ICOS system to describe and orchestrate applications and services is a **must.** Furthermore, those projects that prioritise the up-take and the integration/exploitation of additional technologies offered by ICOS (e.g., in the domain of data management, security and intelligence) will be given preference. [See more: Annex A: ICOS Architecture/infrastructure, Annex B: List of use cases, Deliverable 2.3 covering the ICOS technologies and ICOS data repository on GitHub.].

Your project should have a clear **European Dimension** meaning that your project should participate in increasing European autonomy in data processing required to support future hyper-distributed applications by building open platforms and an open edge ecosystem including business models, driven by European actors. Moreover, it should be in some way triggering a market shift from the widespread of cloud-based infrastructure models dominated by non-EU players, towards a future strategy for European product and system innovation and leadership based on a compute continuum with strong capacities at the Edge and Far Edge infrastructure. It should impact an improved European leadership in the global data economy and reinforce Europe's ability to manage urgent societal challenges.

Due to ICOS being an Open source project by nature, we encourage the developed technology that will **be integrated in the ICOS architecture** to be open source.

3.3 Ground rules

When applying to ICOS' 2nd open call, please also note that:

- **Be on time and use our system:** Make sure you submit your proposal through the online form before the deadline **30th of September 2024 at 17:00 (Brussels time)**). If you submit the form correctly, the system will send you a confirmation of your submission. Get in touch with us if it is not the case (see Section 6). It is important for you to know that we will not be evaluating any proposal sent after the deadline and submitted outside the dedicated form.
- **English language:** Your proposal must be written in **English** in all mandatory parts to be eligible. Only information provided in English will be evaluated. If the mandatory parts of the proposal are in any other language, the entire proposal will be rejected).
- **Every question deserves your attention:** All mandatory sections of your proposal - generally marked with an asterisk - must be completed. The data provided should be actual, true, and complete and should allow assessment of the proposal. Additional material, not specifically requested in the online application form, will not be considered for the evaluation. We will ask you to insert the exact cost estimation/exact budget split in the application form.
- **Be exhaustive:** You have to verify the **completeness of the form**, as it will not be possible to add any further information after the deadline. After the proposal is submitted, you will be able to modify the form until the deadline.
- Applicants can submit **multiple proposals** in this open call. Though applicants could submit multiple applications, neither team members nor any legal entities can be funded twice by ICOS. In the case that more than one proposal with any similar team members or from the same organisation will be among the selected projects, only the one with more points will be funded
- **Conflict of interest**: We will take into consideration the existence of potential **conflict of interest** among you and one or more ICOS Consortium partners[7]. Consortium partners, their affiliated entities, employees, and permanent collaborators cannot take part in the ICOS support programme. All cases of potential conflict of interest will be assessed on a case-by-case basis.

[7] https://www.icos-project.eu/consortium

- **Healthy finances and a clean sheet are a must:** we don't accept entities that are under liquidation or are an enterprise under difficulty[8] according to the Commission Regulation No 651/2014, art. 2.18, or that are excluded from the possibility of obtaining EU funding under the provisions of both national and EU law, or by a decision of both national or EU authority. We also don't accept entities that are meeting national regulations regarding bankruptcy.
- Your project should be based on your original work or your right to use the **IPR** must be clear. Going forward, any foreseen developments must be free from third party rights, or those third-party rights must be clearly stated (you must have a licence agreement or the IPR must be transferred to you from somebody who created the work). In particular, any work related to the implementation of the project described in the application may not violate the IPR of third parties, and the IPR to the application project may not be the subject of a dispute or proceedings for infringement of third party IPR.
- As ICOS is by nature an Open source project, we encourage the developed technology that will **be integrated in the ICOS architecture** to be open source. Results are owned by the beneficiaries that generate them. The Open Call Sub-Grant Agreement will introduce provisions concerning joint ownership of the results generated within the ICOS project, if applicable. This will be assessed and negotiated on a case-by-case basis.
- Beneficiaries of the ICOS' 1st Open Call **cannot** be selected in the ICOS 2nd Open Call.
- **Acceptance of the open call rules:** to apply for this open call you have to accept its rules and regulations detailed in this Guide for applicants.

If you need extra hints on how to prepare your application, check out the section 8 Extra hints before you submit your proposal.

[8] An enterprise will be considered an undertaking in difficulty ii more than half of the capital has disappeared. This refers to the loss of "subscribed share capital". If profit and loss reserves deficit more than 50% of share capital, there is a potential problem with the company. (Article 2, item 18-point a) and b)

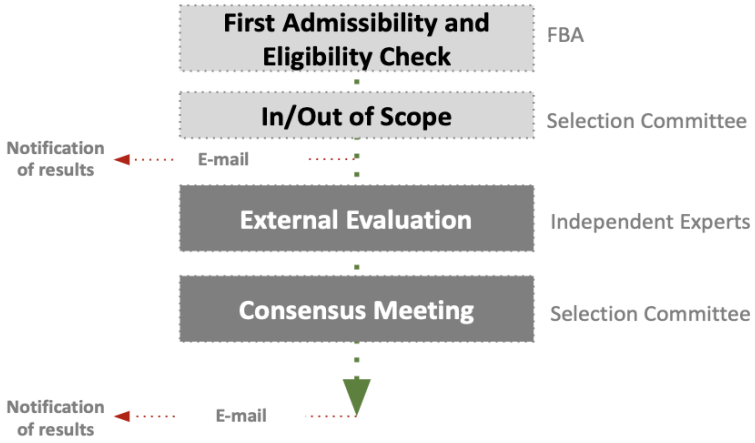
(a) In the case of a limited liability company (other than an SME that has been in existence for less than three years [...]), where more than half of its subscribed share capital has disappeared as a result of accumulated losses. This is the case when deduction of accumulated losses from reserves (and all other elements generally considered as part of the own funds of the company) leads to a negative cumulative amount that exceeds half of the subscribed share capital. For the purposes of this provision, 'limited liability company' refers in particular to the types of company mentioned in Annex I of Directive 2013/34/EU (1) and 'share capital' includes, where relevant, any share premium

(b) In the case of a company where at least some members have unlimited liability for the debt of the company (other than an SME that has been in existence for less than three years [...]), where more than half of its capital as shown in the company accounts has disappeared as a result of accumulated losses. For the purposes of this provision, 'a company where at least some members have unlimited liability for the debt of the company' refers in particular to the types of company mentioned in Annex II of Directive 2013/34/EU.

Please note that, if your SME exists from less than three years, you won`t be considered as undertaking in difficulties.

4 How will we evaluate your proposal?

Our evaluation process is transparent, fair and equal to all our participants with a clearly defined complaint procedure (see section 6.2 Complaints). We will evaluate your project in four phases.



4.1 First Check

Once the open call is closed, we will check whether it meets the conditions set up in section 3. We will do it on the basis of the statements included in your proposal.

At this stage, the eligibility criteria are checked against a Declaration of Honour or self-declarations included in the application form. Later on, the above criteria will be verified during the whole evaluation process (including the final formal check).

The projects that do not comply with these criteria will be rejected.

4.2 In/Out of scope

In order to make sure that our support helps in achieving an optimal impact in the framework of ICOS project it's important that all proposals match the scope of the types of activities described in section 3.2 and clearly demonstrate it.

For this reason, at least, one Selection Committee partners and relevant use case experts will review the following aspects of your proposal:

- **Scope.** The objectives of the proposal must fit within the scope of the project as it is described in this Guide for Applicants. It should be clear that applicants are going to make use of the ICOS platform in the testing for the ICOS uptake which should be conducted on the ICOS platform.

  Please refer to Annex A: ICOS Architecture/infrastructure, Annex B: List of use cases, Deliverable 2.3 covering the ICOS technologies and ICOS data repository on Github, to demonstrate the alignment of your project with ICOS.
- **European Dimension.** As described in section 3.2 above

The experts from our Selection Committee and use cases experts will assess if your proposal complies with the aspects above on a YES/NO basis and will provide reasoning in the cases where no compliance evidence is found. The Selection Committee will justify their assessment in case of rejection of the proposal. The Selection Committee will verify the validity of each rejection.

Be aware that proposals that do not comply with any of the aspects described above will be rejected. The ones complying with all of them will move on to the external evaluation phase

We will inform you about the results of the first check and the In/Out of Scope phase.

4.3 External Evaluation

In this phase, each project will be evaluated by 3 independent experts, appointed according to the specific characteristics of the applicants from the pool of External Experts. Your project will be evaluated within the following awarding criteria:

EXCELLENCE will evaluate:

- Ambition and ICOS platform usage: Applicants have to demonstrate how they plan to use the ICOS platform for integrating, orchestrating and testing their services and products and how the validation of their product will contribute to the ICOS platform. Projects should also have a European dimension and is beyond the state of the art. Applicants have to demonstrate the innovative approach to be applied to foster the further uptake of Final ICOS platform in addressed sectors.
- Innovation: applicants have to provide information about the level of innovation within their sectoral domain and about the degree of differentiation that this project will bring.
- Soundness of the approach and credibility of the proposed methodology.

IMPACT will analyse:

- Market opportunity: applicants have to demonstrate a clear idea of what they want to do and whether the new/improved product/service has market potential, e.g. because it solves a problem in one of the 9 pre-defined sectors (see Section 3.2 and Annex B for more detail)
- Competition: applicants have to provide information about the degree of competition for their particular product and if the idea is disruptive and breaks the market. i.e. the product to be brought to market can be clearly differentiated from the competition.
- Commercial Strategy and Scalability: applicants have to demonstrate the level of scalability of the new/improved product/service) meaning by not addressing a specific problem but able to be commercialised to solve a structural problem in their specific sector/process/etc. of application.
- Environmental and Social Impact: applicants have to demonstrate the project contribution towards environmental, social and economic impacts to contribute to sustainable development, Green Deal and other European policies.

IMPLEMENTATION will consider:

- Team: The applicants have to demonstrate their management and leadership qualities, their ability to take a concept from ideas to market, their capacity to carry through their ideas and understand the dynamics of the market they are trying to tap into. The team should be a cross-functional team, with a strong background and skills base and taking into account its gender balance.
- Resources: Demonstrate the quality and effectiveness of the resources assigned in order to get the objectives/deliverables proposed. Implementation of applications in a specific domain has to be clearly explained.

The evaluators will score each award criterion on a scale from 0 to 5:

- 0 = Proposal fails to address the criterion or cannot be assessed due to missing or incomplete information
- 1 = Poor – criterion is inadequately addressed or there are serious inherent weaknesses
- 2 = Fair – proposal broadly addresses the criterion, but there are significant weaknesses

- 3 = Good – proposal addresses the criterion well, but a number of shortcomings are present
- 4 = Very good – proposal addresses the criterion very well, but a small number of shortcomings are present
- 5 = Excellent – proposal successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

Each evaluator will produce an Individual Evaluation Report. The **threshold for individual criteria** will be 3. The **overall threshold** per Individual Evaluation Report, applying to the sum of the three individual scores, will be 10. The final score will be calculated as an average of the individual assessments provided by the Evaluators.

Ties will be solved using the following criteria. The criteria in order of priority are:

1. The highest score in the Impact Section.
2. Gender balance among the personnel responsible for carrying out the activities.

As a result of the Independent Evaluation, a 'Ranking List' will be produced. All proposals obtaining a score above the threshold, will pass to the next phase.

4.4 Consensus Meeting

The 'Selection Committee' formed by FundingBox, ATOS, Universitat Politecnica de Catalunya (UPC), Ireland's Centre for Applied AI (CEADAR), Engineering (ENG), Worldsensing (WSE), and if necessary use case experts and, 3 external experts (in advisory capacity) will decide by Consensus (minimum ⅔ of the votes) the 'List of Finalists' and the 'Reserve List'. The discussion will be based on the ranking obtained as a result of the External Evaluation.

Whilst normally the highest ranked proposals will be selected for funding, the Selection Committee might have fair reasons for objecting to a specific third party, like the alignment with ICOS' goals and scope, fit to the ICOS Use Cases sector needs, the ability to achieve the highest impact possible, commercial competition, as well as the existence of significant ethical concerns or a potential conflict of interest. In this case, the choice may pass to the next-ranked proposal.[9]

The exact number of proposals approved will be decided based on the overall **quality** of the proposals.

4.5 Formal Check, Sub-grant Agreement Preparation and Signature

Before you get started with the ICOS support programme, you need to sign the Subgrant Agreement with the ICOS Consortium.

Prior to signing the Agreement, you should go through the ethics assessment and provide documents regarding your formal status for the legal check process. The ICOS Consortium will verify them to prove your eligibility.

To confirm your formal status, we may ask you for (not an exhaustive list): company's registration document, the legal representation (optionally POA), tax ID number; ownership structure[10], financial statements; document/s confirming the staff headcount, Bank Identification form, other documents in case of doubts raised during the checks.

[9] Please note that this is not a closed list of reasons.

[10] If the ownership structure is not clear from the registration documents, additional documents confirming the ownership structure, e.g. statute, company deed, founding act, share register, in a joint-stock company - list of the company's shareholders; etc, may be requested.

Be extremely vigilant to:

1. **The nature of the documents** we request.
   If the documents you provide us with do not prove your eligibility, your participation will end here.
2. **The deadlines** that we will give you to hand us these documents.
   If you do not deliver the requested documents on time, without a clear and reasonable justification, we will have to exclude you from further formal assessment. Another applicant from the Reserve list will then replace you.

5 Our Support Programme and Payment Arrangements

Once your eligibility has been confirmed following the formal check and the Subgrant Agreement has been signed, you will become an official grantee of the ICOS support programme. As a selected grantee, you will receive a fixed lump sum of up to €60.000 divided into 3 payments.

The lump sum is a simplified method of settling expenses in projects financed from Horizon Europe Programme funds. It means that the grantee is not required to present strictly defined accounting documents to prove the cost incurred (e.g. invoices) but is obliged to demonstrate that the implementation of the project is in line with the milestones set for it. Simply speaking, it means that we will carefully assess your progress and the quality of your work during Interim Reviews. The milestones (deliverables, KPIs and ethical recommendations) will be fixed in the 'Individual Mentoring Plan' elaborated at the beginning of the programme.

The lump sum method does not exempt you from collecting documentation to confirm the costs under fiscal regulations.

The ICOS 2nd open call programme will last up to 6 months and consists of 3 stages (Stage 1 - Requirements & Design, Stage 2 - Application level, Stage 3 - Sectorial demonstration).

The grant will be paid in the following scheme:

	ICOS uptake projects		
Stages	**Stage duration**	**Deliverable**	**Fixed lum sum**
Stage 1 Requirements & desgin	1 month	Design of application using ICOS	up to 9.000 €
Stage 2 Application level implementation	3 months	Development of application through ICOS final release	up to 35.000 €
Stage 3 Sectorial demonstration	2 months	Implementation at sectorial case and report	up to 16.000 €
TOTAL	**6 months**		**up to 60.000 €**

5.1 Stages and payment schedule

Payment of the given tranche depends on the proper and timely execution of the work planned in the 'Individual Mentoring Plan'. The Selection Committee will evaluate your progress on a regular basis. For more details check the SGA template.

5.2 Review process

Projects selected will define, at the beginning of the support programme, together with the technical mentors allocated, their 'Individual Mentoring Plan' (IMP)[11]. At the end of each milestone, an exhaustive review process will be implemented by the technical mentors in order to pay the projects against the validation of the deliverables and KPIs pre-defined in IMP.

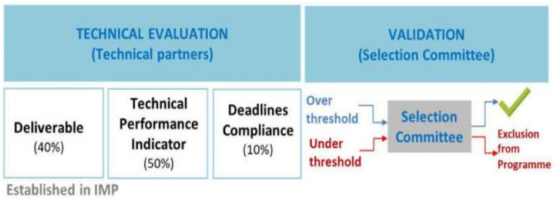
Beneficiaries selected will go through the review process for each defined milestone that will be defined based on the predefined stages, at the beginning of the support programme, together with the Technical partners allocated, in the beneficiaries 'Individual Mentoring Plan' (IMP). At the end of each milestone, The Technical partners will evaluate the beneficiaries' performance according to the criteria where each criterion will be scored from 0 to 10 and the weight of each one of these criteria, in the final score, will be as follow:

- **Deliverables' quality.** (40%) To be scored by the Technical partners, based on the Deliverables established in the IMP.
- **Technical performance indicators.** (50%) To be scored by the Technical partners based on the Milestones established in the IMP.
- **Deadline Compliance.** (10%) To be scored by the Technical Partners.

According to this final score:

- **Beneficiaries over threshold** (which is 7 points) will successfully receive the next payment and become candidates to continue in the program.
- **Beneficiaries under threshold** will be proposed, by the Technical partners, as candidates to leave the Program. And if this decision is finally ratified by the Selection Committee, they will have to leave the Program and won't receive the payment

The Selection Committee will review and validate the Technical partners' proposal, putting special attention to the 'under threshold' cases, if any, by taking into consideration all possible objective reasons for underperformance. The Selection Committee will take the final decision and approve the payments.



[11] The Individual Mentoring Plan (IMP) is the document that establishes the individual budget, KPIs, Deliverables and a schedule that

will be taken into account when evaluating the Grantees' performance at the Milestones Review. The IMP will be defined by the Grantees, together with the technical partners, at the beginning of the Support Program and validated by the Selection Committee.

6 Contact us

6.1 How can we help you?

If you have any questions regarding the application process, please feel free to post them on the Helpdesk Space (hosted by our Discord servers), or send us a message at icos@fundingbox.com. In case of any technical issues or problems, please include the following information in your message:

- Your username, telephone number and your email address;
- Details of the specific problem (error messages you encountered, bugs descriptions, i.e. if a dropdown list isn't working, etc.);
- Screenshots of the problem.

6.2 Complaints

If you believe that a mistake has been made after receiving the results of one of the evaluation phases (when foreseen), you may submit a complaint. To do so please email us your complaint in English at icos@fundingbox.com and include the following information:

- Your contact details, including email address,
- The subject of the complaint,
- Information and evidence regarding the alleged breach.

You have **3 calendar days** to submit your complaint, starting from the day after the communication was sent. We will review your complaint within seven calendar days of its receipt. If we need more time to assess your complaint, we will notify you by email of the extension. Please note that we will not review anonymous complaints or complaints with incomplete information.

Please be aware that the evaluation is conducted by experts in the relevant field, and we do not interfere with their assessment. Therefore, we will not evaluate complaints related to the results of the evaluation other than those related to procedural or technical mistakes.

7 Last but not least - final provisions

Any matters not covered by this guide will be governed by Polish law and rules related to the Horizon Europe and EU grants. Please take into account that we make our best effort to keep all provided data confidential. However, for the avoidance of doubt, you are solely responsible to indicate your confidential information as such.

Your IPR will remain your property.

For the selected grantees, the Subgrant agreement will include the set of obligations towards the European Commission (for example: promoting the project and giving visibility to the EU funding, maintaining confidentiality, understanding potential controls by the EC/ECA, EPPO and OLAF).

The ICOS Consortium might cancel the call at any time, change its provisions or extend it. In such a case we will inform all applicants about such change. Signature of the SubGrant agreement is an initial condition to establish any obligations among applicants and any Consortium partners (with respect to the obligation of confidentiality of the application).

8 Extra hints before you submit your proposal

A proposal takes time and effort and we know it. Here are some few crucial points you should read before submitting your proposal.

- Is your project in line with what ICOS is looking for? You are not sure? You can consult section 3.1 and section 3.2.
- Did you present your project in a way that will convince evaluators? Not sure if you did? Go back to section 4.
- Is your project fulfilling all eligibility requirements described in the Guide? Check again section 3.
- Are you sure you are able to cope with our process of the SubGrant agreement signature and payment arrangements for selected proposals? You may want to go over the section 4.5.
- Did you check our Sub Grant agreement Template? You didn't? Check it here
- Do you need extra help? Contact us or use our frequently asked questions space hosted by Discord.

Good Luck!

Annex A: ICOS architecture White Paper

Motivation and objectives

A continuum, today also referred to as Cloud continuum, IoT continuum, Edge-to-Cloud or Fog-to-Cloud, is expected to provide the means for workloads execution and data processing both in the Edge and the Cloud. According to International Data Corporation's (IDC) forecast, the total Edge spending in the EU will reach 75 billion dollars by 2026. In Europe, Edge computing is expected to increase at an annual growth rate of 26,5%, from €815m in 2020 to €2.6bn in 2025[12,13]. Ensuring the security of data at the Edge as well as setting-up and maintaining an Edge infrastructure that can support highly demanding workloads are among the main barriers to the Edge adoptions in the enterprises[14].

Despite the intensive research activities and clear industrial trends in this field, performance and efficiency of resource usage as well as contextual intelligence of a continuum, remains a daunting challenge. This is not only due to the continuum being intrinsically heterogeneous, volatile, distributed and increasingly cognitive, but also due to the emerging request to be open and collaborative. Networking, AI, green computing and parallel processing are just some of the further research topics that need to be leveraged in order for the continuum to become mainstream.

There is a real need for an integrated platform to unleash the potential of European providers across the continuum. Currently missing from the Edge-Cloud scape is an open, non-proprietary, interoperable, robust, secure, sustainable multi-Cloud and multi-Edge continuum hosting solution, aimed at optimising the execution of workloads, especially in data intensive applications, and able to adapt to different strategies (e.g., execution time reduction, concurrent execution, Edge processing, fog security, locality, high resource utilisation, low latency and high energy efficiency), while being scalable, extensible and open to experimentation.

ICOS pushes the envelope towards the next generation of continuum management by proposing a high-level meta operating system (metaOS) to realise an extensible, open, secure, adaptable, AI-powered as well as well highly performant and technology agnostic continuum.

ICOS continuum will contribute to an open ecosystem, enabling interoperability with existing and emerging frameworks, towards a collaborative European Edge market scenario. It will provide new opportunities to European actors to establish.

[12] Rowan, Brendan, Álvarez, José Enrique, & Kušíková, Zuzana. (2023). Technology scoping paper (1.0). Zenodo. https://doi.org/10.5281/zenodo.8020703

[13] Worldwide Edge Spending Guide (2021). IDC. https://www.idc.com/getdoc.jsp?containerId=IDC_P39947

[14] Future Enterprise Resiliency and Spending Survey (2022). IDC. https://www.idc.com/getdoc.jsp?containerId=US48925022

The ICOS project will design, develop and validate a meta operating system for the continuum built upon the principles of openness, adaptability, data sharing and a future Edge market scenario, addressing the challenges of: i) devices volatility and heterogeneity, ii) continuum infrastructure virtualization and diverse network connectivity; iii) optimised and scalable service execution and performance, as well as resources consumptions, including power consumption; iv) guaranteed trust, security and privacy, and; v) reduction of integration costs and effective mitigation of Cloud provider lock-in effects.

The ICOS Architecture

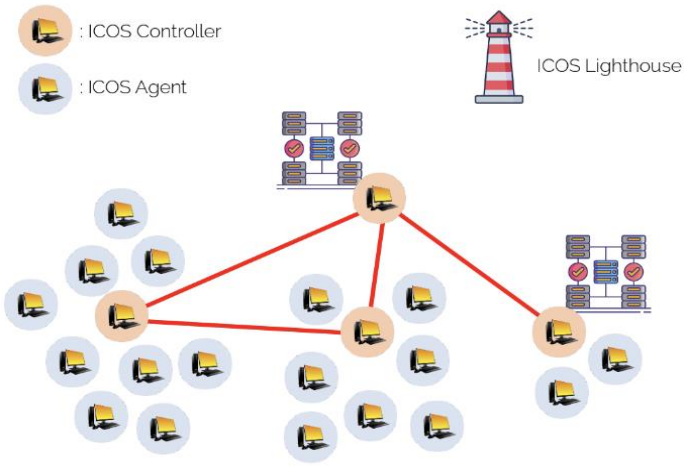


Figure 1: ICOS continuum nodes

ICOS has been conceived as a dynamic metaOS distributed along the continuum. The major design principle in ICOS leverages the capabilities of both the Cloud (virtually unlimited computing and storage capacity, ubiquity) and the Edge (locality exploitation, latency and communication reduction, privacy preservation), to optimise both the usage of resources and the performance of the users' workloads. One of the most interesting characteristics of ICOS is its elasticity, being able to manage dynamic and mobile nodes efficiently and seamlessly. Thus, nodes can join or leave the system dynamically, or move throughout the continuum, establishing new proximity-based relationships between other nodes in different geographic locations. To realise these scenarios, two types of nodes will compose the continuum (Figure 1): the **Agents** that execute the users' workloads, and the **Controllers** that are responsible for managing the agents. The architecture also includes a 'Lighthouse' functionality to simplify and automate the dynamic on-boarding, disconnection, re-connection and migration of ICOS Agents to ICOS Controllers.

ICOS Agents are distributed along the continuum, ranging from constrained computation devices at the far Edge to high performance computing resources at the Cloud level. IoT and storage devices are attached to Agents, so both data access and computation of users' workloads are executed on Agents. The ICOS metaOS has been designed to be able to provide a very large number of heterogeneous Agents distributed over a wide geographical area. In order to efficiently manage such a huge number of nodes while exploiting the advantages of locality, a set of ICOS Controllers should be deployed along the continuum to cover the whole geographical area. ICOS Controllers are distributed with a flat,

unstructured organisation. ICOS will run both on Agents and Controllers realising a unique, distributed Continuum middleware.

The ICOS conceptual architecture is built on four functional layers (Figure 2): the Distributed Meta-Kernel Layer, the Intelligence Layer, the Security Layer and the Data Management Layer. All layers are distributed along the ICOS Continuum providing functionalities at node level (e.g., node security assessment) as well as at continuum level (e.g., global workloads deployment optimisation). This widely distributed approach allows to decentralise the management of the continuum, reduce data transfers, ensure privacy and better exploit computational resources at the Edge without the need for a central point of control. An additional module, referred to as ICOS Shell, includes the user interfaces and the tools to interact with the ICOS continuum.

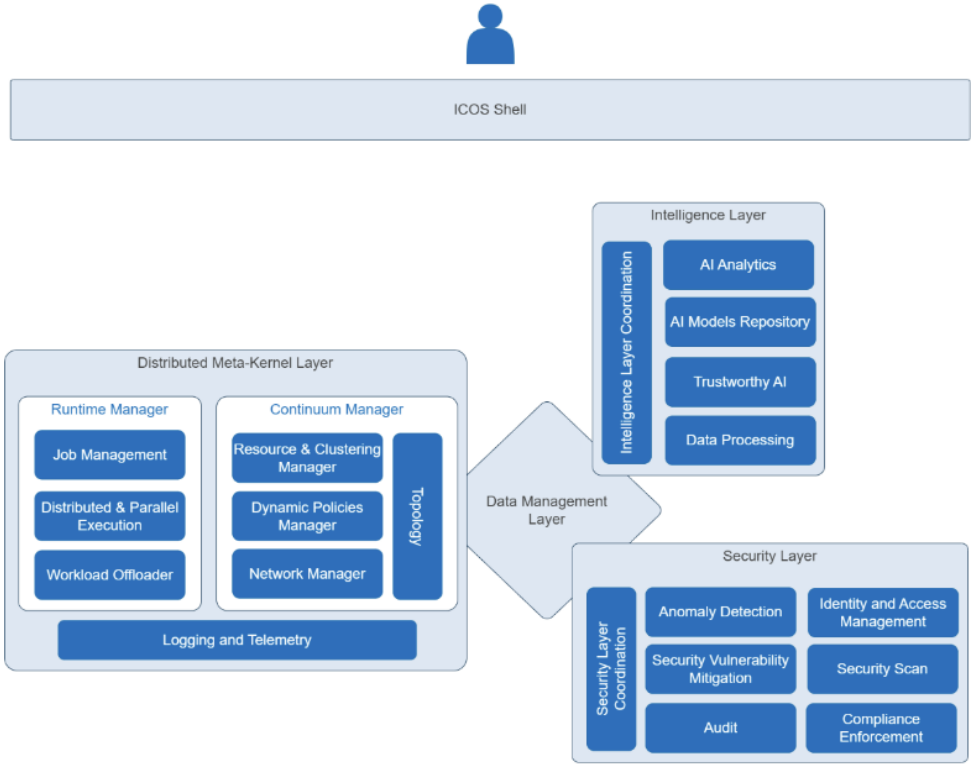


Figure 2: The ICOS conceptual Architecture

The **Distributed Meta-Kernel Layer** provides the base functionalities necessary to make Cloud and Edge resources manageable and ICOS-ready: the set-up and maintenance of an ICOS Continuum, and the execution of user's workloads. Key modules of this layer are described next.

The Continuum Manager is responsible for: i) registering and configuring resources (Cloud resources and Edge devices) to the Cloud Continuum; ii) discovering, labelling, and classifying the Edge devices and the IoT devices; iii) enabling the infrastructure and operational aspects to fulfil the remote execution

of the user's workloads on the ICOS Continuum, and; iv) monitoring the status of the continuum and enforcing system and application policies.

The Runtime Manager is responsible for ensuring the underlying devices to fulfil execution requests from the upper layers of the ICOS metaOS (i.e., the ICOS Shell). The Runtime Manager components will: a) convert the service execution request into a workflow of tasks and generate an execution strategy; b) distribute the execution of tasks into multiple devices and orchestrate their execution; c) enforce optimal allocation policies and react to anomalies adapting the execution, and; d) ensure that the user workload is performing according to the expected Service Level Agreement (SLA) criteria. These functionalities are realised thanks to a joint collaboration of three main components: the Job Manager, deployed in the ICOS Controllers and receiving execution requests; as well as the Distributed & Parallel Execution and the Workload Offloader both deployed in the ICOS Agents and controlling the actual execution.

The Logging and Telemetry facilitates the collection of telemetry from the whole continuum, providing vertical application operators with a single view of performance, errors, logs, and component availability. Its goal is to effectively run and operate an end-to-end, multi-tenant, easy-to-operate and scalable observability system on the ICOS metaOS. The component enables the ingestion, long-term storage, and use of common observability signals, such as Quality of Service (QoS) metrics of applications and resources, logging and tracing from the entire continuum under a single consistent system with well-defined tenancy APIs and signal correlation and prediction (using the functionalities of the Intelligence Layer) capabilities. Monitoring a large and diverse set of distributed computing resources and software, generates a large amount of data of various types and may require these data to be analysed, pre-processed, and aggregated if necessary, and transmitted from Edge nodes / IoT devices where monitored services are deplo<<<<<<<<<<fyed to locations where end-to-end services and resources management decisions are made. To prevent resource and application monitoring data from further contributing to the data overload, intelligent mechanisms will be implemented by the Monitoring and Telemetry component to automatically and dynamically decide what data to collect (i.e., what type of monitoring data to measure), the granularity of the data (i.e., what level of information to collect for a given item), and the frequency of the data (i.e., the interval between two collections for a given item).

The **Security Layer** is responsible for guaranteeing the security of ICOS users, resources, and applications at all times. It includes modules for authentication and authorization operations in the system, assess security of resources and applications and suggest mitigation actions, proactive discovery of anomalous behaviours and verification of the compliance of resources and applications. The main modules of this layer are introduced next.

The layer is coordinated by the Security Layer Coordination module that provides a unified interface for interacting with the Security Layer functionalities. It also manages data flows inside the layer and provides additional logic needed for seamless interactions between Security Layer's modules (e.g., task scheduling and periodic tasks).

The Anomaly Detection module is responsible for detecting anomalies in system and application logs. The Anomaly Detection module follows two workflows. The first workflow is a typical log-based anomaly detection workflow, consisting of log template extraction, learning normality, and anomaly detection[15]. The second workflow is the time series models using the numerical features extracted earlier from log-templates.

The Security Vulnerability Mitigation module operates based on rule triggering by which fulfilment of a certain rule initiates the execution of a certain recovery or mitigation processes. The latter can either be fully independent and automated or require the user's input. The basic rules and responses are pre-defined in static maps that can be further modified by the end user and also the Intelligence layer's AI Analytics module will offer further mitigation strategies and rules.

The Audit module is responsible for executing a series of light-audit checks, defining specific checkpoints that need to be passed to consider the audit successful. Those checkpoints explore different aspects of the Cloud Continuum realisation and take place upon the on-boarding of any infrastructure, ICOS element and resource. The goal of the component is to identify potential vulnerabilities and risks, either during on-boarding or when triggered during runtime by the Security Coordination Module. Furthermore, it can assist in developing a security compliance checklist that may be tailored to each deployed application.

The Security Scan actively checks for security issues within deployed ICOS resources (at runtime and potentially at the design time[16]), detects issues and recommends mitigations and/or recovery processes (with help from the Security Vulnerability Mitigation module). The module may be called by the Audit module in case a security audit is to be enforced.

The Compliance Enforcement module is responsible for defining (and, in general, managing) security compliance policies for resources and applications in the ICOS System, automating the verification of the active policies and triggering remediation activities for compliance violations. Compliance Enforcement will work in conjunction with the Security Vulnerability Mitigation module for the definition of remediation activities.

The Identity and Access Management module has the overall objective of ensuring that the right people will have access to the right resources in the system. The three main responsibilities of this module are, the management of the users and their roles/permissions, the authentication of the users and the authorisation of the requests within the system. All ICOS components will rely on this module to make

[15] Jan Antić, Joao Pita Costa, Aleš Černivec, Matija Cankar, Tomaž Martinčič, Aljaž Potočnik, Gorka Benguria Elguezabal, Nelly Leligou, & Ismael Torres Boigues. (2023, May 15). Runtime security monitoring by an interplay between rule matching and deep learning-based anomaly detection on logs. https://doi.org/10.5281/zenodo.7937448

[16] Matija Cankar, Nenad Petrović, Joao Pita Costa, Aleš Černivec, Jan Antić, Tomaž Martinčič, & Dejan Štepec. (2023, April 15). Security in DevSecOps: Applying Tools and Machine Learning to Verification and Monitoring Steps. ICPE '23 Companion: Companion of the 2023 ACM/SPEC International Conference on Performance Engineering, April 2023 (ICPE). https://doi.org/10.1145/3578245.3584943

sure that the received requests are properly authenticated (the requesting entity is known, and it is confirmed that it is who it says to be) and authorised (the requesting entity has the requested privileges to do that request).

Trust and Privacy are fundamental principles on top of which the Security Layer, and the entire ICOS metaOS, is built. Trust will be implemented at the system-wide scale using a communication protocol that enables automated and assisted distributed systems to publish secure data which can be subscribed to by the safety monitoring ICOS system (both TLS and mutual TLS transport protocols). The safety monitoring system could run on the same virtual or physical ICOS controller (i.e., computer/device, a separate computer/device on the IoT network or a remote computer at the Edge or in the Cloud). Privacy comprehends a set of fundamental elements which can be utilised for transforming data, including encryption and anonymisation. The anonymisation is a part of the Data Management and Intelligence layers. In the case of the former, data stored might need to be anonymised to ensure compliance with the GDPR's specific component requirements. The Intelligence layer contains the data processing module, which aggregates different functions to anonymise data. Additionally, another part of this functionality is to ensure information encryption in communication and storage by using internal SSL/TLS certificates.

The **Intelligence Layer** has the objective of bolstering and enhancing the functions and efficacy of the security and meta-kernel layers. It is responsible for delivering capabilities to facilitate the training, testing, deployment, maintenance, and updating of analytical and machine learning models across data-intensive applications in the Edge/Cloud spectrum, while adhering to particular data and model usage policies, focusing on ensuring trustworthiness. Next, the key modules of the Intelligence Layer are presented.

The layer is coordinated by the Intelligence Coordination module that provides a unified interface for interacting with the Intelligence Layer functionalities. It also coordinates the internal modules to fulfil the incoming requests.

The Data Processing module aggregates libraries and frameworks to allow data processing and transformation at scale in various devices, ranging from Cloud to low-end devices and user applications using the ICOS metaOS. It allows data Access & Storage and preprocessing using the Data Management module (batch, stream, local, remote).

The AI Analytics module aggregates libraries and algorithms to train and forecast using state-of-the-art methods to achieve a smart meta-kernel and support the project ML use cases.

This component comprises a selected stack of streamlined machine learning algorithms and pipelines tailored to train and test predictive and optimisation models. It encompasses deep learning, adaptive and static batch machine learning, traditional machine learning, transfer learning and reinforcement learning libraries optimised to function efficiently on constrained devices. It considers models for both structured (e.g.; time-series) and semi (nested objects) or unstructured data (Text, Images). Advanced techniques, such as transfer learning, are to be considered in the second version of the module. The AI Analytics

module will enable the proliferation of Artificial Intelligence/Machine Learning (AI/ML) algorithms aiming to empower autonomous network management, heavily facilitating, and automating the orchestration of the network resources. Automatic management of AI/ML workflows and life-cycles can act as a significant subcomponent towards zero-touch automation.

The ICOS Model Repository offers a collection of pre-trained analytics and ML models that may be reused, updated, modified (e.g., transfer learning), and integrated to promote the deployment of novel AI approaches across the ICOS metaOS layers. It includes capabilities for training and compressing these models for being used in constrained devices. This repository will make it easier to store pre-trained models of different versions that can be pulled and integrated with the existing infrastructure. The management of all algorithms and libraries used in the various metaOS versions will be possible thanks to this repository, which also supports seamless collaboration, repeatability, and strong version control of the models.

The Trustworthy AI module addresses data privacy issues by using federated learning and data anonymization. Additionally, it provides functions to make models explainable and transparent, explaining what leads to a decision or a forecast.

Its goal is to provide specific algorithms to analyse the datasets and develop models while maintaining the utmost respect for privacy and trustworthiness policies. This can be done by allowing models to be trained in a federated learning fashion to ensure data protection in datasets containing user-specific data and by providing explainable AI algorithms that give meaningful insights into the output of models to the different layers in ICOS. Therefore, this component can be organised two-fold: 1) to ensure trustable, secure & robust model training via federated learning techniques, and 2) to provide model explainability through a series of AI interpretability algorithms, to aid the decision-making process of the models while understanding inputs and outputs. Both explainable AI methods and the ability for models to be trained via federated learning will be made available to provide data security in datasets, including user-specific data. This will give the various ICOS layers confidence in the models' output.

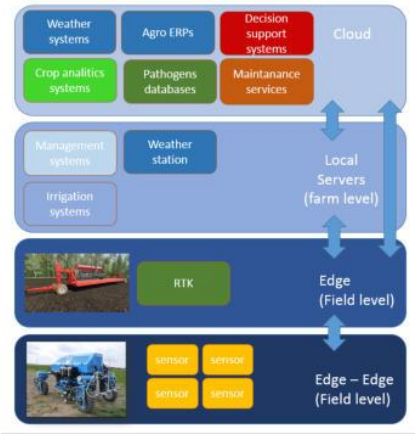
The **Data Management Layer** enables the communication between the different layers abstracting over the distribution of the system. Its main functionality is to ensure that the required data is available in those devices where it is needed and at the time that it is needed, to efficiently support ICOS operations. This layer will abstract infrastructure and communication details, so that the rest of ICOS components can focus on their specific functionalities and remain agnostic of the dynamicity and heterogeneity of the infrastructure. In addition, unnecessary data transfers will be avoided to reduce network congestion and increase overall performance of the platform. This layer also ensures that all data transfers between devices, as well as data at rest, are confidential.

In addition to the four layers, the **ICOS Shell** layer will allow users to interact with ICOS (e.g., infrastructure providers to manage their infrastructures, system integrators to manage their applications). The ICOS Shell will consist of three main components: the command line interface (CLI), the graphical user interface (GUI) and the development and operations (DevOps) tools. The Shell will be able to integrate with other tools and pipelines through support for machine-readable input and output.

Early Adopters: the project's Pilot Cases

The ICOS project includes four pilot cases that play an important role in the project, summarised in two critical aspects. First, pilot cases will provide functional and non-functional requirements for the ICOS System and, second, they will be early adopters of the system providing essential feedback on how to improve it. At the same time, the adoption of ICOS will enhance the pilot cases with unique application deployment and runtime management features implemented by ICOS.

Agriculture Operational Robotic Platform



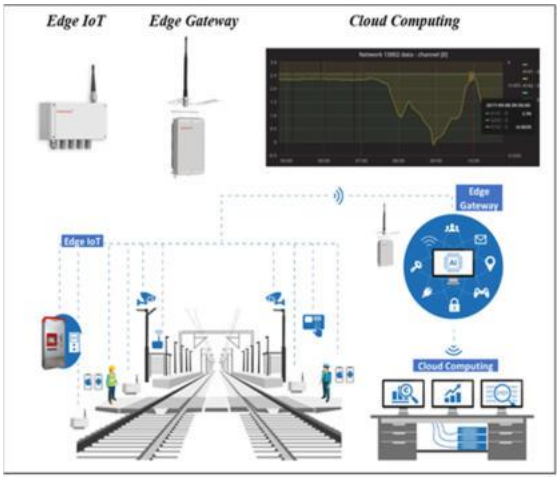
The Agriculture Operational Robotic Platform (AORP) is an agro robot that can execute different tasks and missions, like sowing and tending crops, removing weeds, monitoring crop development, and identifying threats. The platform moves autonomously through the field, performing the assigned missions. The robotic platform consists of control and driving modules. In addition, it is equipped with interchangeable tools - a seeder and a sprayer. The AORP is equipped with cameras, sensors and Edge computational devices that can be connected to the Cloud directly, via the transport platform, or via farm connectivity.

The **challenges** expected to be addressed in this pilot by ICOS are:

- Delays in accessing data affecting the limitation of field robots operating speed.
- Edge to Cloud orchestration of applications according to processing, or time requirements, improving the coexistence of real-time processing and coordination with Cloud services.
- Challenges in connectivity in real conditions and continuous monitoring of device operation.

The **benefits** expected by introducing the ICOS metaOS will be the reduction of the latency in decision taking by combining the computing capabilities on Edge and Cloud, the improvement of the AI models used during the missions, increasing the overall system availability, and the introduction of predictive maintenance in the AORP.

Railway Structural Alert Monitoring system



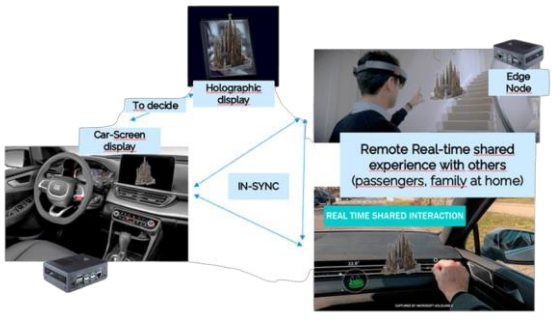
Today, the railway monitoring process is quite archaic. For most railway operators the inspection is done through physical inspections by railway staff or with a special train with sensors on its wheels which runs through the whole rail system. Unfortunately, with these methods, measurements are taken only once or twice a year; in the remaining months, nobody knows what happens, and moreover, there is no established procedure to evaluate the cost-effectiveness of the actions taken to address the identified rail line issues. That is where the IoT devices provided by Worldsensing can minimise the monitoring and maintenance costs and allow operators to monitor in real-time important aspects like: rail tracks levelling, tensions and slope, surrounding areas settlements and falling elements, catenaries maintenance, cyber processes monitoring, etc.

The **challenges** expected to be addressed in this pilot by ICOS are:

- Implement energy-efficient solutions for low-power IoT devices to guarantee safety operation monitoring in real time while ensuring a very long lifetime of the deployed technology in remote locations. Improve raw data transmission and balance processing between the Edge and Cloud.
- Improve wireless networking protocols to achieve reliable system operation in remote locations while ensuring connectivity management for the whole ICOS continuum.
- Edge to Cloud orchestration of several applications according to complexity, processing, or time requirements while using the same devices deployed and improving the coexistence of real-time processing and coordination with Cloud services.

The **benefits** expected in this pilot case by adopting the ICOS metaOS will be a reduction of latency in decision taking (because some decisions will be taken at Edge level), an increase in the overall availability of the system, and an improvement in the data security.

In-car Advanced Infotainment and Multimedia Management system



In-car services are crucial for establishing a positive business case for the development of connected and autonomous vehicles. Mobility is changing, making vehicles an integral part of the customer digital world (or life): as vehicles become increasingly tech forward, the experience will expand beyond the screen to delight all the senses. The rise of autonomous and connected cars will also generate new demand for in-car infotainment and entertainment. The automotive pilot will offer innovative media content and services focused on tourism to enhance the user experience while travelling in a car and getting to know and explore new places. In more detail, this pilot case will provide the user with an in-depth tailored experience about the place they are visiting, showing the tourist extra

information and knowledge around that new area in an immersive way. The possibilities of this technology will be exploited not only for interaction between users inside the car but also for others remotely.

The **challenges** expected to be addressed in this pilot by ICOS are:

- Ensure seamless user experience by optimising the distribution of multimedia content and maintaining high levels of quality of service (QoS) and quality of experience (QoE) also in case of low connectivity.
- Provide secure multiuser communication and interaction infrastructure able to ensure privacy and security of shared data.

The **benefits** expected by the introduction of ICOS will be an optimised distribution of multimedia content so that high-quality reception can be achieved even in low-connectivity situations while avoiding service interruptions. Energy optimization with consequent impact on cost and sustainability are further taken-away expected by the innovative solution.

Energy Management and Decision Support system

The SSEA pilot aims at providing an Energy Management and Decision Support System (EMDS), using the ICOS continuum with data collected from five smart homes. Each house will be equipped with smart technology which may include Micro-generation systems: PhotoVoltaics (PV) or Wind Turbines, Electric Vehicles (EV), Heat pumps, Home energy storage, and Smart meters. Real time energy consumption will be measured with the use of inductive power monitoring clamps (IoT devices), that will send the collected data to an Edge device installed in the house managed by the ICOS metaOS.

The energy management system will generate personalised and optimised energy suggestions tailored to customer needs based on AI models and sustainable solutions. The AI will dictate when/how energy will be used/produced/stored, with hyperparameters adapting or updating through reinforcement and/or federate learning. The customers should be able to track improvements between actual vs optimised costs to build their trust in the energy management system.

The **challenges** expected to be addressed in this pilot by ICOS are:

- Provision of secure solutions, where data protection and data security must be ensured throughout all stages, including data collection, analysis, storage, and processing.
- Provision of customised, innovative solutions for optimal energy usage, and increase of self-consumption to pave the path towards households net zero emissions.
- Ensure viable and sustainable real time solutions in all settings including areas of poor connectivity.

The **benefits** expected by the introduction of ICOS will be the delivery of secure and efficient energy management systems based on advanced and reliable Machine Learning techniques for energy

forecasting and home-to-home parameters sharing to avail of learnings obtained in other houses. Thanks to ICOS, the application will be able to leverage Cloud and Edge capabilities for real time solutions, with latency reduction, increased security and flexibility to tailor to customers' specific needs, increasing client satisfaction and retention.

Roadmap

The ICOS project started in September 2022 and will end in August 2025. The project follows an iterative development approach that includes analysis, design, implementation, integration and validation phases for each iteration. The project has concluded the first analysis phase and defined the **first version of the ICOS Architecture in May 2023** that is presented in this white paper. The fully detailed architecture is documented in the project's deliverable D2.2[17].

In May 2023 the project kicked off the first iteration for the design and **implementation** of the overall system, aiming at implementing a first set of integrated functionalities that can could validated and prove the value of the ICOS meta-OS.

In September 2023 the project launched its **first Open Call** to select 5 solution development projects to enrich the capabilities and functionalities of the ICOS meta-OS. ICOS allocated 1M€ budget for these new projects. The selected projects are implementing their solution in the 12-month support programme.

In November 2023 the first release of the ICOS meta-OS (**alpha version**) was available. It consisted of a deployable and working system that is being validated in the project's early adopters pilot cases.

In February 2024 the first **validation** report from the pilot cases was made available. This was an important milestone for ICOS since it provided feedback to improve and enrich the functionalities of the system.

From March 2024 the project has started a **new development iteration** that is bringing two additional refined and enhanced ICOS meta-OS releases: the beta version (June 2024) and the final version (April 2025).

In July 2024 the project will launch the **second Open Call** to select 15 ICOS uptake projects to validate the ICOS solution across 9 pre-defined sectors with a total budget of 900K€. The selected projects will use and validate the ICOS meta-OS and will receive support to integrate ICOS in their solutions.

ICOS is part of the EUCloudEdgeIoT.eu[18] initiative that promotes the collaboration between research projects, developers and suppliers, business users and potential adopters to realise a **common roadmap** for the understanding, the development and the adoption of the Cloud, Edge and IoT (CEI) Continuum in Europe. ICOS is active and will contribute mainly to the Open-Source Management, Architecture, and Market & Sectors task forces.

[17] D2.2 - ICOS architectural design IT-1 (2023). ICOS project - https://www.icos-project.eu/deliverables

[18] https://eucloudedgeiot.eu/about/

Who we are

ICOS is a project funded by the European Union's HORIZON research and innovation programme under the grant agreement N° 101070177. ICOS brings together 22 organisations (7 industry partners, 8 academia and research centres, 6 SMEs, and 1 organisation from the public sector) from 10 European Union countries, Switzerland and Israel. Background and experience of the partners covers different areas and disciplines such as IoT-Edge-Cloud continuum management, AI, Security, OS development, Data Management, Networking and Ethics. This allows a multidisciplinary approach and creates a strong and solid basis for ensuring success of the project's activities.

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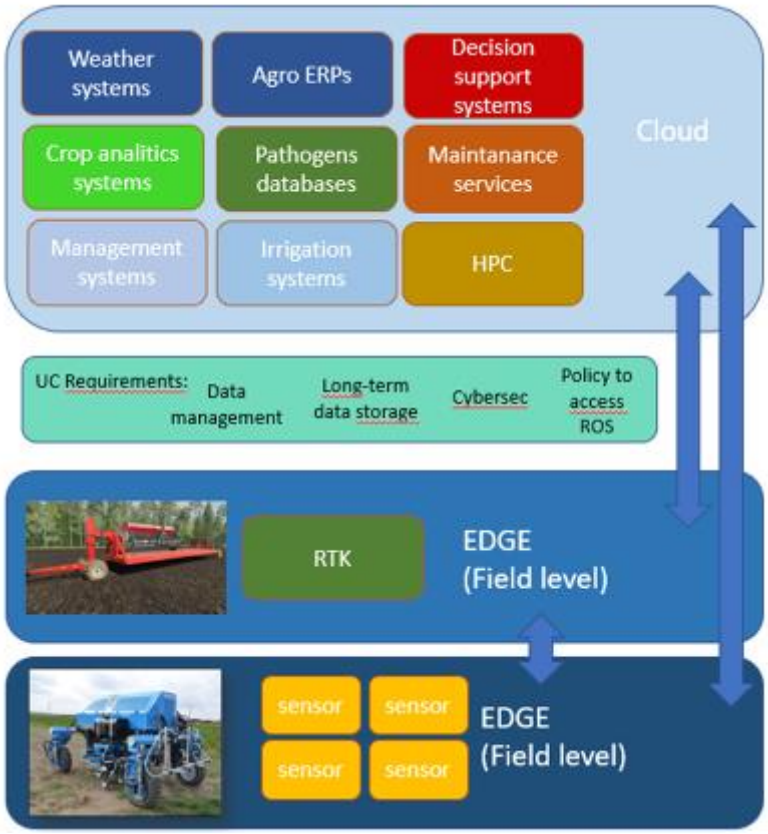
Annex B: List of Use Cases

1 ICOS PILOT use cases

1.1 UC1: Agriculture Operational Robotic Platform (AORP)

The Agriculture Operational Robotic Platform (AORP) is used to implement Use Case 1. Its field tasks and missions include sowing and tending crops, removing weeds, monitoring crop development, and identifying threats. The platform moves autonomously through the field, performing the assigned missions. The robotic platform consists of control and driving modules. In addition, it is equipped with interchangeable tools - a seeder and a sprayer. The accuracy of the tasks is controlled by an RTK GPS, while the working environment is monitored using a camera on the front of the robot and ultrasonic sensors. Besides the robotic platform there is a transport platform that could act as a gateway.



The Agriculture Operational Robotic Platform High Level View.

The mobile platform takes advantage of four independent steerable wheels; each wheel's rotational speed can be controlled separately. With such a mobile platform, advanced manoeuvres in the field, such as skid steering and Ackermann steering, are possible. The diesel engine on the mobile platform provides the power for hydraulic pumps and alternators to generate enough electricity to charge the batteries. These batteries are connected to a power inverter to provide electricity to external electronic equipment. The capacity of the fuel tanks is sufficient for 88 hours of continuous operation.

Autonomy: On the robot, a rugged embedded industrial computer (Neousys Nuvo) is providing computational power to processes on the robot, where an Ubuntu server is installed as the operating system, and on top of that, ROS2 is functional. A ROS2-CAN bridge node is responsible for low-level communication with the robot's ECU through a USB-CAN adaptor. The robot is equipped with RGB and RGB-D cameras, lidar, IMU, encoders, a GNSS system, etc., and its data is being processed in ROS2.

Cameras and lidar together are used for segmentation, object detection, navigation, and mapping, while taking advantage of two GNSS receivers beside global positioning provides global heading information. The data from GNSS is fused with IMU and encoders to provide more accurate state estimation.

With the raw sensor data and navigation stack on ROS2, the robot can simultaneously localize itself on the map and navigate to the destination while avoiding obstacles. The communication channels to the driving platforms (local) and the internet (cloud) would allow the robot to be controlled and/or monetised, as well as receive mission plans and transfer data to and from the cloud.

Communication with the machine will be upgraded to LoRa, WIFI, and xG modems.

Functionalities: Three main functionalities have been selected for implementation that will profit from and make use of the ICOS:

- Predictive Maintenance of the machinery and remote steering
- Crop management analytics (weed map) - main focus in ICOS
- Validation and Improvements of the ML models for robot operations and steering

Predictive maintenance of the machinery and remote steering: Data from cameras, logs, and information from all other devices installed on the robotic platform will be stored using ICOS as raw data on the cloud. Data size per day can reach 100 GB. The next step will be cloud analysis (prediction), which will take vibrations and signal control information into account. In the event of any issues, it will send back the control signals to the robotic platform. The data should be stored using data management tools in long-term storage.

There is a need to create a user interface for maintenance management, and parameters storing and control. As the robots are expensive devices, particular focus should be put on securing the connection. There should also be a way to define in ICOS the limited policy to access from the ICOS meta system.

Crop management analytics (weed map): During the first pass of the robot in the field, using the predefined mission, machinery will take field images that will be used for the purpose of creating a weed map. During the second pass the robot should already make a precision treatment based on the location on maps. The expected accuracy is 2-3 cm.

The computation will start on the edge but will need in short time any possible processing power and be able to send input images. Depending on the network it can be far edge, (to the platform), or it can be near edge . The data management tools should allow for transparent management in the continuum. Depending on the constraints (e.g. connectivity) and on the requirements (e.g. precision, e2e delay) the ICOS system will optimize the use of ICOS Elements (computing, storage, network resources) along the Cloud Continuum.

Validation and improvements of the ML models for robot operations and steering: This functionality will allow us to improve the AI models used on the near and far EDGE. The data will be sent from the devices to the cloud to train, validate and improve AI models that will be used for further missions, and for improving the robot capabilities. Usually, predefined missions are being used. From a computational perspective the robot will use mostly the EDGE due to the requirements related with movement speed and the management of the unexpected obstacles or events (e.g., obstacle detection).

1.2 UC2: Railway Structural Alert Monitoring system (RSAM)

The main challenge to be addressed by the use case is related to the continuous monitoring of critical infrastructure on rail tracks to ensure safety and improve maintenance activities.

Functionalities. Three main operational challenges should be supported by specific solutions that leverage ICOS solutions, including:

- Energy-efficient solutions for low-power IoT devices to guarantee safety operation monitoring in real time while ensuring a very long lifetime of the deployed technology in remote locations. Improve raw data transmission and balance processing between the edge and cloud.
- Improve wireless networking protocols to achieve reliable system operation in remote locations while ensuring connectivity management for the whole ICOS continuum.
- Edge to cloud orchestration of several applications according to complexity, processing, or time requirements while using the same devices deployed and improving the coexistence of real-time processing and coordination with cloud services.

The initial area to deploy and validate the use case for the Railway Structural Alert Monitoring system (RSAM) is the line in Lleida-La Pobla due to its difficult access to several of the areas of the line and its orography generating possible geological incidents.

La Pobla railtrack and train circulation under high risk orographic environment

The line is along an area where communications may be limited in availability and bandwidth, making it possible to benefit from processing at the edge while sharing limited amounts of extremely relevant information to the upper layers of other applications. There has been an identification of different applications relevant to the use case.

- Rail track geometry: the application will support safe operations by deploying a digital and wireless monitoring system that will collect and deliver real-time information regarding the quality parameters to monitor critical infrastructure status to support the decision makers and to timely detect possible anomalies or physical threats regarding the railway track.
- Alarm detection: The alarm detection module is connected to the deployed devices, and it allows detection and acquisition of possible alarms. The detection of alarms and response actions can be required to be processed at the edge to ensure safe operations even if connectivity with upper layers is not fully available. Such response to events detected might also include the request for additional information to the physical devices to collect additional contextual data about the possible incidents and thus to better design or select a response plan.

Maintenance: To optimise the decision-making process and to exploit all the available resources, the maintenance application will also be onboarded within the ICOS architecture. The objective of the application is to identify the trend and predict the moment when the condition where quality parameters

would not be met, and therefore plan maintenance activities to mitigate such risk. The proposed application will request available resources at edge and cloud level based on connectivity and data transfer requirements and will run appropriately.

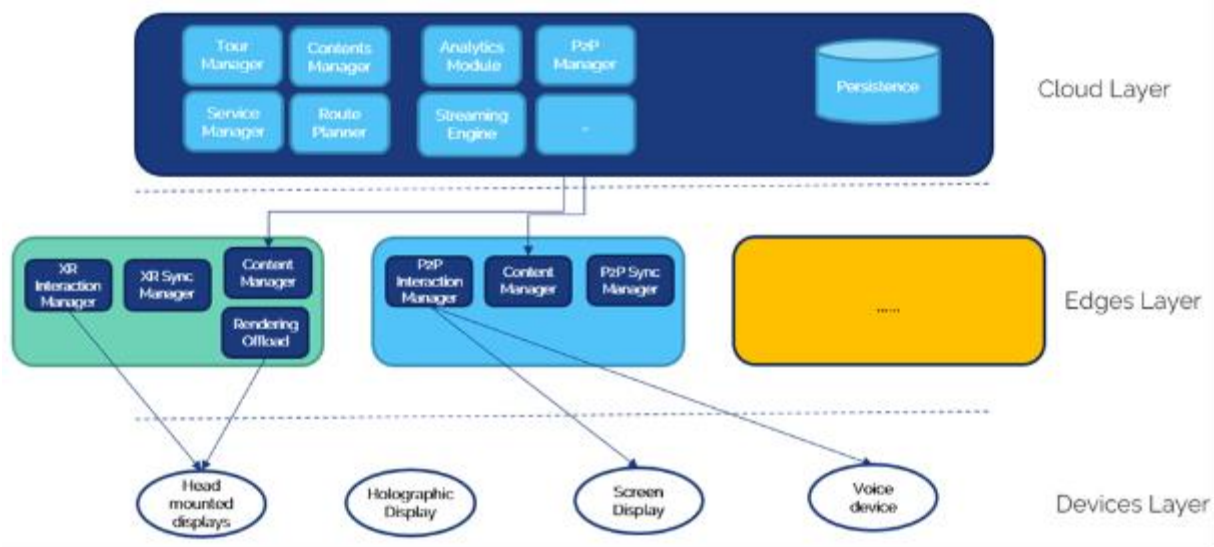
1.3 UC3: In-car Advanced Infotainment and Multimedia Management system (IAIMM)

This ICOS solution is designed to provide to the user a mixed reality interaction service by optimising the distribution of multimedia content (such as Videos, Interactives 3D models, Audio) and maintaining high levels of Quality of Service (QoS) and Quality of Experience (QoE). The solution also provides a secure multiuser communication and interaction infrastructure able to ensure privacy and security of shared data. This is achieved through a multilevel resource and data management system that utilises cloud, edge, and device resources to provide location-aware services. The service aims to provide high-quality multimedia functionality for planning and enjoying trips and visiting tourist sites (Points of Interest - PoI), even in low connectivity situations. The service architecture includes nomadic edge nodes for hosting rendering and pre-processing services that ensure high quality content with low latency. Cloud nodes are used for hosting complex analytics modules, an Extended Reality (XR) manager, and a media content repository for large datasets.

The service will use real-time and dynamic information from the Car System to determine when the car will be in a specific location, considering factors such as traffic and weather. Additionally, the ICOS System will prepare in advance for when the service will be used, allowing for seamless and efficient operation. One of the key features is the Automatic Retrieve of 3D Models and Media Contents by Location (or Search). This feature allows for fast downloading of large data on-the-fly and on-demanding, making it easy to access and utilise. Additionally, the service also allows for the Visualization and Interaction of the 3D Models and Media Contents, with the capability for remote offloading at the Edge. The service also includes several collaboration tools, such as the ability for Interaction among Peers, the creation of Teams, P2P Messaging, P2P Video Calls, the ability to Share Models, and synchronized Interaction.

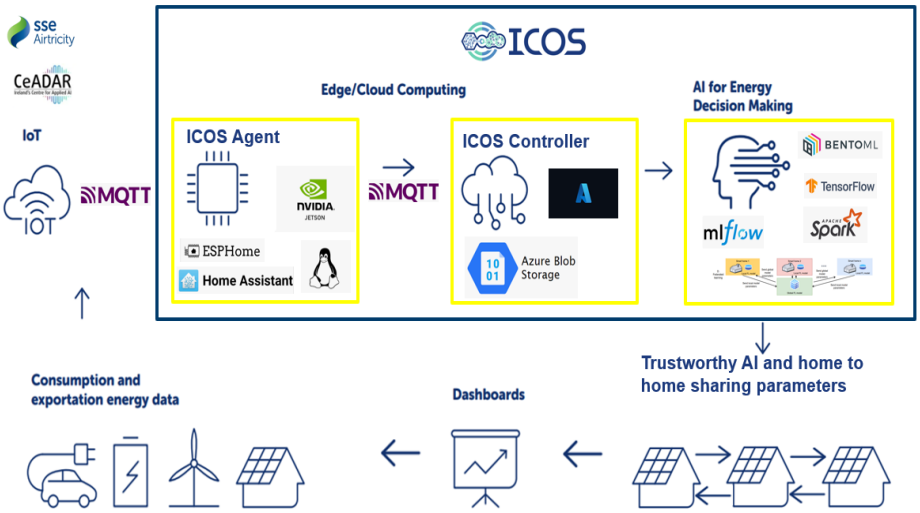
Lastly, the service will also be linked with car devices and sensors, allowing for events triggered by the car to impact the operational of the Service.

The following picture introduces the high-level architecture of the IAIMM service highlighting functionalities provided and software modules and where the components will be executed in a three layers deployment Cloud, Edge and End-User device.



Three layer high-level architecture highlights the IAIMM functionalities and software modules

1.4 UC4: Energy Management and Decision Support system (EMDS)



The roll out of smart metres in Ireland, initiated in 2019, is part of the national Climate Action Plan and supports the development of smart grids, microgeneration, and the transition towards low carbon emissions. Smart metres enable customer cost awareness, which can lead to the shifting of energy consumption to cheaper times of the day, providing the customer with cost savings and accurate bills based on actual usage instead of estimates. In addition, smart metres can measure the export of microgeneration and facilitate remuneration for electricity exported to the grid. Therefore, customers are or will be empowered with several possible options, including:

- Buying from or Selling to the grid (where home battery storage exists, or customers have EV's with bidirectional charging)
- Sell or trade energy with peers (P2P energy trade is still at its infancy in Ireland, with infrastructure needed for energy trading in the process of being tested/developed, this is however outside the scope of ICOS project).

- Store energy.
- Create dispatchable demand (i.e., heat water, charge the EV).

Smart metres, together with the increase of smart controllable devices, provide the necessary data granularity (data intervals of every half an hour, e.g., 48 intervals per customer per day) to obtain meaningful AI models. However, customised solutions with secure data transfers coupled with CO2 emissions linked with these transmissions, are some of the challenges intrinsic to the use of smart devices.

ICOS meta-operating system will exploit edging capabilities linked with IoT devices and cloud scalability to provide secure and more sustainable solutions by analysing energy data from five smart homes. User case participants will be selected internally by SSEA to be in compliance with Data Protection and Data Privacy regulations, using a survey. This survey will assess the presence of the optimal technologies needed to test the ICOS software and the willingness of the household to partake in a trial where automated decision making is a feature and where results will be used for dissemination and publication.

The SMART technologies to select the participant households should include the following:

- Micro-generation systems: PhotoVoltaics (PV) or Wind Turbines.
- Electric Vehicles (EV).
- Heat pumps.
- Home energy storage.
- Smart meters.

To increase the data granularity and quality, SSEA in collaboration with the ICOS project, proposes to install additional technologies such as:

- Bi-directional chargers.
- Fixed/portable energy Storage batteries.
- Occupancy sensors/inductive power monitoring clamps.

Bi-directional chargers allow electricity to flow from the Grid into the Vehicle (G2V) and from the Vehicle to the Grid (V2G), in addition surplus of energy can be redirected towards the house (Vehicle to Home, V2H). V2H enables an EV to be used like a home battery system to store excess energy. Due to the large battery capacity, a fully charged EV could support an average home for several days at a time.

Home batteries can be fixed or portable and installed as a single storage unit or coupled together to store energy either straight from the power grid or generated from renewable sources. Home batteries enable reduced energy costs by storing energy at off-peak time and discharging during the most expensive hours.

While SMART METER data are available on a day +1 basis (data collected every 30 minutes by the DSO and shared with the energy providers), inductive power monitoring clamps will allow an increased data granularity down to tens of seconds with real time communication between the clamps, the IoT devices installed into the smart homes and the ICOS operating system. Occupancy sensors can be of different natures, but in general, they detect the presence of movement within a given range and transmit the signal to a control unit. This determines if the space is occupied and switches the lights on or sends data to the thermostat to heat or cool the space accordingly. The sensor can be infrared, ultrasonic, or microwave and is used to save energy by switching on and off the connected appliances.

The data collected by these SMART technologies will be used by the ICOS continuum to derive automated decisions, which will allow the customers to directly participate in demand and supply energy distribution. The ICOS AI ‘brain’ will shape the future of the Prosumers with the aim of flattening the demand curve by removing demand on the grid at peak time and boosting energy usage at night-time. It

will improve demand flexibility (e.g., the capacity of demand-side loads to change their consumption patterns on a time scale), make the electric grid more reliable (avoid grid loss), and increase the usage of renewable energy sources (mitigating wind curtailment). ICOS would, at scale, enable participation in flexibility schemes at the Distribution and Transmission System Operator level (DSO and TSO) by providing sufficient aggregated demand-side and supply capability to be of material interest to DSO's and TSO's. Finally, the cost savings from the AI will aid in promoting the use and distribution of SMART metres and time of use tariffs.

The SMART metres transfer data regularly with the network provider where communications are technically feasible. The data requirements include high levels of security and privacy. ICOS edge capability will allow a minimization of data transfers, achieving a higher level of security, low latency for real-time decision making, and lower emissions (less data traffic).

The ICOS continuum will provide valuable solutions to the user Case at data management and processing level, with Cloud/Edge infrastructure and distributed applications handling. More importantly ICOS will provide a suite of Machine Learning Algorithms and trustworthy AI Models with high level of adaptability and integration from prior learning (federate learning) able to address EU policy guidelines requirements and to ensure data security and protection.

The AI models will generate automated decisions around energy usage and storage of the five houses, for example by scheduling the charge of EV cars when this is most cost effective (i.e., at night-time) or by using green/renewable energy (from the solar panel or the wind turbines) instead of grid energy. The automated decision will generate cost savings (and consequently a reduction of CO2 emissions) that should be clearly shown to the customers in a graphical format (i.e., dashboard showing costs with/without automated decisions). In addition, the resulting energy management system will enable customers to proactively manage their energy generation and storage. In time, the use and development of ICOS Metaverse Operating System, along with smart technologies and AI models, will result in an energy paradigm shift with a more efficient, cost-effective domestic systems, where electric vehicles with V2G options, home batteries and renewable energy generating systems will enable customers to contribute in the decarbonization process and in the increase of green energy consumption.

ICOS UC4 will provide a means of validating the ICOS infrastructure and allow for the integration of green energy sources, microgeneration, minimise wind curtailment, reduce CO2 emissions and to pave the way towards 2050 net zero emissions.

2 ICOS 1st Open Call Use Case projects

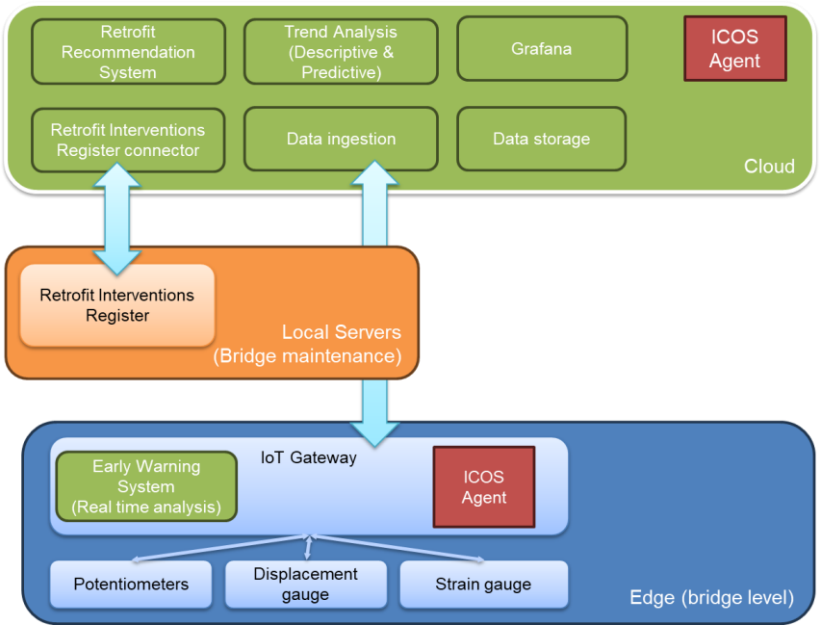
2.1 1OC1: Structural Health Monitoring (SHM) with Advanced Retrofit analyTics 4 Bridges

Bridges infrastructure faces challenges from increasing service demands, loads caused by natural hazards and extreme weather events driven by global warming, and ageing structures. These factors can impact the operation and resilience of the infrastructure. In Europe, most of the bridges were built after World War II to support economic growth and urbanization12. However, many of these structures have now reached or exceeded their design life expectancy of 100 years for bridges. Many of these assets have experienced significant changes in loading conditions and may have undergone significant deterioration in their operational life. The ageing infrastructure is often worsened by durability issues such as fatigue, corrosion, and creep. This poses safety risks and shortens the functional end-of-life.

It is important to note that these civil engineering structures were designed according to codes with lower standards than those of today. Additionally, ageing infrastructure faces additional structural challenges due to increasing traffic loads and hazards caused by global warming. For example, over 30% of bridges in EU countries require repairs, with approximately 10% of them being in poor condition. One of the longest bridges in Greece, with a length of 1,372 m, is the Servia High Bridge, which has been designed by Riccardo Morandi, and its construction started in 1972 and completed in 1974. The bridge is a part of the GR-3/E65 and is located 15 km southeast of the city of Kozani and 5 km northwest of Servia. Today a semi-wireless system consisting of numerous sensors and a telemetry system for monitoring the health of the bridge has been deployed. The existing system faces a number of challenges related to

the increased number and type of sensors, the inefficient way of data transmission, which can even happen manually in some occasions and the limitations set by the commercial off the shelf monitoring solutions that they do not lend themselves to integration. The main challenge of the Use Case deals with the structural health monitoring of the Servia High Bridge focusing on the monitoring of the behaviour of existing cracks. In particular, engineers pay special attention to the behaviour of the cracks during and after strengthening works.

SHMart4Bridges solution will have three main layers: i. Edge; ii. Local servers; & iii. Cloud. The edge layer will be responsible for getting the measurements from the sensors that have been already described and feeding cloud with data required for the analysis. The local servers layer will host the repository with the past retrofit interventions. These interventions are the strengthening works of the bridge that need to be correlated with the behaviour of the bridge and the cracks specifically. The layer of the cloud will host the data storage collected from the sensors and will also do a first data ingestions required for the post analysis of the data. The post analysis of the data also happens at the cloud layer and deals with the trend analysis of the bridge measurements, and a retrofit recommendation system.



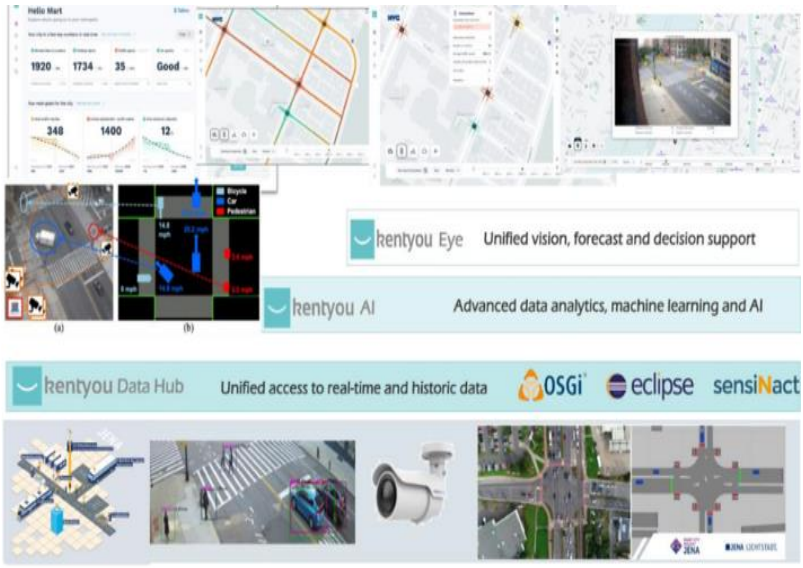
SHMart4Bridges components

2.2 1OC2: ICOSmart: ICOS for safe and smart mobility in cities

The ICOSmart project will deal with an important social, economic and environmental problem: efficiency and safety at urban road intersections. In Europe, about half of the road accidents occur at intersections, many of them causing fatalities. Furthermore, intersections have an important role in urban traffic flow management, and the resulting economic and environmental consequences. The overall goal of the ICOSmart project is to adopt and integrate ICOS' MetaOS implementation and validate its IoT-edge-cloud continuum concepts under a relevant smart intersection use case within the Jena city's smart city testbed.

The main output of the project will be an ICOS Meta-OS empowered software platform and associated tools to help cities to enhance traffic flows, to improve citizens safety, and ultimately to enable data-driven decision making to support the broader goal of building smarter and more sustainable cities. The use case architecture will be composed of four main layers :

- Smart intersection testbed using Jena's smart city infrastructure
- Kentyou Data Hub layer where data will be collected, unified and will be prepared for further processing. This will be the layer where most of the ICOS components will be integrated.
- Kentyou AI layer where data processing, correlation, analysis, prediction and simulations take place. Some of the data management related components from the ICOS architecture are expected to be integrated at this layer.
- Kentyou Eye layer which is the user interaction layer with data visualisation and decision-making support and impact monitoring features.



The project will test two main case scenarios to test and validate the solution:

- Monitoring intersections at real time for achieving better situational awareness (e.g., of traffic, soft mobility), forecasting and recommending relevant actions for more efficient traffic management.
- Increase safety for pedestrians and drivers, by timely detection of potentially dangerous situations.

The project will bring together two complementary enterprises: i) Kentyou, an innovative award-winning startup which will bring its interoperable AI-driven data platform and its tools for visualisation and decision making support. ii) Data in Motion, use case partner located in Jena city, a close technological partner of the city, which will bring the testbed infrastructure and domain specific expertise.

2.3 1OC3: GridSync

The GridSync use case for ICOS addresses critical challenges in low voltage distribution grids, focusing on the monitoring of transformers, which are increasingly strained due to distributed generation and the widespread electrification of structures. This scenario amplifies the need for sophisticated monitoring solutions capable of ensuring operational reliability and longevity of grid infrastructure. Transformers, vital for energy distribution, face significant operational challenges due to the lack of observability. This deficit complicates maintenance operations, particularly for small grid maintenance teams that rely on timely and accurate data to perform effective interventions.

Furthermore, without detailed insights into transformer conditions and other critical assets, it becomes challenging for utilities to make informed investment decisions, often leading to suboptimal allocation of resources and delayed responses to emerging issues. In this context, GridSync, integrated with ICOS, provides an essential solution. By using advanced IoT hardware developed by Linc, the system captures a wide array of data types including electrical, spectral, thermal, and mechanical metrics. This detailed data acquisition allows for comprehensive monitoring of asset conditions, offering a nuanced view of transformer health and other critical components of the low voltage grid. AI-Energy leverages this data to enhance power analytics capabilities significantly. By processing the diverse data streams, AI-Energy can forecast energy demands, assess real asset ageing, and optimise maintenance schedules. This

capability not only improves the operational efficiency of the grid but also supports robust investment planning by providing utilities with a clear, data-driven view of asset health and grid performance. Overall, GridSync's use case within the ICOS framework effectively addresses the critical need for enhanced observability and analytical capabilities in low voltage distribution grids.

This integration is not only vital for the day-to-day management of energy distribution but also aligns with broader EU policies on sustainability and cybersecurity, marking a significant advancement in smart grid management technology.

The proposed solution involves a strategic deployment of IoT sensors in medium-low voltage distribution transformers of Trefor El-net (our DSO pilot partner in Denmark), facilitated through the ICOS framework. This solution is designed to significantly enhance grid monitoring and management by providing high-resolution, real-time data analytics capabilities.

IoT Sensor Deployment and Data Collection

- High-resolution monitoring: Install IoT sensors on medium-low voltage distribution transformers. These sensors are capable of monitoring voltage, current, power, harmonics, spectral analytics, and power quality with one-second resolution.

Temperature and environmental monitoring:

- Sensors will also capture temperature readings of both the transformer and the ambient conditions within the substation enclosure, providing a holistic view of the environmental impact on transformer performance.
- Extended monitoring network: Similar sensors will be placed in network feeder/distribution boxes, enabling a comprehensive analysis of network loading and stress across the grid.

Real-Time Data Transmission and Synchronisation

- LTE/5G gateway for data relay: Data from the sensors will be transmitted in real-time using a robust LTE/5G gateway, ensuring timely data delivery crucial for immediate operational adjustments and analysis.
- Sub-second time-synchronised data: All sensors will report data with sub-second time synchronisation. This precise data coordination is essential for conducting accurate and comprehensive load flow analysis throughout the network.

Analytics and Operational Insight

- Integration with AI Energy: The high-resolution data collected will be transmitted to AI Energy, where advanced analytical tools will process the data. This integration facilitates deep insights into grid health and operational efficiency.
- Value-added analytical outputs: AI Energy will provide processed data outputs such as temperature forecasting, dynamic load ratings, asset ageing assessments, and other critical analyses to enhance operational decisions and grid reliability.

This solution, embedded within the ICOS framework, will enable DSOs to advance their grid management capabilities, enhancing the reliability, efficiency, and adaptability of the grid to meet modern energy demands and integration of renewable energy sources. The deployment of cutting-edge IoT technology and the utilisation of advanced data analytics will transform grid operations, aligning with strategic goals for sustainability and resilience in energy distribution.

2.4 1OC4: Distributed Cosmic Ray Observatory Continuum

This project aims to create a network of next generation sensors based on cosmic rays detectors to generate unprecedented data for Climate and Space Weather applications in real time. Each detector will act as a node that performs atmospheric estimations through the use of AI models optimised for each specific location.

The weather forecasting market was valued at 1.90 billion in 2023 and is expected to grow at a CAGR of 8.2% until 2028 to 2.8 billion. The growth is being driven by the efforts on minimising losses and enhancing production efficiency. Government support and private investment are also boosting the market; other factors are the growth of demand from power companies, the expanding sea and air transportation and the increase of extreme climate conditions. A 2023 report points out the increase of adoption of big data, AI, IoT/IIoT and data analytics by the market, which aligns with our project.

About Space Weather, Lloyd's quantifies the economic losses in cities in 2015-2025 in Europe due to Solar Storms in US$10.3 billion, compared with US$2.2 billion from Terrorism. It is an estimate for cities, and it does not include losses from black-outs, or the losses for sectors such as Telecoms, Aerospace, Space and Satellite companies. The customers can be divided into two main groups: 1) Institutions in charge of Space Weather services (NOAA/NASA, ESA, MET office, European Warning Centres, etc) and 2) Industrial end-users. The industrial customers targeted would be Power, Telecomm, Satellite, surveying and drilling, GNSS service providers, banking and insurance, and weather forecast industry, around the world. Currently the stratosphere is monitored by satellites and balloons. Both methods make discrete measurements whilst they drift. Compared to these technologies, we will have fixed stations making continuous monitoring of the full column of the atmosphere up to the stratosphere, which again will open the door to data analysis as not possible with the current techniques.

2.5 1OC5: Safe Work Net (SWN)

In occupational safety management, the risks to which workers are exposed in their working

environment must be identified and, if necessary, appropriate corrective measures implemented. This process of identifying occupational risks has traditionally been done by expert observation or by self-reporting of risk situations by the workers themselves. However, both methods produce significant inaccuracies due, among other factors, to human subjectivity.

In this sense, Computer Vision (CV) represents an opportunity for process standardisation and cost reduction. In particular, there are opportunities for measuring ergonomic risks, detecting hazardous situations and monitoring the use of personal protective equipment (PPE). These systems allow a parallel and real-time processing approach of images from different cameras and devices, which can be used to monitor a working environment automatically and accurately. From a computational point of view, the most recently developed Convolutional Neural Networks (CNNs) represent ideal tools for typical CV tasks, such as object detection, person tracking and instantaneous posture identification of a worker, among others.

Industry 4.0, based on the digitalisation of the working environment, offers new solutions to solve these repeatability problems in ORAs. Risk monitoring in work environments is an area of research of growing interest in Industry 4.0, as its results allow for improved decision-making by experts and thus reduce the economic, social and ethical cost generated by occupational accidents. In recent years, this problem has been addressed mainly in two ways: through the use of inertial gauges (direct measurement), and through CV techniques (indirect measurement).

Today, it is evident that I4.0 technologies present a broad outlook for growth and applicability in key sectors such as industry and construction. However, this is a cumbersome process to adopt, often due to

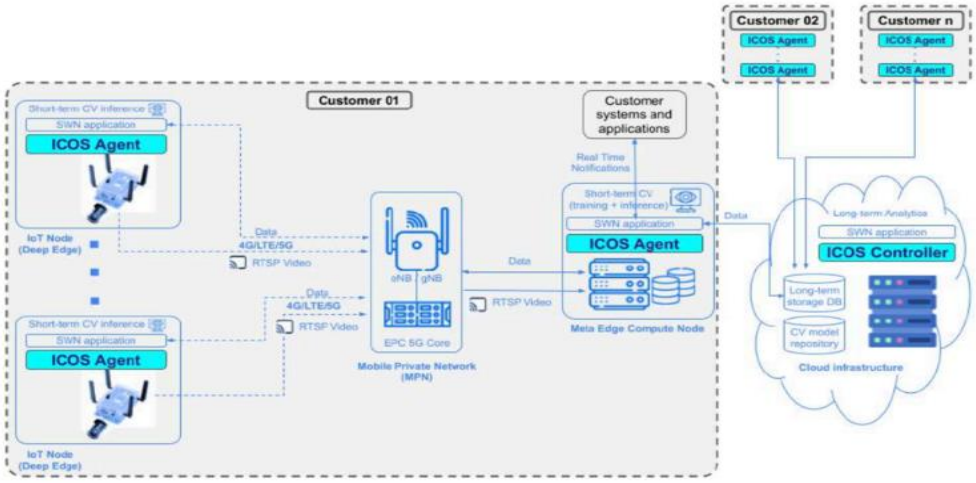
the need for highly trained personnel, time and financial resources. Reducing TMEs is especially costly in changing work environments, typical of the construction sector, particularly with the use of direct measurement ORA methods, as they require inertial gauges that are attached to the worker's body, reducing comfort and limiting the naturalness of the work to be assessed. In contrast, the use of CV methods only requires computer equipment and portable cameras.

To overcome these limitations, the proposed SWN Project aims to investigate and test new alternatives for occupational safety improvement processes based on the use of Artificial Intelligence (AI)-based CV techniques and models, designing and training a Computer Vision System (CVS) to be used in the monitoring of movements that may generate a high ergonomic risk for the worker, to document in an automated way the traceability over time of the use of PPE by the workforce as well as to detect high-risk situations in order to prevent the possible accident..

More specifically, the SafeWorkNet (SWN) project, which we propose as an ICOS use case, aims to deploy an innovative digital occupational safety and health (OSH) surveillance system based on a network of nodes with CV capabilities interconnected through a low latency 4G/LTE/5G network. The system consists of IoT nodes with vision sensors and limited computational capacity (deep edge) and nodes with extended computational capabilities (meta edge). The IoT nodes will collect and analyse real-time video by running lightweight AI models that enable the recognition of safety risks in the workplace. These IoT nodes will be plug&play, can be attached to structures where needed and reused in other installations. The meta edge nodes will run heavier AI models for the detection of more complex situations, such as ergonomic risks. The system is completed by the cloud infrastructure that hosts the central SWN application in charge of both managing and administering the system and its

multiple tenants, as well as running deep analytics on the accumulated historical data for the

identification of risk patterns and critical areas. Finally, by integrating SWN with the orchestration and computational continuum management capabilities and functionalities offered by ICOS, SWN will ensure a distributed, collaborative, robust and resilient real-time OSH system.



Main functional requirements of the SWN System:

- SWN-FR-01. Real-time video stream management: The system shall be able to manage, and process live video streams from a variety of sources, including fixed cameras and devices.
- SWN-FR-02. AI-based automatic incident detection and classification: SWN shall be able to accurately identify and classify a range of occupational safety and health incidents.
- SWN-FR-03. Alert generation: The system shall be able to generate automatic notifications and alerts following the detection of certain incidents, providing essential details to those responsible for ORP.
- SWN-FR-04. Analysis and reporting capabilities: The system shall provide full reporting and analysis capabilities for both tracking safety and OSH incidents and conducting performance evaluations.
- SWN-FR-05. User interface for incident monitoring and management: SWN shall provide a user-friendly interface for ORP personnel to monitor incidents, select cameras, choose AI models and receive notifications.
- SWN-FR-06. Interoperability and integration capability with pre-existing systems: SWN will provide open APIs to facilitate integration with existing safety and ORP systems to improve overall operational efficiency.
- SWN-FR-07. Easily deployable, scalable and flexible infrastructure: The system
- architecture must be easily deployable, have dynamic scalability mechanisms to adapt to varying levels of demand and be flexible to be deployed in different industrial and logistical environments.
- SWN-FR-08. Robust connectivity and communications: The system shall maintain stable, high-speed network connectivity that ensures communications for uninterrupted data transmission and smooth operation of its services.
- SWN-FR-09. System reliability and fault tolerance: SWN must have continuous monitoring tools, be highly reliable and have mechanisms in place to cope with failures or interruptions without significant loss of functionality.
- SWN-FR-10. Data privacy and security: SWN shall ensure the highest standards of data privacy and security by complying with relevant laws and regulations. The integrating thread that provides unitary coherence to the SWN Project is the fundamental hypothesis that CV can support the decision-making process of occupational safety management. Thus, within the framework of the above hypothesis, three specific themes are addressed:
  - Monitoring the use of PPE.
  - Detection of high-risk situations that may lead to an accident.
  - Automated measurement of musculoskeletal risk.

These three themes will be applied throughout the SWN project, individually or in combination, leading to the concrete functionalities and use cases that will be tested in the real test environment.

The end result, in the form of a future commercial product supported by the advances made in SWN, will be a solution characterised by the following advantages for the end-user:

- Ease of deployment as it can be applied to existing camera systems as well as to new cameras installed specifically.
- Flexibility by allowing configuration changes by the end user himself either by relocating cameras or by applying specialised models without the need for experts in programming and/or data science,
- Scalability of a modular solution both in terms of hardware and software including specialised models.
- Adaptability to the detection and analytical needs of each type of risk, offering on the one hand a rapid response in those cases that require it (e.g. pedestrian collisions or entrapment of workers by machinery) and in parallel a more in-depth data analysis for more complex cases (e.g. musculoskeletal risk and use of PPE).
- Continuous monitoring and evaluation of worker safety based on objective criteria.

3. Conclusions

This deliverable, as well as the work on the Task 6.2, is a joint effort of the consortium members, especially Selection Committee members (FBA, ATOS, UPC, CEADAR, ENG, WSE).

In order to complete the Open Call package of documents, T6.2 Leader (FBA) engaged the Selection Committee and the wider project in order to align and validate the documents from both a managerial but especially a technical point of view, taking into account learnings from the 1st Open Call and comments from the mid-term Review.

Through this approach, all project partners, especially Selection Committee members, could contribute to the draft of the documents simultaneously using “suggestions" and “comments" to make sure the 2nd Open Call is aligned with the ICOS project objectives in a way that would also enrich the selected FSTP projects who will benefit from support via the 6-month ICOS Support Programme.