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The Projects of ICOS Open Calls

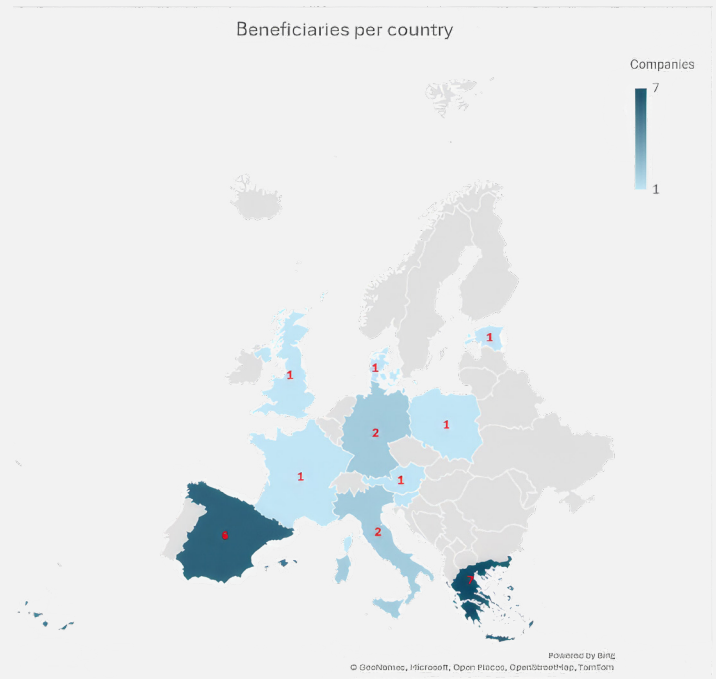
The ICOS project embeds a well-defined set of functionalities, ending up in the definition of an IoT2cloud Operating System (ICOS). The main objective of the project ICOS is to **design, develop and validate a meta operating system for a continuum**.

To do so, **ICOS 1st Open Call**, that started in M18 of the project, has focused on finding consortia of 2 organisations (SME/midcap; technology provider, and an end-user to validate the developed project) to **develop projects within a specific sector, through ICOS technology**. ICOS 1st Open Call has funded 5 projects to support ICOS implementation in 5 new verticals (different to the internal pilot use cases of the project).

The 2nd Open Call, that started in M30 of the project, has aimed at projects from technology providers (SME/midcap) developing services/ products in the sectors of the ICOS pilot use cases and the use cases proposed by the 1st Open Call projects. The 14 selected projects for **the 2nd Open Call address the uptake of the ICOS platform**. The services/products are onboarded to the ICOS system and test the ICOS functionalities and performance allowing the ICOS team to improve the ICOS final product.

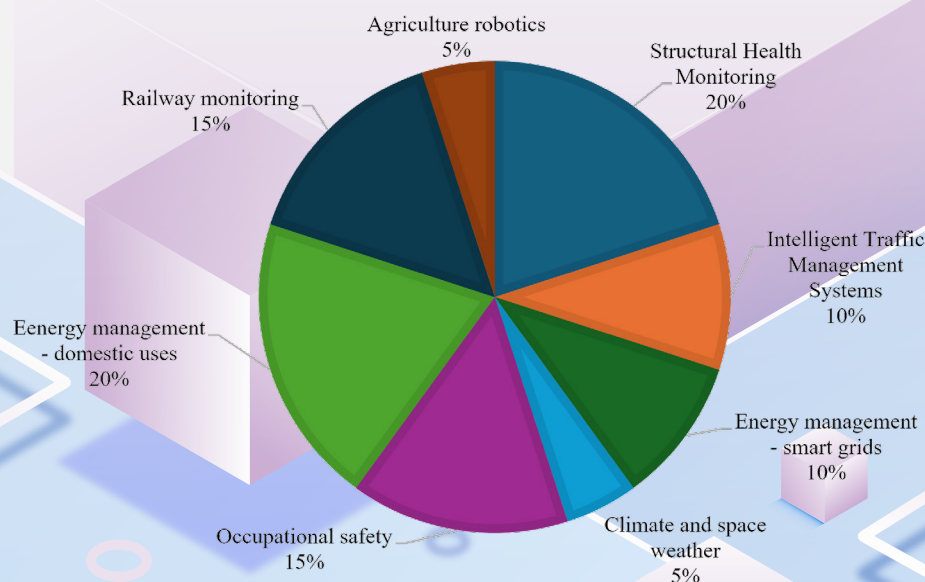
The 19 funded projects of the two Open Calls have been dispersed among different European countries. In total, **24 different companies** (5+5 in the 1st Open Call and 14 in the 2nd Open Call) from **11 countries** have worked with ICOS towards designing and

implementing innovative solutions, as shown in the following map.



The 19 projects have covered multiple business domains showcasing the adaptability of ICOS for different purposes towards fulfilling user needs. **8 different domains** have been covered by the projects of the two Open Calls, as shown in the next figure.

USE CASES PER VERTICAL



1st Open Call Projects

“SHMart4Bridges” project

Description

One of the longest bridges in Greece, with a length of 1,372 m, is the Servia High Bridge, that has been designed by Riccardo Morandi, and its construction started in 1972 and completed in 1974. 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, that 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. SHMart4Bridges will apply ICOS framework to build a solution that 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.

Results

This project is planning to leverage on the SHM4Bridges prototype based on ICOS and offer an SHM product/system as well as a set of services. Specifically, services will be offered related to the Design, Configuration, Deployment, Training and Support for the SHM system. Moreover, this project plans to use the SHM4Bridge solution to enhance the safety, efficiency, and quality of critical infrastructure projects across all phases. During construction, SHM sensors track strain, stress, displacement, and vibrations in real time to verify whether structural elements perform as designed, helping detect issues early and



avoid costly rework. Post-construction, the SHM system provides baseline performance data for handover to asset owners. In design-build contracts, the company can use SHM data to validate engineering assumptions and streamline approvals. SHM also supports quality assurance by documenting compliance with specifications. For long-term maintenance contracts or PPP models, the company can monitor structural integrity over time, schedule predictive maintenance, and demonstrate performance to stakeholders. By embedding SHM early, the construction company positions itself as an innovation leader and gains a competitive edge in bidding for large-scale infrastructure projects where safety, data transparency, and lifecycle performance are increasingly critical.

“ICOSmart” project

Description

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 project will test two main case scenarios to test and validate the solution: (a) 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, (b) increase safety for pedestrians and drivers, by timely detection of potentially dangerous situations.

Cloud computing in smart city contexts. The demonstration of interoperability with Eclipse sensiNact opens up interesting perspectives for future deployments that leverage distributed architectures.

“GridSync” project

Description

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.

Results

The pilot demonstrated that ICOS can be effectively used to monitor and manage distribution substations, providing DSOs with valuable visibility into their low-voltage networks. Key benefits observed in GridSync are: a) Improved insight into transformer health and loading, supporting proactive

Results

The ICOSmart project successfully demonstrated both the technical feasibility and practical value of a mobility monitoring solution built on the Kentyou platform for the City of Jena. It also validated the interoperability between the Eclipse sensiNact platform and the ICOS platform, showcasing their potential for integration within real-world urban mobility systems. Through this pilot, Kentyou established a solid proof of concept for traffic monitoring and early detection of dangerous situations. This not only provides a strong foundation for further development tailored specifically to Jena’s needs but also opens a clear commercial pathway for a more generalized, productized version of Kentyou’s mobility solution. As a result, Kentyou has committed resources to this opportunity by appointing a Chief Product Officer to lead the creation of a dedicated mobility product line within the next six months. The collaboration with the City of Jena and Data In Motion has already led to discussions about continuing the development initiated during the ICOSmart project. Various partnership and funding opportunities are currently under exploration, with the goal of extending the current deployment and deepening integration with municipal mobility teams. This next phase will involve refining use cases and redefining user needs based on the pilot’s outcomes in order to create a minimum viable product (MVP) that directly addresses pressing challenges in traffic monitoring and incident detection. From a technical perspective, the ICOS platform offers promising capabilities for Edge-to-



maintenance and network planning, b)
A scalable model for integrating edge
monitoring with centralized analytics, c)
Stronger collaboration between technology
providers and DSOs, aligning solutions with
operational needs. The project has produced
a proven, real-world use case that can be
replicated for other DSOs facing similar
visibility challenges.

“DRACO” project

Description

The DRACO 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 optimized 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 minimizing 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. Currently the stratosphere is monitored by satellites and balloons. Both methods make discrete measurements whilst they drift. Compared to these technologies, DRACO 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.

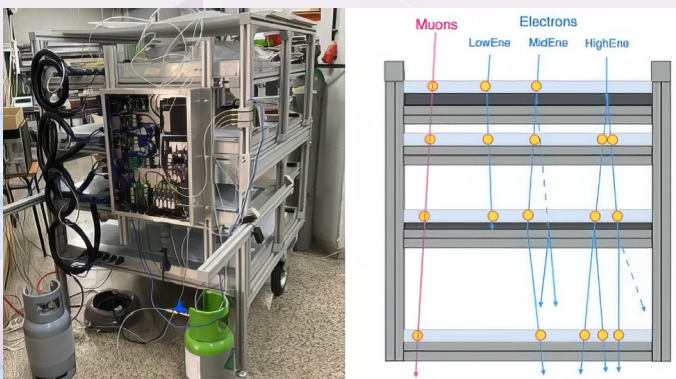
Results

The work carried out within DRACO has proven that a single mRPC detector can be used to make accurate temperature predictions in the atmosphere, providing a completely new way of obtaining these measurements. Furthermore, it has been validated through simulations that there is a significant correlation between space weather events and variations in particle readings on the ground. For the use case owner (Hidronav), these results open up new research and commercialization opportunities in the field of meteorology and space weather, allowing for the development of innovative services based on high-resolution, real-time data. For Logicismelt (the technology provider), the project has also offered a unique opportunity to develop the software that constitutes the backbone of the application. The whole solution (detector + software) will be offered to weather, space and research agencies as a state-of-the-art instrumentation device for weather applications. Finally, beyond the immediate commercial aspects, DRACO has been crucial in significantly boosting knowledge in the complex areas of virtualization orchestration and Kubernetes by utilizing ICOS. This improved know-how enables to confidently and successfully tackle increasingly complex technical challenges.

“SafeWorkNet (SWN)” project

Description

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 to, among other factors, human subjectivity. 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 (personal protective equipment) by the workforce as well as to detect high-risk situations in order to prevent the possible accident. More specifically, the SafeWorkNet



(SWN) project 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). 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.



Results

Significant progress has been made in the implementation of SafeWorkNet (SWN) with the ICOS ecosystem. The now functional version of SWN represents an important milestone in bringing the project's vision of an AI-driven workplace safety system closer

to reality. A key breakthrough has been the implementation and laboratory testing of peripheral devices that use computer vision (CV) models to monitor safety conditions in the workplace. The computer vision models have been successfully trained and tested, namely models detecting people and forklift trucks, as well as a specific model for welding glove detection. The SWN management application has also come a long way. Key components of the application, such as API management services, video stream management and user authentication (integrated with Keycloak), are now operational. This configuration ensures that the system can manage video streams in real time, enabling faster identification and notification of workplace hazards, such as improper use of personal protective equipment (PPE) or dangerous worker-machine interactions. Another breakthrough has been the successful deployment of a mobile private network (MPN) in our laboratory environment, which facilitates secure, low-latency communication between SWN edge devices and the central infrastructure. This network has been configured using Open5GS and is crucial for maintaining the real-time nature of SWN's occupational safety monitoring system. Finally, progress has been made in defining the integration of ICOS components that are considered key to the SWN system, such as telemetry and dynamic policy management functions, which ensure continuous monitoring of system performance and alert stakeholders if deviations or bottlenecks arise. These advances contribute directly to SWN's ultimate goal of providing a robust, real-time occupational safety system that can be deployed in a variety of industrial environments.

2nd Open Call Projects

“Environmental Factor-Based Decision System for Smart Cities” project

Description

The Environmental Factor-Based Decision System for Smart Cities is designed to evaluate and enhance the ICOS platform's ability to process extensive IoT data streams. By continuously providing high-frequency sensor data from smart city infrastructure, the project rigorously tests the system's scalability and efficiency. The focus lies on evaluating ICOS capacity to ingest and analyze real-time urban data, identifying potential bottlenecks, and optimizing overall performance.

Ultimately, this initiative aims to refine ICOS as a practical solution for smart city applications, strengthening its role in data-driven urban decision-making. The project primarily seeks to validate ICOS efficiency in handling large-scale real-time IoT data streams, particularly focusing on camera feeds and sensor-generated data. Another essential goal is to pinpoint and resolve performance challenges in data ingestion, ensuring stable and effective data management. Furthermore, the project aims to enhance ICOS function in smart city applications by optimizing its real-time decision-making capabilities, allowing

for improved urban planning and infrastructure management.

Results

Overall, pilot's experience with ICOS was positive, particularly regarding the platform's potential to simplify distributed application management across edge and cloud environments. The ability to onboard infrastructure, deploy applications declaratively, and receive built-in observability with minimal setup was a clear strength of the system. During the pilot, it was able to successfully integrate and monitor over a dozen real-world IoT data sources using a lightweight telemetry pipeline. The ICOS orchestration mechanisms proved effective in matching applications to available edge resources, while the modular design of the platform supported a clear separation between application logic and infrastructure. The ICOS framework enabled to focus on data processing and insights rather than infrastructure plumbing. It is a promising toolset for projects working across heterogeneous environments. This pilot demonstrated ICOS's potential value in smart city and industrial IoT scenarios.

"SECURIFY" project

Description

SECURIFY aims to offer to the construction industry sector a multiplatform IoT-based occupational safety tool for worker's safety management including a set of AI/ML models for data processing and analysis integrated with BIM models, enabling the visualization on a dashboard of hazardous zones or triggered alarms directly within the 3D building design. This integration will enhance the overall situational awareness and will facilitate the decision-making process throughout the

overall construction process. By leveraging the ICOS edge-to-cloud continuum architecture, SECURIFY will be a unique solution clearly differentiated from traditional solutions in terms of occupational safety. SECURIFY project main objectives are: (a) enhance the occupational safety in the Construction sector, (b) leverage all the continuum resources by integrating FAVIT's MANTRA IoT-based multiplatform app into the ICOS meta-OS framework for ensuring an efficient data processing, reduced latency and real time response to critical safety alerts, (c) integrate the Edge-to-Cloud Continuum with BIM models, (d) develop AI Models for Hazard Detection, and (e) validate the SECURIFY platform in a real environment.

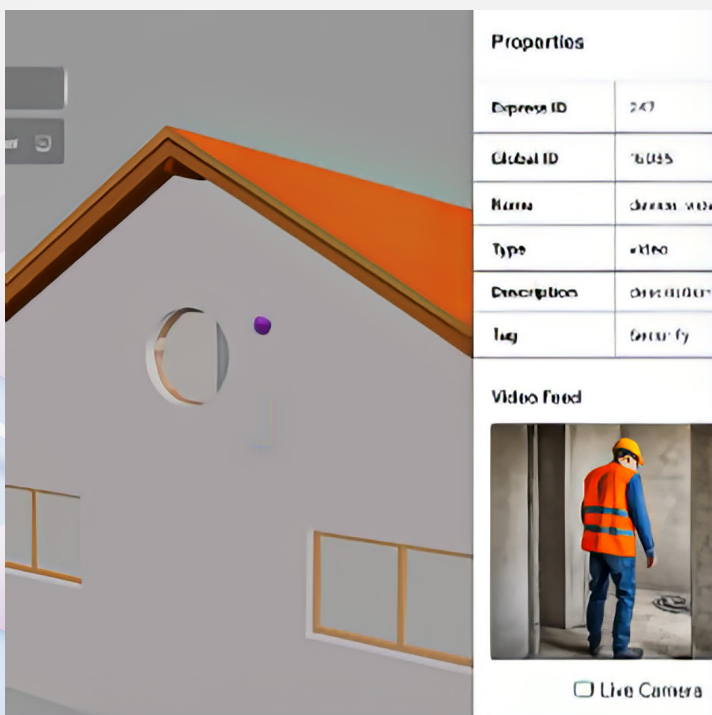
Results

The SECURIFY use case has successfully demonstrated the deployment and integration of its occupational safety solution within the ICOS framework. This pilot highlighted the platform's strong potential to orchestrate complex Cloud-to-Edge-to-IoT applications in real-world conditions. The overall feedback collected has been excellent, with a high degree of acceptance from both technical and operational perspectives. Users and developers praised the structured orchestration model provided by ICOS, which facilitated the modular deployment of backend services, edge-level AI models, and real-time IoT data collectors. The visibility and control offered by the platform were fundamental to simplifying debugging, resource management, and secure access to services. Among the most valued features were: i) Automated, consistent deployments across heterogeneous environments, ii) Improved reliability and observability, especially in performance monitoring and issue Resolution, and iii) Support for complex AI workflows at the far edge, which is critical in safety-critical applications. ICOS helped bridge the gap between AI innovation and real-world deployment. It gave control and flexibility needed to orchestrate safety-critical services across diverse devices and environments. Overall, the pilot validated ICOS as a scalable, secure, and production-ready platform that can effectively support distributed applications – both in this specific occupational safety context and in broader industrial domains where edge intelligence is essential.

"SHARC" project

Description

SHARC (Structural Health Analytics for Resilient Civil Infrastructure) enhances structural health monitoring (SHM) for bridges by deploying advanced IoT solutions at the far edge, leveraging the ICOS Meta Operating System. By integrating lightweight AI for real-time anomaly detection on IoT devices, SHARC distributes processing in the IoT- edge-cloud (IEC) continuum, significantly reducing energy use, operational costs, and increasing system efficiency. Commercial systems



primarily rely on centralized cloud computing, leading to high energy consumption, latency, and dependence on costly cloud services. SHARC disrupts this model by employing edge AI, where real-time anomaly detection is performed, closer to sensing data source. This significantly reduces data transmission, cuts dependencies costs, and minimizes latency. Moreover, SHARC introduces virtual sensing, to provide virtual measurements, expanding monitoring coverage and robustness without the need for additional physical sensors. This innovative approach reduces the operational costs and rigidity associated with widespread sensor deployments. Finally, SHARC follows a flexible and scalable architecture via TinyML and integrates Explainable AI (XAI) features (on the higher architecture's stack) to offer infrastructure operators clear insights for detected anomalies.

Ylisense, in collaboration with Olympia Odos S.A.'s Technical Department, selected as case study the underpass K605 which is situated in Patras by Pass. The underpass is constructed on 2003 and is an isostatic reinforced concrete slab on deformable bearings based on wall abutments. This phase is particularly important for our company, Ylisense, as it enables the successful completion of our implementations and demonstrates the system's effectiveness in a realistic environment. The pilot not only serves to fine-tune our technologies under real-world constraints but also provides valuable feedback for future scaling and commercialization.

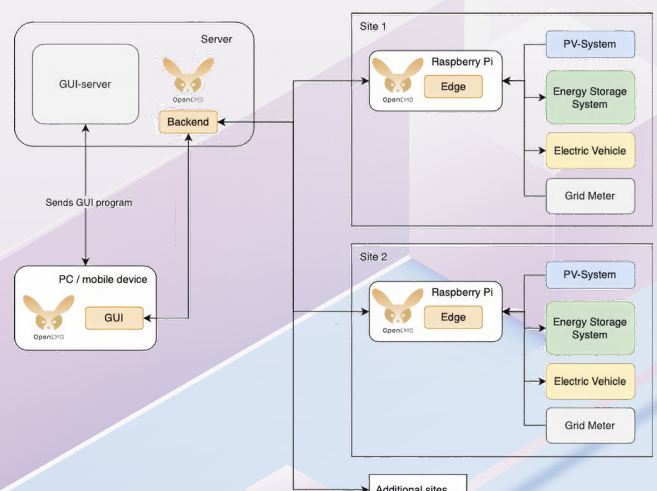
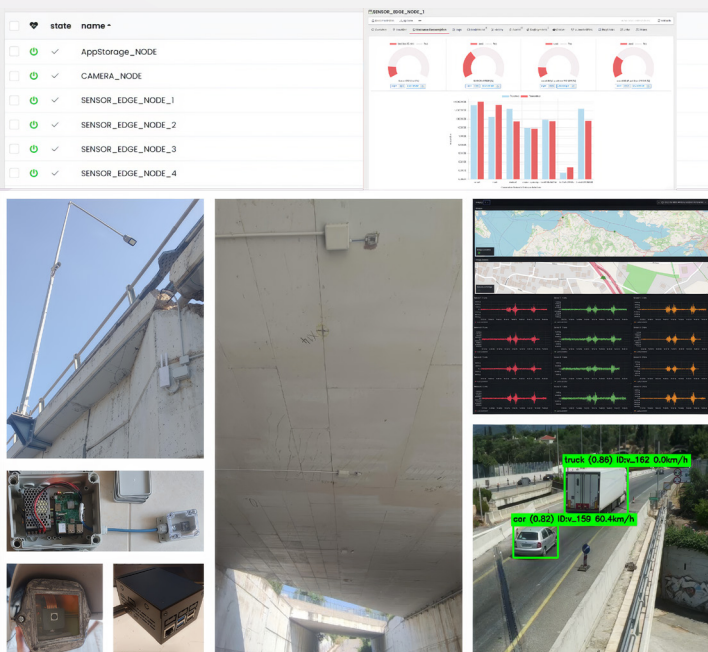
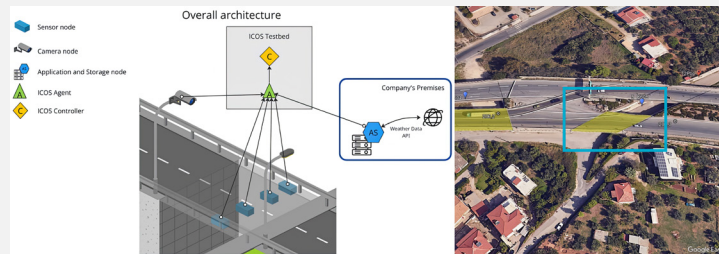
"VoltICOS" project

Description

VoltICOS enhances the ICOS framework by integrating AI-driven energy management solutions, including adaptive algorithms, battery lifecycle management, and grid frequency stabilization through peak shaving. By addressing critical energy challenges and expanding ICOS's capabilities, VoltICOS is an excellent fit offering scalable, sustainable solutions that improve grid efficiency and resilience. The energy sector is rapidly evolving with increased integration of renewable energy sources, fluctuating demand, and the need for efficient energy storage solutions. Managing these challenges requires innovative solutions that can optimize energy distribution and storage while ensuring grid stability. Integrating AI-enhanced energy solutions into ICOS allows us to address current challenges in energy management, improve ICOS functionalities, and contribute to its final product development. VoltICOS plans to leverage the modular and open architecture of the ICOS platform to integrate its AI-driven services and products seamlessly. By adopting the ICOS framework, we can ensure interoperability among heterogeneous devices and systems within the virtual power plant (VPP) ecosystem. The platform's support for virtualization and edge computing allows us to deploy our AI algorithms efficiently across

Results

The implementation was divided in three main pillars: i) Edge devices and data management, ii) AI/ML model development and iii) Application services. All the tasks have been executed, and we have reached a working vertical solution, ready to be demonstrated via ICOS ecosystem and deployed in a real-world use case. During pilot finalization, the focus shifted to on-site installation and real-world pilot deployment, marking a critical milestone for validating our solution in operational conditions.



various network topologies and hardware configurations.

Results

ICOS provides a way to leverage many computing resources to efficiently deploy applications. Its combination of many software suites, deployed using one central setup, is very powerful. Key benefits of using the ICOS system were the central deployment and updating of applications, node failure management and resource monitoring. Our energy management system is a growing network of energy storage sites. The onboarding of new Edge devices and deployment of our applications heavily benefits from the ICOS system. The most impactful features are: (a) Deployment and updating of applications, (b) Secure connections between devices, (c) Monitoring of Edge devices, (d) Redeployment on redundant nodes. The ICOS security layer offers authentication and authorization, secure and trusted communication protocols as well as anomaly detection, which we will use to provide a secure energy management system. The capability of ICOS to monitor and restore application from failed nodes ensures redundancy where needed. The metaOS, designed to operate across the Cloud-Edge continuum, provides dynamic device management solving device volatility and heterogeneity. The ICOS data management layer allows seamless distribution of monitoring data across the continuum, addressing the distributed AI challenges that OpenEMS struggles with. The deployment and updating of applications are a big step up, with the ICOS controller's Grafana instance providing good central monitoring. VoltICOS has set up their own ICOS-continuum, leveraging a server running the ICOS core, controller and agent suites. Two instances of the worker suite run on local PCs. The rest of the devices are Raspberry Pis located in different regions in Austria, each connected to an energy system: (i) Linux server with a K3S cluster running ICOS Core, Controller and Agent, (ii) Two local Kind clusters on PC, running an ICOS Worker Suite each, (iii) Five Raspberry Pis, located at different locations in Austria, running a K3S cluster and ICOS Worker Suite each.

“MELANIE” project

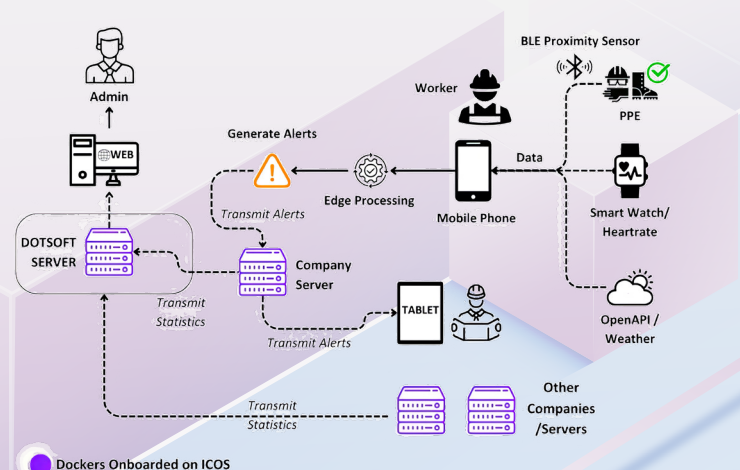
Description

MELANIE (Smart PPE Compliance for Occupational Safety) is designed to revolutionize worker safety by integrating advanced IoT-driven PPE compliance monitoring with the ICOS meta-operating system. The primary goal of MELANIE is to reduce workplace accidents and improve

worker safety through real-time monitoring of workers and associated PPE equipment using proximity sensors, GPS sensors, and AI-powered anomaly detection. Apart from proximity-related data relevant with PPE equipment, the system collects physiological and movement data from mobile devices and wearable technologies to ensure continuous compliance with occupational health and safety regulations. Unlike traditional PPE compliance systems, MELANIE operates in real-time, providing automated alerts for potential safety violations and hazardous conditions.

Distinct from traditional compliance systems, MELANIE offers automated, real-time alerts for PPE violations and hazardous situations, enabling rapid and effective responses to emerging risks. Key innovations include: a) Edge-to-cloud processing: Data are processed close to where they are generated, allowing low-latency safety interventions while ensuring efficient use of cloud resources, b) Federated learning: AI models are trained across distributed devices, ensuring high privacy standards and GDPR compliance, as no sensitive worker data needs to be centralized, and c) Seamless integration: The solution operates with ICOS's robust security and data management layers, allowing interoperability with various infrastructure types and maximizing system reliability.

The context of MELANIE aligns with the broader ICOS project by utilizing edge-to-cloud processing for data management, ensuring that safety-related insights are processed efficiently while maintaining high security and privacy standards. Leveraging federated learning, the system ensures distributed AI model training without centralizing sensitive worker data, thereby addressing GDPR and privacy concerns. The integration with ICOS's security and data management layers allows MELANIE to interoperate seamlessly with various cloud and edge computing



infrastructures, further strengthening its robustness as a next-generation safety monitoring tool.

Results

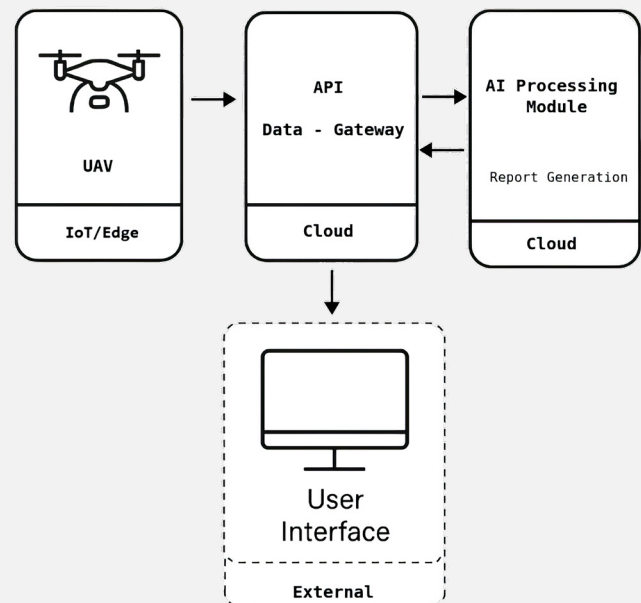
Overall, the MELANIE application, upon deployment within the ICOS ecosystem, has validated the effectiveness of tightly-coupled IoT, edge computing, and federated AI for workplace safety. The main results and outcomes are: a) Demonstrated reduction in safety incidents: Real-time alerts and continuous monitoring have improved compliance with PPE usage and early detection of hazardous behaviors, especially in high-risk settings like construction and logistics, b) Privacy-preserving analytics: By using federated learning, sensitive data remain on-site, addressing data protection and GDPR requirements—an essential feature for worker acceptance and legal compliance, c) System robustness and interoperability: The MELANIE solution has shown seamless integration with different cloud/edge infrastructures through the ICOS meta-OS, confirming its value as a model for scalable and secure occupational safety monitoring, and d) Key insights: The development and initial roll-out highlighted strengths (rapid alerting, high accuracy of anomaly detection, user acceptance due to privacy measures) and areas for further improvement (e.g., expanding sensor types, enhancing UI/UX for frontline supervisors, optimizing edge-cloud balance for large-scale deployments). In summary, MELANIE has provided a proof-of-concept and operational demonstrator for smart PPE compliance, setting the groundwork for future commercial solutions in occupational safety, and validating the benefits of edge-cloud intelligence and privacy-first AI in real-world industrial environments.

“UAV-InspectX” project

Description

UAV-InspectX is an autonomous UAV system designed for structural inspection of bridges, integrating AI-powered defect detection with real-time data transmission through ICOS. The project enhances bridge inspection efficiency, reducing human risk and optimizing maintenance planning. The project aims to: (a) develop an autonomous UAV-based inspection system, (b) integrate UAV-InspectX with ICOS for real-time data processing, (c) implement AI-driven defect detection with at least 80% accuracy, and (d) ensure seamless UI integration displaying post-flight AI processed results. UAV-InspectX will integrate with the ICOS ecosystem, using its orchestration and telemetry services for system monitoring. The application will manage data transfer with protocols like

Zenoh and store captured data in a cloud-based storage service.



Results

The UAV-InspectX team successfully onboarded all required nodes (UAV, API, AI) into the ICOS platform, deployed the individual components, and validated core functionality such as real-time telemetry, image transmission, and initial AI post-processing. The AI model was retrained and optimized, reaching a crack detection precision of 82%, exceeding the initial performance target. The automated reporting system was enhanced with three key features: a per-section risk analysis table, a crack severity heatmap across the bridge span, and a visual gallery highlighting the top six most severe detections. These additions improved the diagnostic depth and usability of the output. The ICOS Shell CLI was effectively used for node management and deployment model creation, and the ICOS Controller (Grafana) proved valuable for real-time observability and monitoring. The onboarding and visibility of nodes within the ICOS continuum was seamless using Nuvla. Moreover, ICOS Shell CLI provided a clean and structured way to define, manage, and submit application descriptors. ICOS monitoring tools offered useful insights for debugging and performance observation.

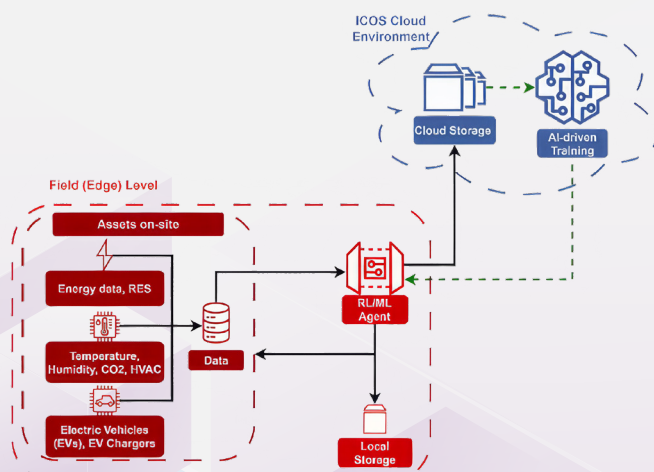
“SENSEI” project

Description

The SENSEI project is dedicated to revolutionizing energy management in residential settings by integrating artificial intelligence (AI) into smart home ecosystems.

This project focuses on empowering homes with smarter, greener energy solutions through the deployment of AI-driven predictive models and real-time resource management. Leveraging the ICOS platform, SENSEI optimizes energy consumption by utilizing a Cloud-to-Edge-to-IoT continuum, ensuring efficient processing and decision-making across distributed systems. SENSEI is designed to ensure robust IoT interoperability, supporting a wide array of smart devices and communication protocols such as Modbus, Z-Wave, LoRa, Wi-Fi, Bluetooth, and Zigbee. It handles device, protocol, semantic, edge-to-cloud, and cloud-to-cloud interoperability, utilizing data formats like JSON and NGSI-LD to enable seamless communication and integration across diverse systems. The SENSEI project significantly contributes to the ICOS ecosystem by showcasing the practical application of its Cloud-to-Edge-to-IoT continuum in a smart home context. By deploying AI-driven solutions across this continuum, we leverage ICOS's resource management, data orchestration, and deployment tools to create an energy-efficient, scalable system. The integration of our infrastructure—comprising Raspberry Pi edge nodes and IoT sensors—demonstrates ICOS's ability to manage heterogeneous resources effectively. Furthermore, the deployment of vertical solutions highlights ICOS's support for containerized applications and predictive analytics, providing a blueprint for other projects aiming to harness AI within distributed architectures. SENSEI validates ICOS's versatility and offers insights into optimizing its features for real-world energy management scenarios.

continuum infrastructure, enabling localized data processing and seamless integration with cloud-based resources. The project has completed infrastructure setup and onboarding. The ICOS Worker Suite has been deployed via Docker containers across all four Raspberry Pi nodes, ensuring full compatibility and operational efficiency within the ICOS platform. Additionally, the ICOS Command-Line Interface (ICOS-CLI) has been installed, providing a powerful tool for managing resources and executing deployment commands. The onboarding of infrastructure and resources was finalized, allowing transition smoothly into the deployment of vertical solutions. The project has also deployed Vertical Solutions. SENSEI successfully initiated and finalized the deployment of vertical applications designed to enhance energy management. These solutions include AI-based predictive models—specifically linear regressors, PID tuning and neural networks—that analyze real-time environmental data to forecast indoor temperature and humidity and provide control recommendations. These predictions enable proactive adjustments to heating, cooling, and ventilation systems, optimizing energy usage while maintaining occupant comfort. The vertical solutions have been integrated into the ICOS platform, demonstrating practical applications of its orchestration capabilities. In the SENSEI use case, the Application Model encapsulates every aspect of the deployment—from the containerized software components themselves to the policies that govern their runtime behavior—into a single, declarative specification. By unifying static topology, deployment constraints (latency limits, data-locality requirements, security boundaries), and dynamic policies in one model, ICOS's intelligence layer can perform sophisticated matchmaking: it reasons over real-time telemetry to assign services to the optimal execution environment whether a resource-constrained Raspberry Pi at the network edge or a powerful cloud VM and can continuously adapt placements as conditions change. In this way, the Application Model becomes both a blueprint and a living document that drives the automated, policy-driven orchestration of our SENSEI solution.



Results

The implementation of SENSEI has proceeded according to the project timeline, achieving key milestones that establish a robust foundation for future phases. The deployment strategy utilizes four Raspberry Pi 4 Model B devices, each configured as Nuvla nodes within the ICOS ecosystem. These edge devices form the backbone of SENSEI's

"ELM" project

Description

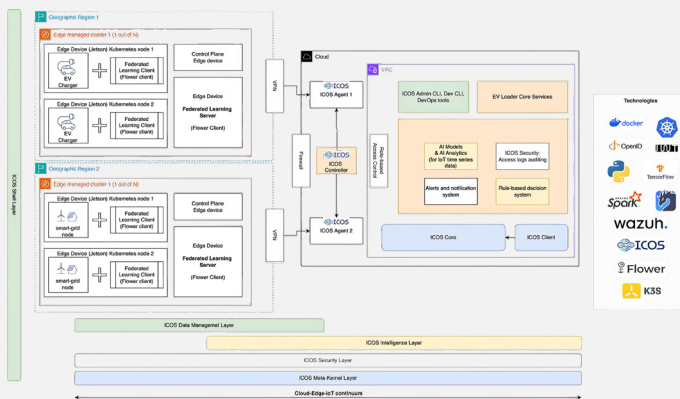
The Edge Load Management (ELM) project addresses the increasing need for real-time energy load control in complex buildings. These environments often include a high density of flexible loads (EV chargers, battery energy storage systems (BESS), and heat pumps). These devices can create significant volatility in the demand curve of building

as large loads are entered then removed (multiple Electric vehicles and then stop). For that reason local load balancing with very low latency (sub 200 ms in server command execution) is required to avoid exceeding grid or site-level power constraints. By leveraging the Cloud-to-Edge-to-IoT continuum enabled by ICOS, ELM distributes intelligence across edge nodes (Raspberry Pi devices) while coordinating globally through cloud infrastructure. This architecture enables the deployment of Federated Learning (FL) models directly at the edge, allowing load prediction and control algorithms to operate in real time. This ensures continuity of service during network disruptions, since core functions can execute locally without relying on a constant cloud connection.

“Automatic detection of critical faults in railway catenary” project

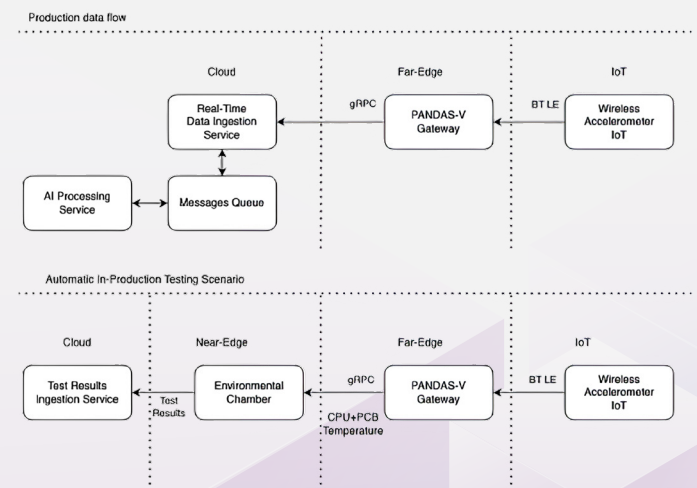
Description

The project focuses on developing advanced technology for detecting and resolving railway infrastructure issues, particularly damaged dropper wires, through the implementation of the upgraded PANDAS-V Mk 4 device. Railway maintenance has traditionally relied on periodic manual inspections, which are time-consuming and prone to delays in identifying defects. PANDAS-V addresses these challenges by providing a real-time, remote monitoring solution that identifies anomalies in pantograph-overhead line connections with unparalleled speed and accuracy. By enhancing computational capabilities from 26 TOPS to 248 TOPS, the system supports advanced edge processing and instant fault reporting, reducing operational delays and maintenance costs. The PANDAS-V system leverages the ICOS platform to ensure seamless integration with IoT devices, real-time data orchestration, and robust cybersecurity. By validating and enhancing ICOS’s analytics and decision-making frameworks, PANDAS-V contributes to predictive maintenance advancements across industries. Its unique combination of AI-driven fault detection, real-time analytics, and scalability positions PANDAS-V as a transformative solution for railway operations, setting a new standard for infrastructure reliability, safety, and efficiency.



Results

Reliable Load Management is one of the core features clients require from the software platform EV Loader. Large hotel complexes such as Holiday Inn and Crowne Plaza and municipal buildings such as Serafeio Athletic complex in Municipality of Athens utilize the platform to monitor flexible loads such as EV Charging Stations and ensure that maximum electrical capacity is not compromised during peak demand hours. A key challenge for the team has been when cloud connectivity was lost in these locations. Before integrating ICOS services and deploying ELM (Edge Load Management), there was lack of visibility of the status of devices during times of lack of cloud connectivity. Now with the ELM service that integrates ICOS components (Continuum Manager and the Agents Module), the load management systems continue operating at the edge even during cloud connectivity outages. Facility managers on the site can keep monitoring their assets locally without any downtime.



Results

The ICOS platform has brought significant value to the deployment and service management process—particularly in the context of our PANDAS-VR devices, which operate in challenging environments aboard moving trains. Thanks to ICOS, it was able to automate and streamline the deployment of services to these devices, ensuring a more robust, reliable, and monitored system. This

is a critical advantage, as continuous service availability is essential to maintaining real-time monitoring of train overhead installations for clients. ICOS enabled to bring automation, stability, and transparency to a highly mobile and mission-critical environment. It is a step forward in operational resilience. ICOS will continue to help reduce service downtime and improve the long-term reliability of infrastructure in future deployments. Overall, the key benefits of using ICOS include: a) Streamlined Deployment and Management: ICOS enabled a straightforward deployment process for dedicated nodes or node groups, significantly reducing the complexity and time needed to scale or update environments, b) Real-Time Monitoring and Observability: The built-in Grafana integration provided live dashboards for monitoring service health and performance, which enhanced operational visibility and supported faster decision-making, and c) Service Resilience Through Automation: ICOS automatically restarts services when they are terminated or crash, ensuring higher availability and reducing manual recovery efforts.

“TrainLedger” project

Description

The TrainLedger project, developed by AstraCode, is designed to enhance railway safety and efficiency by leveraging advanced IoT, AI-driven sensor fusion, and blockchain technology. Aligned with the objectives of the ICOS platform, the project integrates edge-to-cloud computing to improve train localization, and data security. By utilizing ICOS’s meta-operating system, TrainLedger ensures seamless data orchestration between edge devices and cloud infrastructures, enhancing real-time monitoring capabilities in railway networks. TrainLedger focuses on improving the accuracy of train localization by integrating GPS data with additional onboard sensors, such as inertial, odometric, and Lidar systems, overcoming limitations in traditional railway tracking solutions. A key differentiator

is the use of blockchain technology for immutable data certification, ensuring the reliability and security of railway operation data.

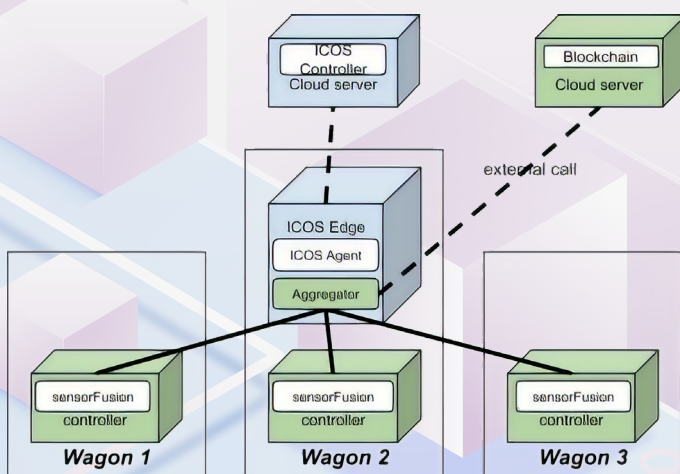
Results

During the TrainLedger pilot within the ICOS ecosystem, valuable feedback was received from the project’s stakeholders and participants. The general impression was positive, with users appreciating the seamless integration and operational benefits that ICOS brought to the system. Users highlighted the ease with which TrainLedger was deployed on the ICOS platform, especially thanks to its Cloud-to-Edge-to-IoT continuum, which enabled real-time data processing at the edge. This resulted in improved operational efficiency and reduced latency, making it a significant upgrade over previous systems. The key Benefits and added value from using ICOS are: a) Real-Time Decision-Making: Processing data at the edge led to near-instantaneous responses, improving train localization accuracy and enabling better anomaly detection, b) Scalability and Flexibility: The ability to easily onboard new devices and sensors within the ICOS ecosystem allowed TrainLedger to scale seamlessly, adapting to different hardware configurations, and c) Cost Efficiency: The edge processing model helped reduce reliance on cloud infrastructure, resulting in cost savings and energy-efficient operations, which are especially important for the railway environment. Overall, ICOS has enabled to enhance the TrainLedger system’s performance, giving a real-time, scalable solution that ensures safer and more efficient operations. The pilot successfully demonstrated the value of real-time data processing, improved operational safety, and scalability across distributed infrastructure. These improvements have not only streamlined our operations but also set the stage for broader deployment within the railway sector.

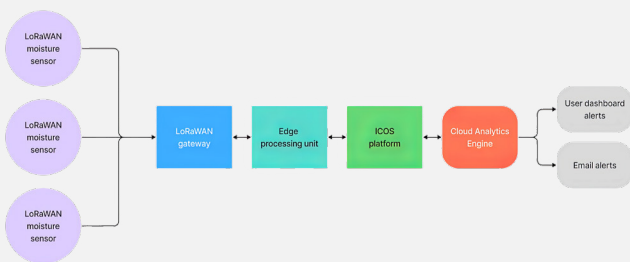
“WaterGuard360” project

Description

WaterGuard360 (WG360) is an advanced Structural Health Monitoring (SHM) solution that prevents water damage in industrial halls, cellars, and other vulnerable areas. By integrating LoRaWAN-based IoT sensors, edge computing, and cloud analytics, WG360 enables real-time moisture detection and predictive maintenance, minimizing infrastructure risks and maintenance costs. The project aligns with ICOS priorities by leveraging its cloud-edge continuum, ensuring seamless data processing and interoperability. WG360’s scalable, data-driven approach enhances infrastructure



resilience, supporting EU sustainability and climate adaptation goals. The project aims at: (a) seamless integration with the ICOS platform, leveraging edge-to-cloud interoperability, (b) real-time detection of moisture anomalies to enable early intervention and damage prevention, (c) optimization of system performance through low-latency data transfer and predictive analytics, (d) scalability and adaptability for various industrial, residential, and commercial use cases, and (e) ensuring high reliability and fast response times for critical infrastructure protection.



Results

ICOS enabled rapid deployment, node orchestration, and real-time telemetry across an edge-cloud infrastructure. OCM was chosen due to its lightweight design, which fit the Dragino's limited resources. The unified descriptor format and developer tools accelerated deployment and ensured resource compatibility. WaterGuard360 validated the full lifecycle of an edge-cloud application using ICOS. The descriptors, deployment model, and OCM management confirm readiness for real-world adoption. We observed significant potential for scalable infrastructure orchestration, especially in sensor-heavy environments like ours. Particular benefits of WaterGuard360 from exploiting ICOS are: a) Fast onboarding using CLI scripts and clean YAML descriptors, b) OCM and Grafana offered effective monitoring across edge and cloud, and c) Unified design process between app modeling and infrastructure matchmaking helped reduce complexity.

“ICOS-Thercom” project

Description

ICOS-THERCOM, focuses on occupant-driven energy management in buildings by harnessing advanced predictive analytics, real-time data, and intuitive user interactions. The system monitors subjective comfort indicators and dynamically adjusts energy usage, delivering sustained thermal comfort

while prioritising resource efficiency. It leverages cloud-edge interoperability to optimise performance and achieve rapid response times. This approach aligns with the ICOS platform's core objectives by enabling seamless device integration, ensuring robust data security, and providing cost-effective implementation across diverse building environments. It also advances the platform's vision of promoting adaptability, scalability, and sustainability, contributing to an energy ecosystem that benefits occupants and grid operators alike. ICOS-THERCOM marks a decisive advance in occupant-driven energy management by merging predictive analytics, real-time system orchestration, and user-centric feedback loops. Its synergy with the ICOS platform addresses pressing needs for interoperability, scalability, and robust security in distributed computing environments. The resulting framework promises to strengthen thermal comfort while lowering energy consumption, contributing significantly to a more sustainable, resilient, and forward-looking energy ecosystem.

Results

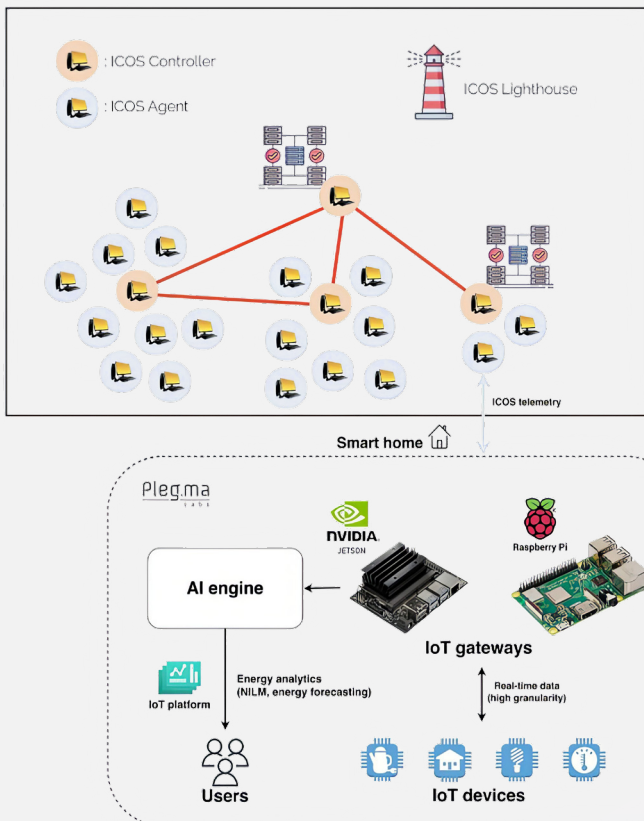
The ICOS-THERCOM application benefits substantially from the ICOS infrastructure, with the most impactful features being: a) Container-based deployment support: ICOS enables the direct execution of containerised applications at the edge, reducing latency in processing environmental signals and user inputs, b) Secure data communication: The platform ensures encrypted data exchange through secure VPN channels and certificate-based validation, protecting user data and control decisions, c) Support for real-time energy availability prediction: ICOS allows the integration of external forecast data, enabling the system to adjust operations based on grid conditions and support demand-side flexibility, and d) Observability and monitoring infrastructure: The platform provides telemetry mechanisms that continuously report on system performance, energy usage, and response to control actions, allowing for comprehensive monitoring.

“fantastlCOS” project

Description

fantastlCOS aims at transforming residential energy management in an innovative manner through AI-driven edge analytics, and provides real-time, secure, and efficient energy insights towards energy optimization. fantastlCOS facilitates real-time Non-Intrusive Load Monitoring (NILM) and high-granularity energy forecasting, enabling smart home occupants to make data-driven energy decisions without requiring appliance-level meters. By leveraging the

edge-cloud continuum, fantastICOS ensures low-latency, privacy-preserving energy analytics, distinguishing itself from traditional cloud-dependent solutions that suffer from high costs, security risks, and slow response times. What makes fantastICOS unique is its integration with the ICOS metaOS, utilizing ICOS Agents for real-time, edge-device AI analytics and ICOS Controllers for



orchestration and efficient node optimization, especially for resource-intensive tasks. All of this, through a single energy meter that measures the total energy consumption of the house. To support the broader adoption of the ICOS platform, fantastICOS is demonstrated in a real-world living lab of 10 households managed by Plegma and already equipped with meters and IoT gateways, validating the practical integration of ICOS metaOS components and showcasing its scalability and real-life applicability.

Results

The fantastICOS pilot successfully showcased a distributed and scalable AI-based energy management solution, leveraging the ICOS cloud-edge continuum to enable real-time load disaggregation (NILM) and short-term energy forecasting for residential buildings, while validating the application's ability to operate across heterogeneous and geographically distributed nodes. Overall, the activities of fantastICOS have progressed smoothly, thanks to the detailed

documentation of the ICOS MetaOS and the invaluable support of the ICOS team. Real energy meter data from households were integrated through edge IoT gateways (Raspberry Pi devices) onboarded to the ICOS continuum. The core fantastICOS energy analytics applications, focused on non-intrusive load monitoring and energy forecasting, were deployed directly on these edge devices via the ICOS Shell. The solution was validated in a living lab of 10 households, demonstrating real-time energy insights without appliance-level meters. The NILM module was trained on high-resolution energy data (10-second intervals) collected from real households. The NILM module achieved device status detection accuracy of 99.44% for boilers, 96.7% for washing machines, and 97.99% for air conditioners, resulting in an average device status detection accuracy of 98.03%. Additionally, integration with ICOS features such as the ICOS controller, ICOS agents, ICOS Shell, Matchmaking, ICOS Dynamic Policy Manager, and Telemetrium Leaf enabled seamless deployment, orchestration, and monitoring of the edge-based AI modules. Lastly, the project met four functional requirements from its original technical roadmap: ICOS continuum integration, real-time data processing from IoT devices, Non-Intrusive Load Monitoring, and energy time-series forecasting. Deployment was successfully completed on both Raspberry Pi and cloud VM nodes, demonstrating the solution's portability across heterogeneous edge-cloud continuum resources.

"RAILSAT" project

Description

RAILSAT focuses on predictive maintenance for railway tracks. It leverages: (a) earth observation data to monitor ground motion and vegetation growth, (b) AI-driven predictive analytics that integrate insights from satellite images with IoT data to anticipate maintenance needs, avoid costly disruptions, and provide continuous safety assessments of railway tracks, (c) edge-to-cloud processing, where critical insights are processed locally and only essential data is sent to the cloud. This innovation enables railway operators to transition from reactive to proactive maintenance, reducing delays, improving safety, and lowering operational costs by leveraging satellite data with possible integrations with IoT data. RAILSAT targets at: (i) enhancing railway safety by detecting ground instabilities and vegetation encroachment using satellite data, (ii) reducing operational costs through the early detection of railway vulnerabilities via satellite-based monitoring, (iii) integration with ICOS, leveraging its metaOS for efficient

data flow management across the edge-to-cloud continuum, (iv) ensuring scalability to make the system adaptable to large national rail networks and regional lines, (v) leveraging insights from satellite data at the edge, enabling real-time responses to infrastructure risks.

Results

The integration of ICOS technologies into the RAILSAT use case brought several concrete benefits that enhanced both the performance and operational reliability of the application:

- a) Improved scalability through intelligent resource allocation (Matchmaking): The ICOS Matchmaking service facilitated the efficient allocation of computational tasks across the edge infrastructure. This allowed

- to scale up the area of analysis—processing a longer railway segment—without degrading performance. The system dynamically matched workloads to available resources, ensuring optimal execution and supporting real-time vegetation monitoring at scale, and
- b) Support for timely decision-making through edge-level alerts: By allowing real-time execution at the edge and integration with external cloud data (Latitudo 40), ICOS facilitated low-latency alert generation for vegetation risks. This capability supports preventive maintenance and increases the safety and reliability of railway infrastructure.



Who we are

The ICOS project brings together a consortium of leading academic and industrial partners from across Europe, with expertise in cloud computing, edge computing, artificial intelligence, and cybersecurity. The project is funded by the European Union's HORIZON research and innovation programme under grant agreement No 101070177.

The partners involved in the development of the Intelligence Layer and integrated components include:

Atos

BSC
Barcelona
Supercomputing
Center
Centre Nacional de Supercomputació

CeADAR
Ireland's Centre for Applied AI

zetta
scale



PSNC

ΔΗΜΟΚΡΙΤΟΣ
DEMOKRITOS

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