EUCloudEdgeIoT.eu

# Meta-OS Use Cases Overview

EU-CEI Task Force 5

December 2023

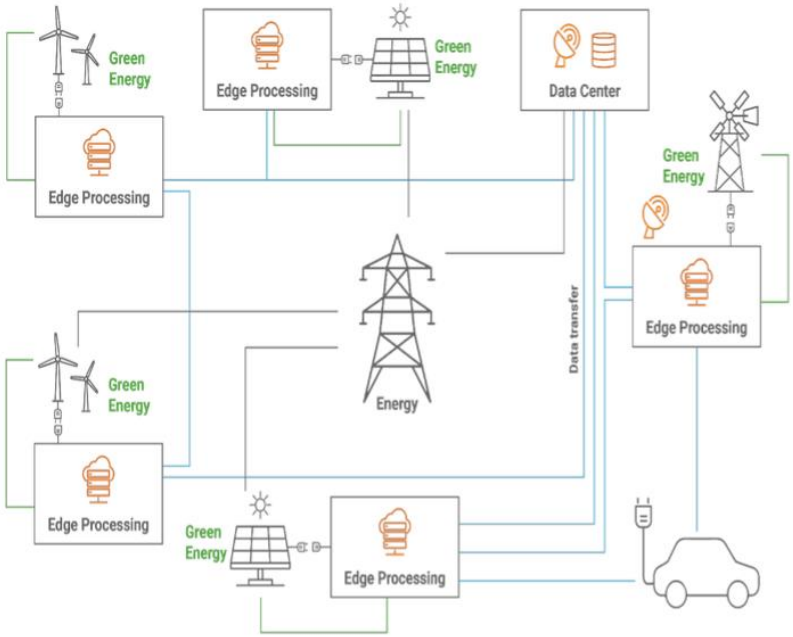
# Edge Computing Containers near Renewable Energy Sources

## Concept:

Data flows from IoT devices of the **wind, photovoltaic and hydro energy sources** in real time (or also periodically (e.g. hourly, daily) to **federated edge computing nodes** located directly at energy sources and connected to them. The **nodes (Infrastructure Elements)** process the data and provide them back to the IoT devices to manage them in real time. They also provide and receive SOME **aggregated** data to/from the cloud of the **data center**.

## Benefits:

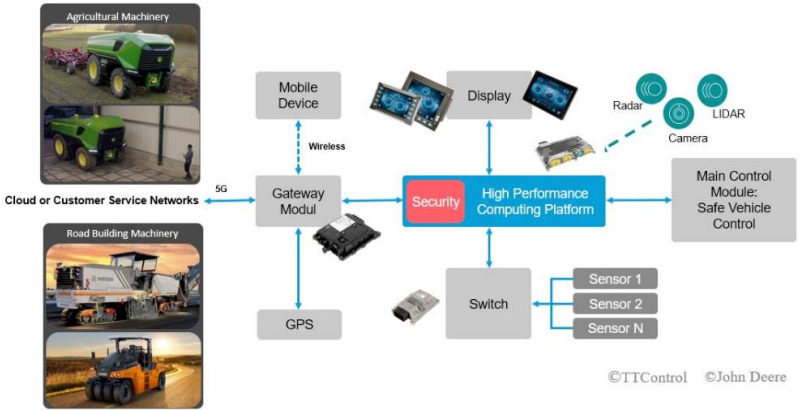
Real time (and hourly, daily) information from the energy sources is processed in **the edge computing node, where smart orchestration and self actions -powered by AI -occur**. Coupled with the **cloud intelligence of the data center (manageability interface)**, energy providers can make coordinated decisions to balance the elecitricity network. Orchestration of energy production of **wind and photovoltaic sources** and of energy consumption **sinks** including the **electric vehicle charging** leads to more optimal consumption of renewable energy and increased profits of the **energy** providers.



# Connected and Cooperative Mobile Machinery focused on agriculture

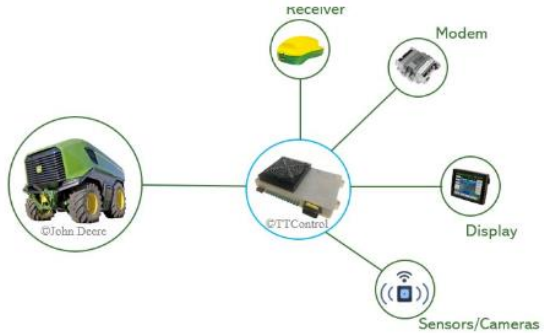
## Concept:

Tractors and other mobile equipment across road (or crop fields, etc.) collect location, network status and surrounding environmental data and process in **(semi)real time** instructions from cloud control center. The establishment of a computing continuum would allow to implement a **swarm** that would optimise M2M cooperation and coordination among **platooning machines**.




## Benefits:

Achieving the continuum would clearly improve the end user experience. A jointly working cloud control system with local computing capacity running management workloads over cooperating machinery. Efficiency and optimisation of the on-board equipped computing capacity would be achieved through the proof-of-concept for a **partial or full automation of a vehicle swarm operating safely and securely**.



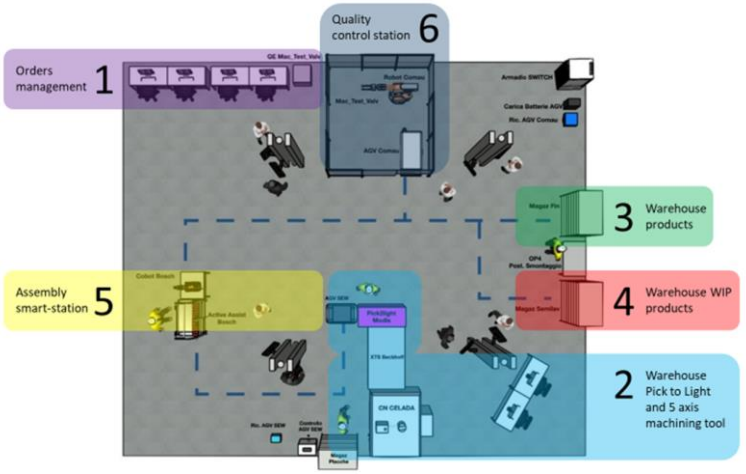
# Data-driven Cognitive Production Lines

## Concept:

The use case pursues the creation of highly flexible, sustainable (green) **modular digital production lines** as well as providing high autonomy levels (MAL4) in production lines including quality control processes (CMMs) by implementing smart rapid response features via **aerOS distributed edge-powered modular approach**. The edge-cloud continuity will also allow active energy monitoring and self-adaptive scheduling of AGVs.

## Benefits:

This implementation will allow to **achieve zero breakdowns** while keeping automation flexibility and continuous monitoring. Also, building on the **swarm approach** of the various elements in the production lines, a more efficient, individualised tracking will be leveraged, associating specific energy and CO2 emissions to **each particular element and moment of time**. At the same time, the AGVs will become smarter, **increasing the overall productivity** of the manufacturing line.



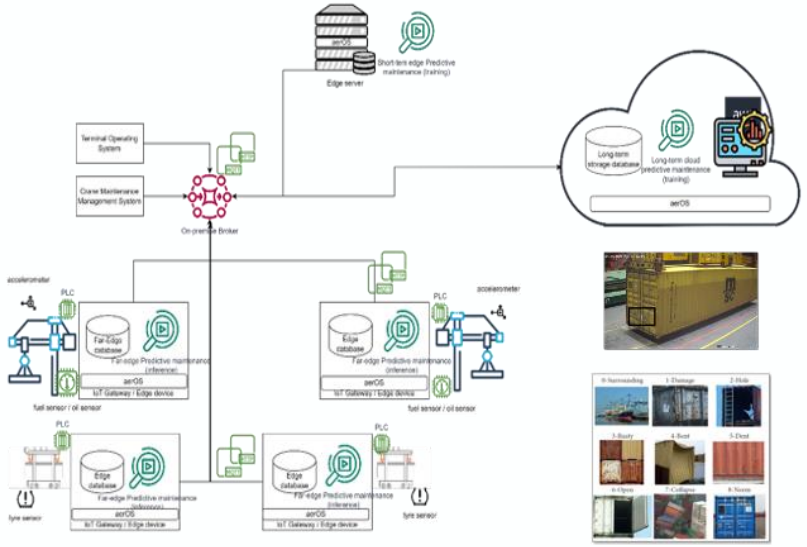
# Smart Edge for the Port Continuum

## Concept:

EGCTL's cargo operations rely on PLC-controlled cranes, providing accurate crane status representation. However, **a gap exists between on-site precision and cloud-based analytics, impacting real-time observability and causing latency issues**, constraining terminal efficiency and risk mitigation. aerOS continuum will allow to smartly cover this gap by introducing distributed AI making use of heterogeneous computing elements.

## Benefits:

With aerOS, an on-the-fly, **real-time integration between the HW of the cranes and the overall controlling software** will be achieved. By integrating aerOS in the edge nodes, the data will be processed at the precise location, in time and keeping better privacy, creating federation strategies that will redound on **finer identification of patterns for improved and container defects recognition**. It is expected to reduce idle times of machinery, minimise malfunctions and be less dependent on manual reporting of damaged containers.



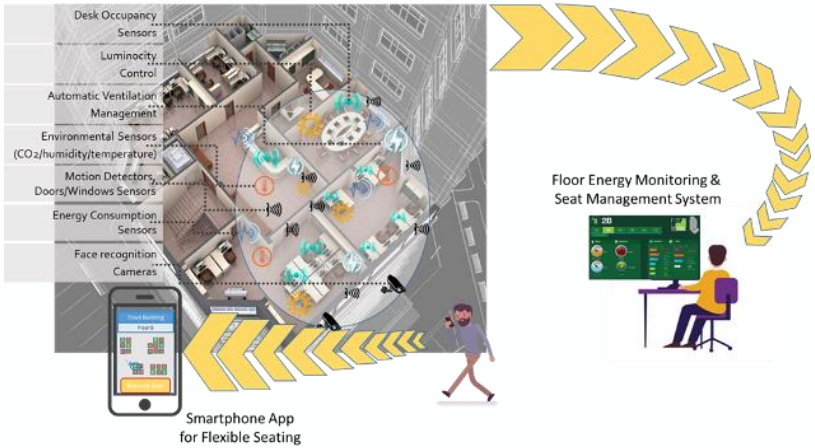
# Energy Efficient, Health Safe & Sustainable Smart Buildings

## Concept:

Proper employees' placement, social distancing, energy efficiency, along with business and personal preferences becomes a complex dynamic task. Real-time processing of data and **decision making close to events**, supporting distribution through aerOS capabilities, can offer **autonomous solution for safe, more energy efficient and and sustainable buildings**.

## Benefits:

Clear benefits of applying aerOS in this scenario are the capacity of **making buildings smarter**, playing an active role in the energy reduction goal. Also, the quantity and quality of data required for performing advanced predictivon will be relaxed. At the same time, the **data sovereignty at the edge** will be improved, reducing the dependency of cloud data centers. Also, the model will be able to be replicated and encompass other buildings in the same city, forming **more energy-efficient communities**.



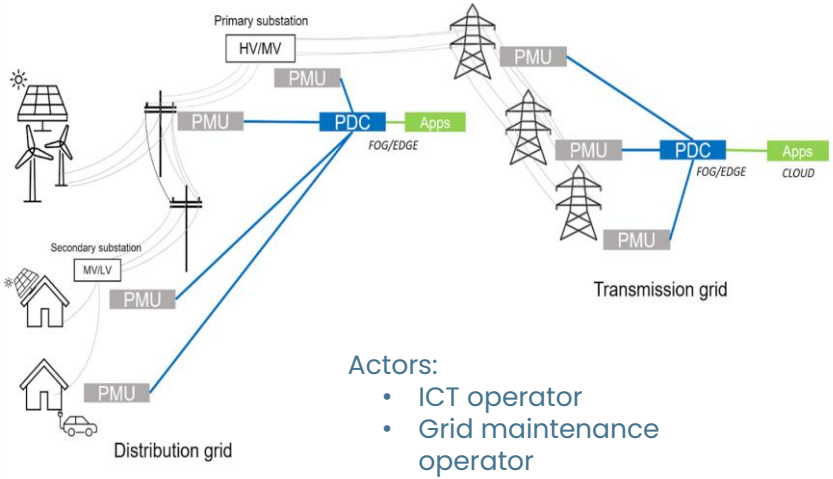
# Intelligent Power Grid

## Concept:

Integration of **cloud-edge processing** with the **power grid**, incorporation of sensors measuring (real-time) electricity parameters in the continuum, network analytics-based issue detection, with **advanced resiliency capabilities** of the ICT services also in case of network partitions.

## Benefits:

The automatic and seamless orchestration in FLUIDOS enhances the availability of electrical parameters (namely, seamless phasor data concentration and grid state computation) even in presence of multiple ICT outages and/or disconnection from central control centers, hence **reducing the risk of electrical downtime in the power grid**, which needs accurate phasor-data estimations in order to deliver electricity to end-users. FLUIDOS will orchestrate the PDCs based on node-to-PMU latency and enable local processing maintaining PDCs and analysis applications' functionality during communication interruptions.




Actors:

- ICT operator
- Grid maintenance operator
- Grid administrator

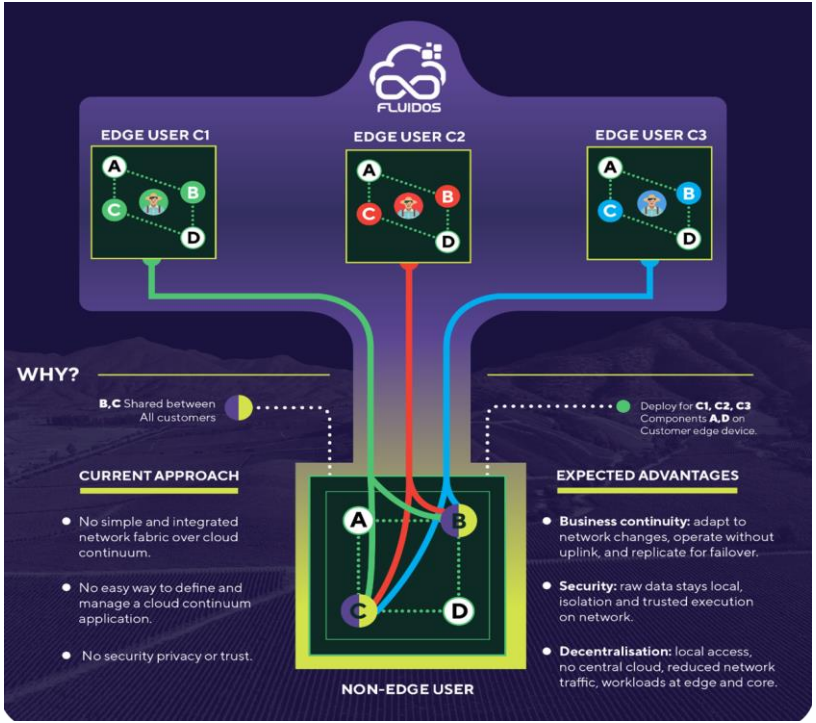
# Smart Viticulture

## Concept:

Enabling **smart farming** for viticulturalist using Terraview's climate SaaS platform bringing data from multiple sources with proprietary AI/ML pipelines to help create intelligence for the practitioners on the ground, to make better decisions, leveraging **the best computing resources available at the edge and in the cloud**.

## Benefits:

Leverage FLUIDOS to **simplify the deployment of ICT services** across the **IoT-edge-cloud continuum** and the process for critical decisions on the ground using intelligence from various sources, automatized data and analytics with connected reports, automatic alert response system, increased efficiency of workforce, improved health of crops and reduced loss of vines, decreased use of chemicals.



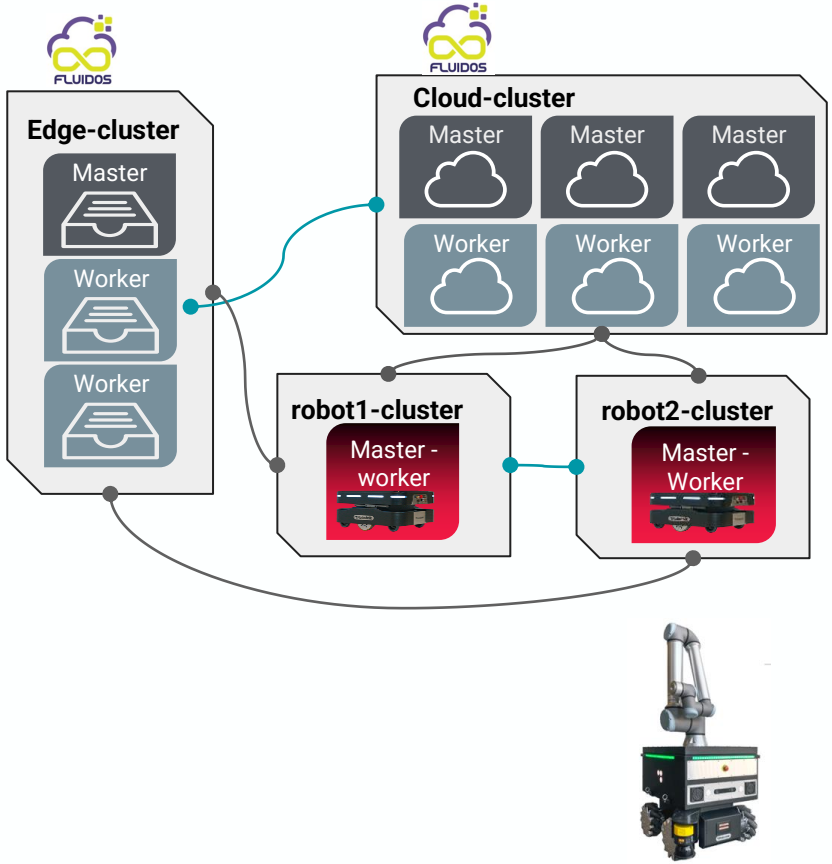
# Robotic Logistics

## Concept:

Integration of **cloud-edge processing** with **factory robots**, implementation of machine learning for coordination and orchestration purposes, optimization of object recognition capabilities in small robots, leveraging the **best computing resources available nearby**, while **saving battery power** on moving robots.

## Benefits:

Integrate FLUIDOS to increase the individual and collective **energy efficiency of moving robots** (e.g., saving battery power), capacity-based distribution of energy and computing resources, without draining robot batteries and **reduce deployment and hardware costs**. Possibly, predictive strategies on future energy demand based on past loads and strategies.



# In-car Advanced Infotainment and Multimedia Management system (IAIMM)

## Concept:

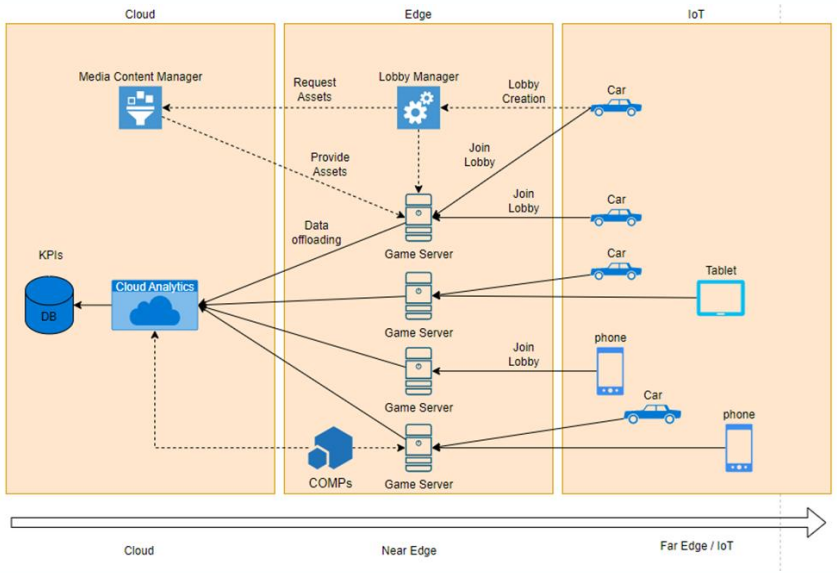
**Multi-users and Multi-sites Virtual Sharing Experience to interact in sync with high-definition media contents** (3D models, immersive videos, pictures, etc.) with **in-car passengers and other users far away**.

The service provides and enriches **multimedia functionalities** for planning, enjoying trips and visiting touristic sites. Its deployment architecture includes **edge nodes to host rendering** and preprocessing and more powerful **cloud nodes**.

## Benefits:

Ensure **seamless user experience** by optimizing 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**



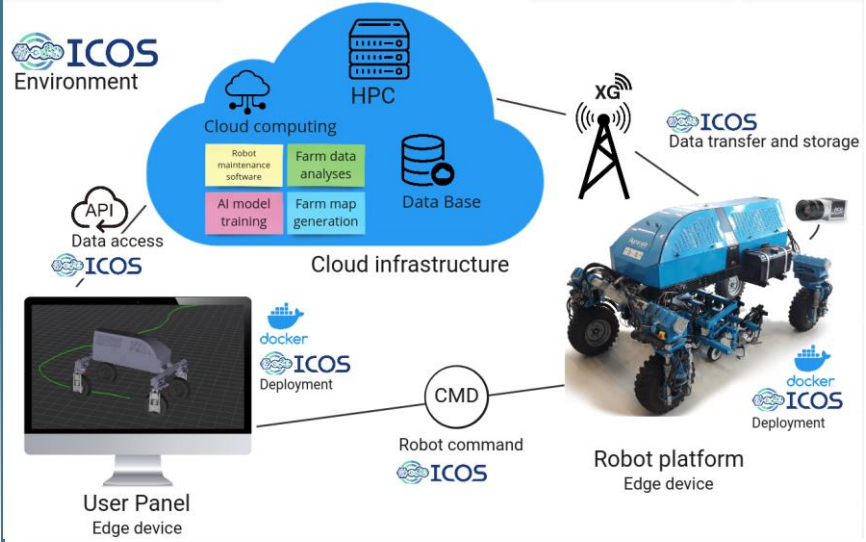
# Agriculture Operational Robotic Platform (AORP)

## Concept:

Further development of digital and robotic systems based on **data exchange ecosystems and services** based on their **semantic processing** to provide knowledge and tools that will increase efficiency, ensure safety, and confirm product quality in the supply chain, while reducing costs and providing valuable and up to date information to farmers.

## Benefits:

Optimizes farming with agro robots (Agbots). Agbots are used for precision agriculture to develop processes on farms **reducing operating costs, improving awareness of technology potential impact, digital competences, improves effective use of resources as well as reduces the amount of used plant protection products.**



# Railway Structural Alert Monitoring system (RSAM)

## Concept:

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.

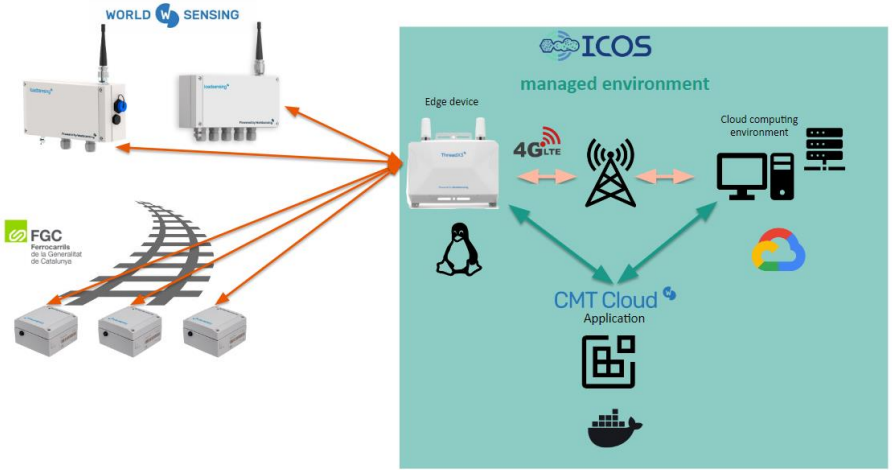
The railway  line along an area select for the use case is where communications are limited in availability and bandwidth. **META OS will make it possible to benefit from processing at the edge while sharing limited amounts of extremely relevant information to the upper layers of other applications.**

## Benefits:

**Time saving** through continuous monitoring by limiting intensive personnel inspections that are done every day before trains circulations.

**Cost savings** by implementing corrective actions in advance to avoid reparation costs.

**Improves safety** by establishing velocity limits to avoid risky situations with quality of the operation decrease.



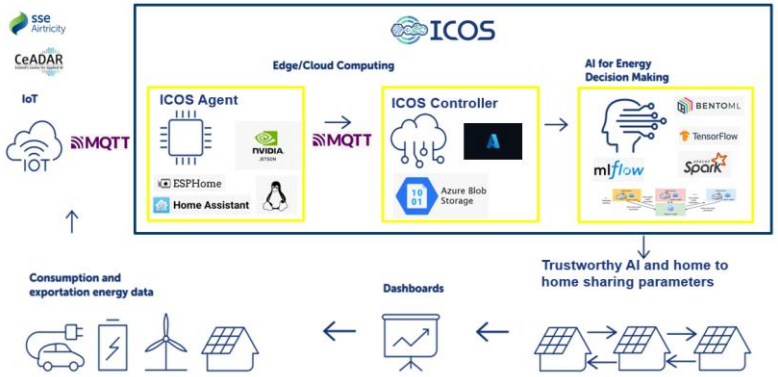
# Energy Management and Decision Support system (EMDS)

## Concept:

**ICOS EMDS system aims to deliver a secure and efficient energy system, 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.** The ICOS AI 'brain' will shape the future usage 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.

## Benefits:

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, using automated decisions to decrease costs, reduce generation curtailment, maximise consumption and usage of renewable energy, increasing client satisfaction and retention.**



# Environment Crisis Management

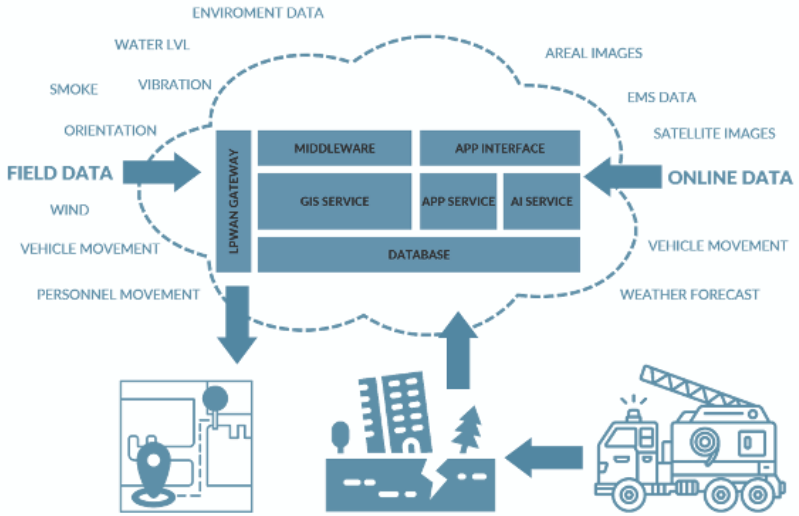
## Concept:

NebulOuS addresses disrupted communication during crisis with its **adaptable fog computing platform**. This technology enables **efficient coordination and data processing** in large-scale disasters, utilizing **AI algorithms** to enhance situational awareness for crisis management and response teams. The platform ensures reliable communication and computation capabilities, even in situations where traditional infrastructure is compromised

## Benefits:

**The flexible fog computing solution** of NebulOuS can be tailored to specific disaster scenarios, ensuring versatility in communication and computing capabilities.

**The deployment of AI algorithms across various levels of the edge-cloud-continuum enables real-time data processing,** significantly improving the situational awareness of crisis management staff and response teams.



# Transportation and Logistics: Supply of Fresh Food to a City

## Concept:

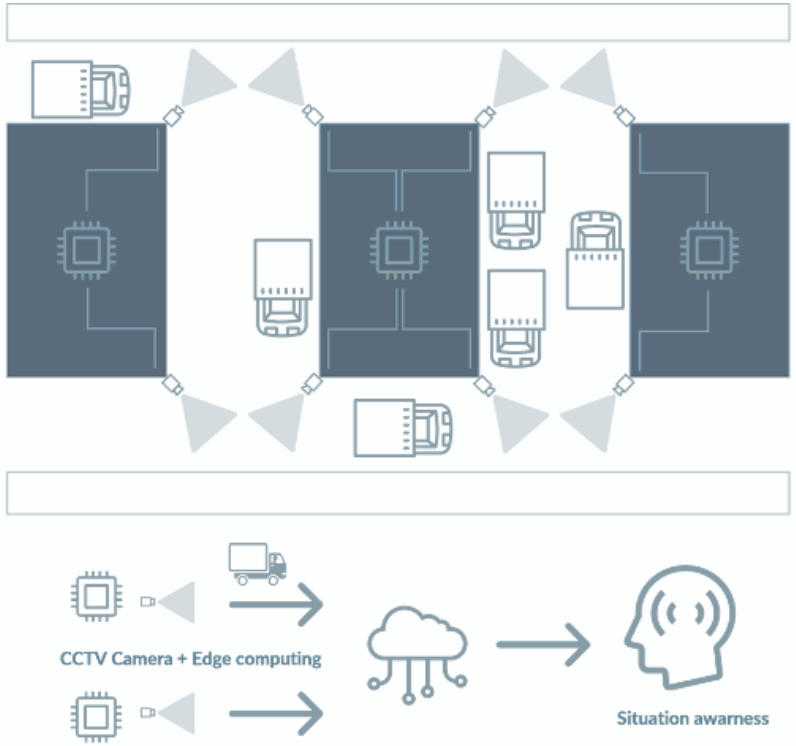
Mercabarna a 24/7 fresh food supply hub, houses 600 companies specializing in distribution, preparation, and import/export of fresh and frozen goods. Using AI algorithms to track vehicles from CCTV cameras, this pilot aims to provide facility managers with a tool for **real-time traffic tracking** and simulating policies to alleviate road congestion. The pilot will be demonstrated through a **digital twin approach**, which will **enable efficient and decentralized management**.

## Benefits:

**Real-Time Monitoring** – integration of IoT/sensors and edge processing allows constant monitoring of delivery routes using real-time data.

**Optimized Route Planning through Cloud -** Utilizing cloud-based computing, the system plans optimal delivery routes by considering different factors

**Enhanced Data Analysis an** efficient use of the resources and the infrastructure.



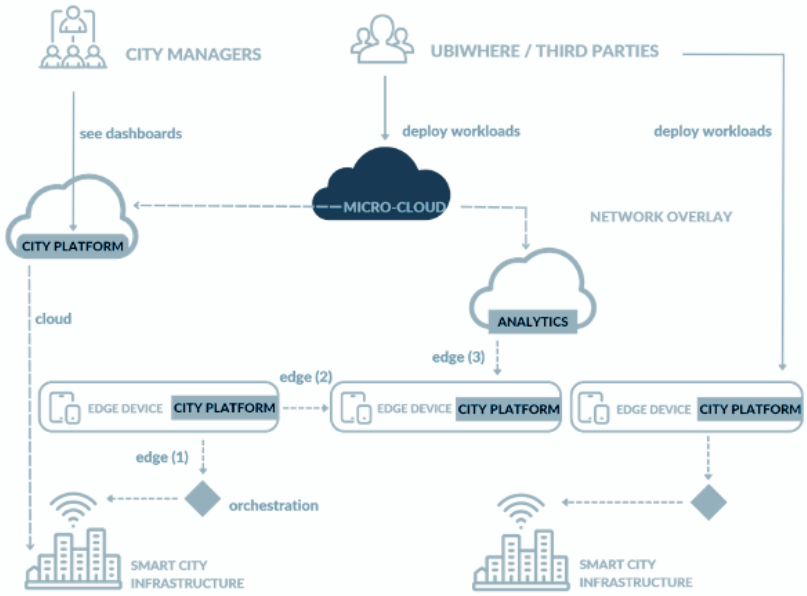
# Smart City: Computer Vision for City Maintenance

## Concept:

The use case involves l**everaging IoT for real-time data collection in cities** to understand changing demand patterns. With a focus on smart-city maintenance, t**he pilot will validate 5G technology, integrating IoT sensors for data collection and edge processing.** This enables real-time analysis and actionable insights directly from edge devices. Specifically, the use case applies computer vision to detect damage in buildings and infrastructure.

## Benefits:

By pairing the NebulOuS platform with Computer Vision technologies, **algorithms can be deployed on multiple levels to give connectivity, edge analytics, and interoperability** to the cities, making it easier to evolve.



# Energy and utilities: Windmill Maintenance

## Concept:

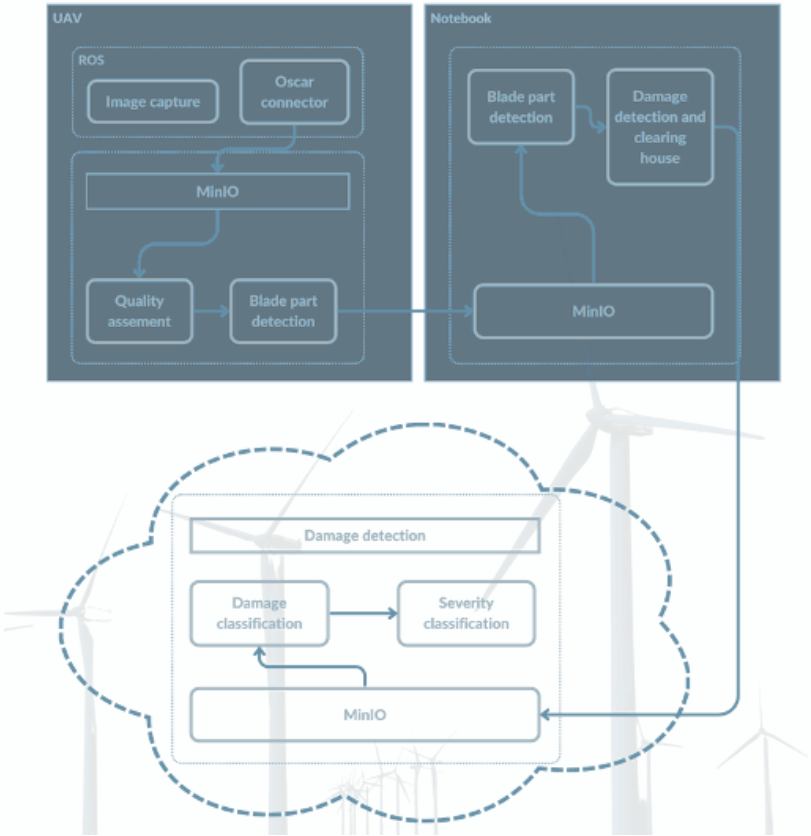
The windmill Maintenance use case is to **automate the process of data acquisition and processing using drones.** This will allow automatic and real-time handling of the turbine damage detection process being infrastructure agnostic and requiring minimal human intervention. The use case will demonstrate how the NebulOuS framework can efficiently deploy wind turbine inspection software, efficiently utilizing cloud and fog resources.

## Benefits:

**Immediate quality feedback and on-line process.**

**No dedicated data upload step** - the data processing begins at the edge and is redirected to private or public cloud resources only if a potential anomaly is identified.

**Asset management application involved only after data is processed** - minimal amount of data collected and stored for further offline analysis.



# Agriculture: Precision agriculture

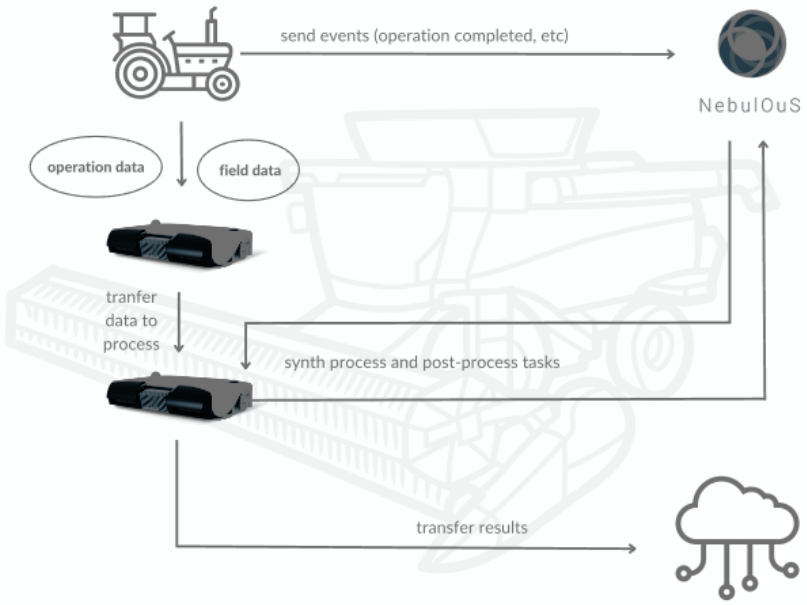
## Concept:

The use case leverages idle IoT devices in the field. T**he goal is to reduce the tasks sent to the cloud provider, significantly reducing costs, and optimizing time and task completion.** NebulOuS will provide efficient task scheduling and secure data transmission, adapting to network bandwidth and connection stability. NebulOuS technology allocate data streams propagation and processing across diverse micro local clouds, private clouds, public clouds and edge resources.

## Benefits:

NebulOuS technology **will enable to allocate some of the data streams propagation and processing to a combination of heterogeneous micro local clouds, private clouds, public clouds as well as edge resources, increasing the transfer of valuable data at the same cost.**

By doing this, NebulOuS platform will **optimize processing jobs that can be time-critical** like pattern recognition for spotting low vegetation areas that do not need any fertilizer, or post-operational analysis applications like leaf pattern recognition for spotting certain diseases.



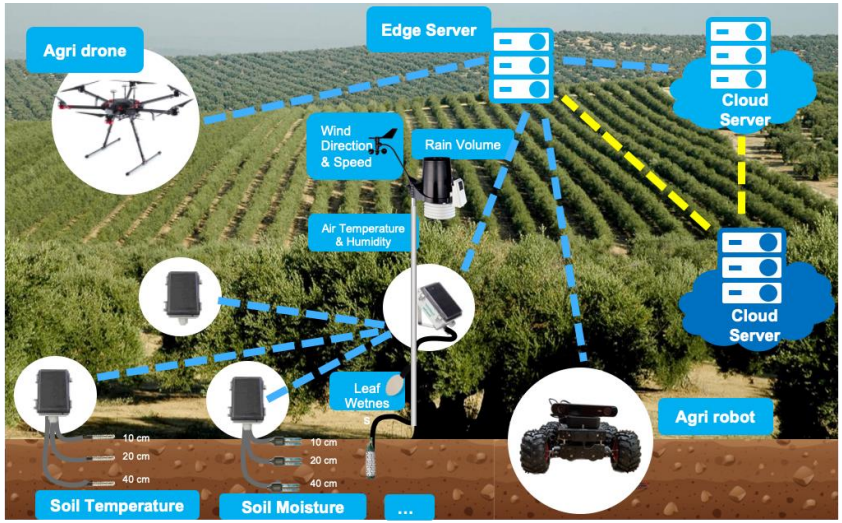
# Smart Farming and Precision Agriculture

## Concept:

**Aerial Precision Bio-Spraying -** micro-clima data collected via Synelixis SynField® IoT nodes and real-time video analysis of olive groves from visual and multi-spectral cameras on drones.

**Terrestrial Precision Bio-Spraying –** Autonomous robots collect images for locating weeds and enabling optimal precision spraying with organic insecticide.

Both cases rely on ML models, running on the drones/robots, trained through Cybersecure Federated Deep Reinforcement Learning (CF-DRL) and flexible training across the IoT, edge and cloud resources.




## Benefits:

**Increased energy efficiency** through flexible deployment of services IoT-edge-cloud continuum

**Reduction of CO2 emissions** by moving operations closer to the edge or better exploiting green energy availability

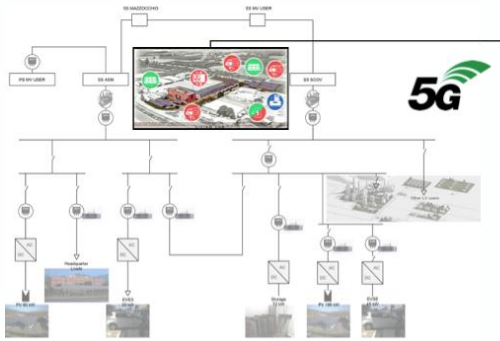
**Enhancement of precision bio-spraying** with advanced multimodal ML models, lead to cost benefits for the farmer

# Smart Energy & Smart Mobility

## Concept:

**Smart Grid Flexibility** –monitoring and analysing of MV/LV electricity voltage quality by using innovative power sensors able to protect MV/LV substation breakers and Smart meters which measure electricity generation and consumption.

**Smart Mobility/City** – drivers-friendly scenarios based on traffic flow and parking prediction (EV, EVSE, cameras,…); dispatchable charging of EVs based on RES demand-response along with human-centred smart micro-contracts and micro-payments.





## Benefits:

Ensuring **electricity grid stability** by monitoring and balancing voltage, reducing the risk of power failures.
Improving the use of renewable energy sources, promoting a more **sustainable and eco-friendly power generation**.
Increasing the **efficiency of electric vehicle charging** in urban areas, making it more user-friendly.
Utilizing EV charging as a demand response mechanism, contributing to the overall **balance and stability of the energy grid**.
**Reducing CO2 footprint** through micro-services migration and green data center infrastructure, contributing to environmental sustainability.

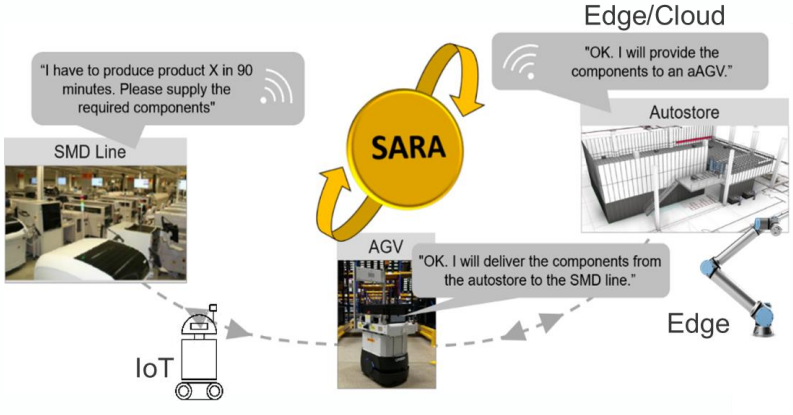
# Smart Manufacturing & Industry 4.0

## Concept:

**Fully automated indoor logistics/supply chain:**
Fully automated material picking (SMD-Components) from Auto Store and autonomous transfer to the production line. High speed and ultra-low latency (TSN) private wireless network will support massive data uploads to the edge cloud facilities.
**Human-centred indoor factory environment safety:**
High precision AGV localization layer merging real time localizations info. Enable autonomous avoidance of potential collision between AGVs, or between a worker and an AGV.

## Benefits:

**Fully automatic** supply of production
**Seamless "just in time" material transport** between different floors
Existing traffic bottlenecks are eliminated One central system in place for all material supply processes
Constant material flow processes
**Minimum of lead times**
**Elimination of production stocks** - Less stock in circulation more productivity



# Smart Media / City & XR

## Concept:

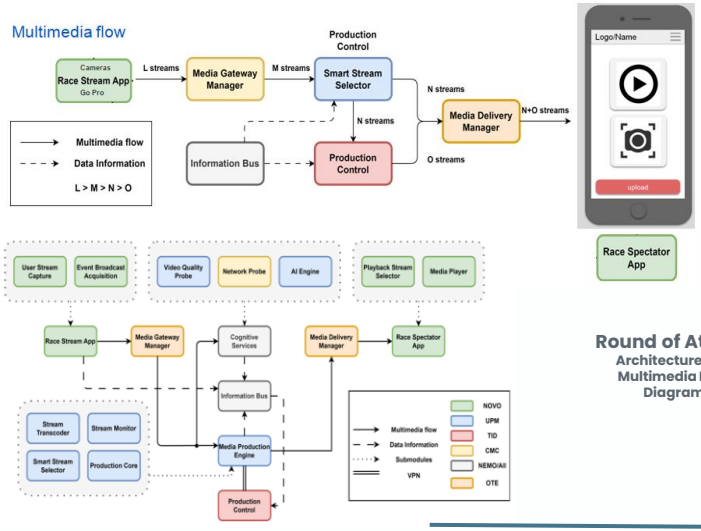
**Enhance** the boundaries of **live media capture** and **user involvement** as well as enhance the **VR experiences** using sensorial stimuli and bio data.

**Round of Athens Race:** Enhance **live sport event spectating experience** through **AI driven driven data and content analysis**. Emphasis on real-time **user generated content processing** and rendering using FML hosted locally on the IoT nodes (smart phones), in the edge and at the cloud.

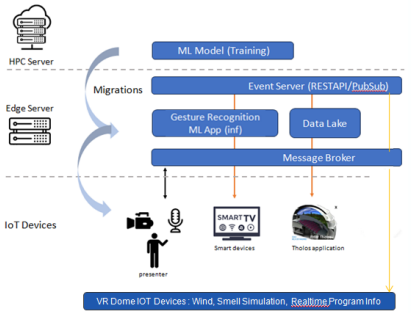
**XR Time Machine:** Enhance H**MD and real-time VR Dome experience** using **sensorial stimuli** and **bio data**. Use case will be validated with heterogeneous IoT devices (i.e. VR glasses and sensors), extreme bandwidth requirements (up to 12K resolutions for 360o video & geometry plus textures for 3D media).

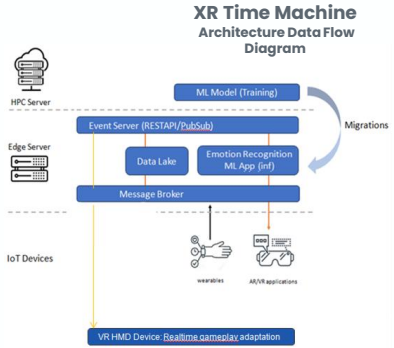
## Benefits:

**Fast**/time sensitive services **migration** from edge to cloud and extreme **large media** from **thousands of users**.
**Media processing**, **AI annotation-segmentation-labeling** and rendering at the **IoT-to-Edge-to-Cloud continuum** to support multiple users using their **mobile phones**.
**Advanced FML** analytics to calculate the accurate **positions**, recognize **Gestures** and **Emotions** to enhance **VR Experience**.
**Validate NEMO user acceptance** from a **citizen** viewpoint for **Culture** and Live **sport events**.




**Round of Athens**
**Architecture and Multimedia Flow Diagram**




**XR Time Machine**
**Architecture Data Flow Diagram**

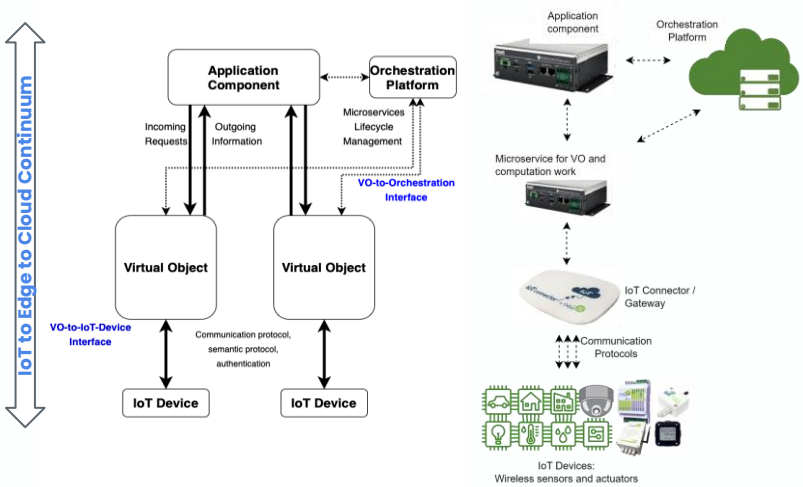
# Energy Management in Smart Buildings/Cities

## Concept:

Development and evaluation of Nephele technologies (Virtual Object and Virtual Object Stack). The goal is to apply these technologies in **intelligent monitoring** and **remote energy management** within the spectrum of **smart buildings**. The key objectives include the development of applications that facilitate **energy-efficient control**, the provision of personalized services to end-users, and the establishment of an automation schema grounded in **real-time data**. The use case is also focus on video analysis for detecting individuals and objects.

## Benefits:

**Real-time** monitoring and data processing using **AI models** and **CEP rules** for decision making and control automation thanks to the aggregation of data from different sources. The use of Virtual Objects allows adding to constrained IoT devices **advanced computing capabilities** that allow **complex cryptography**, **advanced security systems**, **device intelligence**, **better management of device and network resources**, **improving performance and savings energy**, while offering broader and more intelligent control of the energy management systems.




- Secure communication in IoT device group
- Distributed complex decision making in buildings
- Distributed authorization scenarios
- True presence detection in building
- Communication radio offloading
- Customizable IoT devices to support energy-efficiency and well-being in buildings

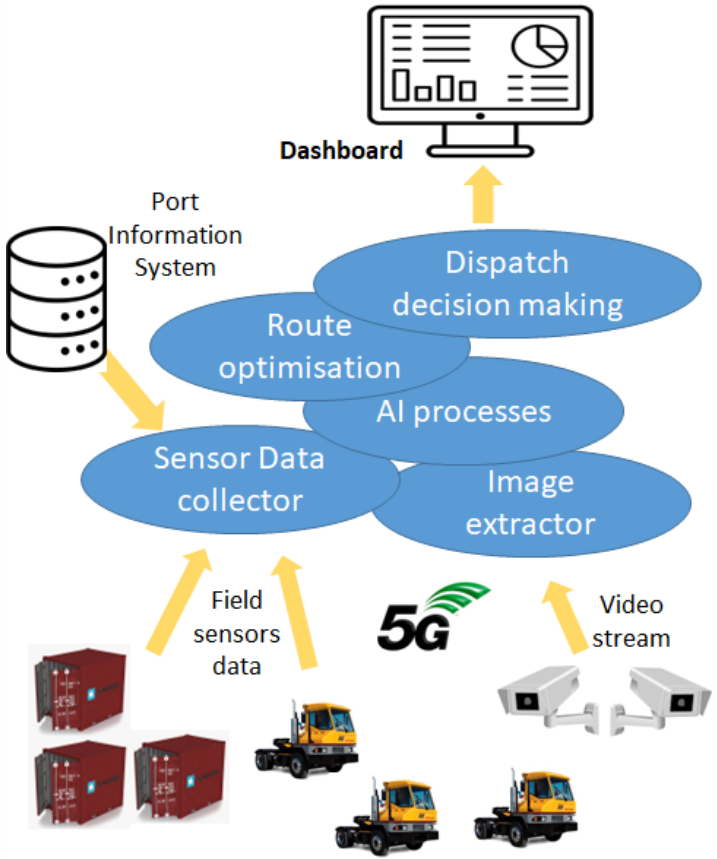
# Smart Port

## Concept:

By utilizing **Virtual Object** and **Virtual Object Stack** concept, data collected from multiple **sensors in the field** and **video cameras** are first (pre)processed in IoT gateway (far-edge), then combined with **business process related data** originating from Port Information system and processed in the edge, while certain specific tasks are delegated for the processing in the cloud, thus relying end-to-end onto the **IoT-Cloud-Edge Continuum** approach. **Optimizing process of routing containers** also include **machine-learning** algorithms for **problem-solving** and **risk avoidance** deployed at different components of IoT-Cloud-Edge Continuum.

## Benefits:

Increase in **system flexibility**, **stability**, and **portability** will be achieved through IoT-Cloud-Edge Continuum harmonisation. Port stakeholders **resource optimisation** due to the containers routing process optimisation through decentralised predictive decision-making bringing also **increased coordination capabilities** with different external networks (road, railway), **reduced greenhouse gas emissions**, **security compliance** and **upgraded service level agreements**.



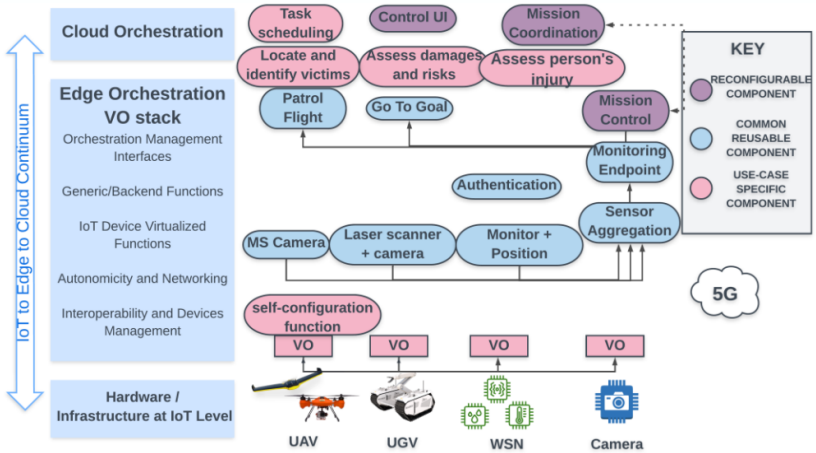
# Emergency/Disaster Recovery

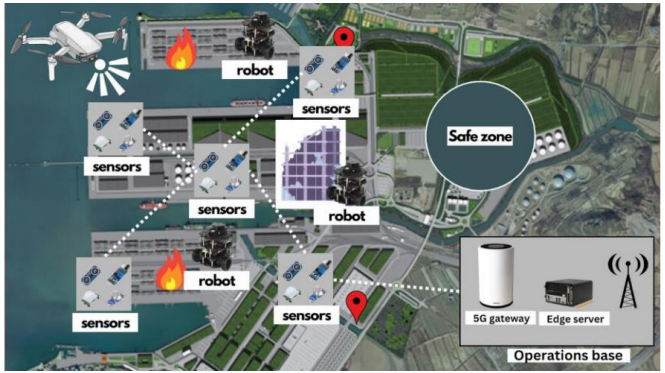
## Concept:

Establishment of a IoT-Edge-Cloud continuum for **emergency initiatives**, integration of **sensor-carrying robots** and smart devices in the continuum, deployment of **edge computing for low-reception** scenarios. Deploying an **autonomous exploration and monitoring solution based on multiple robots** that allows **autonomous and adaptive exploration** of an unknown area.

## Benefits:

Provide **risk assessment tools** to enhance situational awareness of the first responders
Increased **victim-locating capabilities** through the processing of data from the sensors in the continuum
**Optimisation of injury assessment and treatment** through data gathered by the smart devices
**Predictive emergency operations** through system-wide analytics.



# Remote Healthcare

## Concept:

The current **ultrasound medical imaging processes** are constrained by both the technical features of the local device and the knowledge of the local healthcare operator.

**Connect, decompose and virtualize ultrasound medical imaging systems** into the cloud-edge continuum to lose any barriers due to the hardware capabilities and localization of current physical systems.

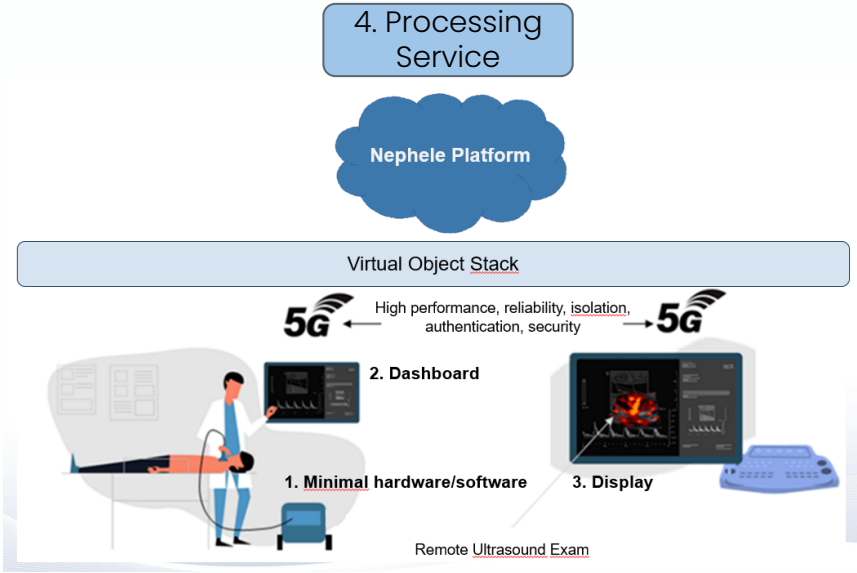
## Benefits:

Allow to **exchange data and resources** among the physical components involved in the use case.

Provide additional capabilities such as **distributed data management and analysis**.

Allow the orchestration of data and resources between the cloud and edge computing orchestration platforms.

**Virtualize ultrasound medical imaging systems** into the cloud-edge continuum




Ultrasound acquisition hardware and medical imaging viewers are required for this use case.

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