spine

# PORT NERVOUS SYSTEM

## Powered by Edge Computing and Computer Vision

ubiwhere

# Introduction

ASSIST-IoT is a research project supported by the EU's Horizon 2020 ICT-56-2020 program that aims to design, implement, and validate an open, decentralised reference architecture, as well as the associated enablers, services, and tools, to help human-centric applications across a variety of fields.

ASSIST-IoT will design, implement and validate, in a realistic, measurable, and replicable way, a unified innovative multi-plane (semi-)autonomous decentralised edge-cloud reference architecture, supplemented by cross-cutting digital enablers.

## In ASSIST-IoT there was continuous assessment and verification of the project results in three pilots, representing: Port Automation, Smart Safety of Workers and Cohesive Vehicle Monitoring and Diagnostics. SPINE – Supply Ports with Innovative CV edge Nodes to increase their Efficiency – was driven by Ubiwhere and port terminal operator Terminal Link Group (TL). A solution was deployed in the Malta Freeport terminal (MFT).

The City Nervous System (CNS) offers the necessary technology to upgrade street furniture (such as lampposts, cabinets or kiosks) with wireless, computing, networking, storage and administration capabilities turning them into neutral hosting and edge computing platforms for 5G deployment, implementation of IoT and EV Charging solutions as well as data collection and analysis (at the edge) via open and standard interfaces. The CNS leverages existing infrastructure to create novel use cases and business models, allowing telecom operators and other players to share it within an open-access model.

Besides significantly reducing the expenses of deploying and operating mobile networks, EV chargers, and other equipment relevant for the communities, it provides a web platform to connect Infrastructure Owners, System Integrators, MNOs (Mobile Network Operators), Cities and Verticals (Service Providers and Operators from different industry sectors) to jointly develop open and standard testbeds for Smart Cities, Airports and Ports. With SPINE, we will exploit a new instance of our innovative concept: the Port Nervous System, co-created with and demonstrated in Malta's Freeport Terminal.

Ubiwhere has been working on this vision for a long time now, with the intent of providing a single way to use telecommunications infrastructure in reliable and repeatable ways. We are applying our research to product strategy in this Nervous System concept, which means that we are developing a product rooted deeply in research and innovation where we aspire to include ASSIST-IoT.

The main idea of the SPINE project is to integrate, evaluate, improve (if needed), validate, and demonstrate ASSIST-IoT Core Enablers, both from the Data management plane and the Application and services plane to alert operators of the remotely operated cranes of Malta's Freeport Terminal (MFT) on potentially dangerous situations between people and containers. By detecting these situations, the SPINE system can decrease and optimise crane operations manoeuvre time and crane operations downtime.

# Our challenge

## The main idea of SPINE is to supply ports with innovative edge nodes to increase their efficiency and security. Through a digital twin platform of each port and a web solution on the cloud, it is possible to monitor in real-time the port's devices and their status.

SPINE is based on computer vision technology that performs vehicle, person, truck, container and other object detection to prevent collisions. Therefore, SPINE aims to create a solution that allows automatic detection of objects and incidents, providing operators with alerts that allow them to better manage the equipment, while also increasing the security and efficiency of the port.

During the project, our approach was to deploy edge computing solutions that use computer vision (with OpenCV and TensorFlow) to enable video analytics about people and other objects entering specific port locations, where cranes are operated remotely, to support the operators who lack contextual information of their work environment and need to leverage the cameras installed in the cranes.

**Through a demonstration at the Malta's Freeport Terminal (MFT) SPINE integrated, evaluated, and demonstrated ASSIST-IoT Video Augmentation Enabler, both from the Data management plane and the Application and services plane to alert operators of the remotely operated cranes on potentially dangerous situations between different objects and containers. By detecting these situations, the SPINE system can decrease and optimise crane operations manoeuvre time and crane operations downtime.**

# Spine as a Solution

The SPINE system is designed through a multi-layered architecture, each with several microservices. A detailed package view of the architecture, including the main interactions between each component of the layers already defined, is provided in Figure 1.

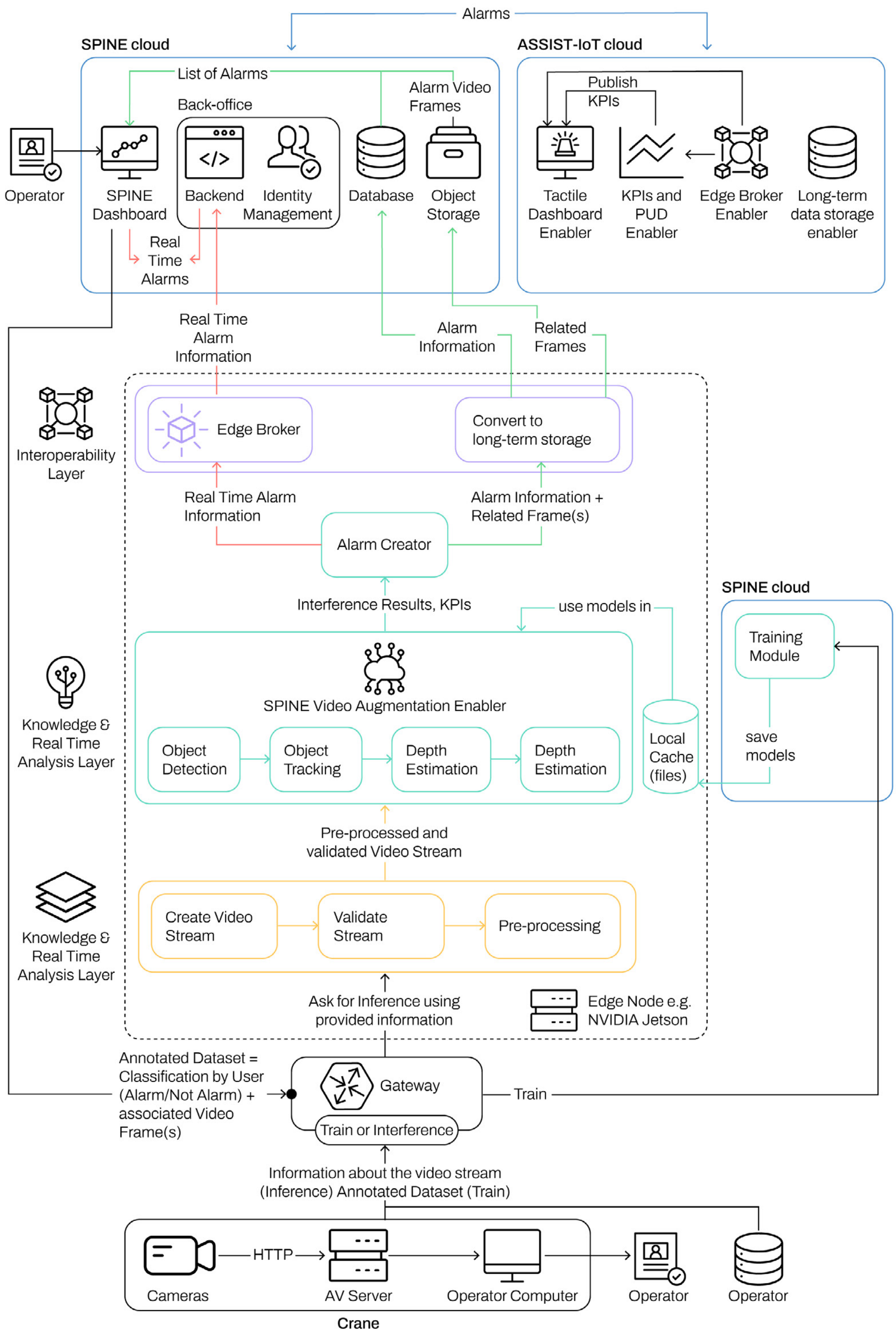
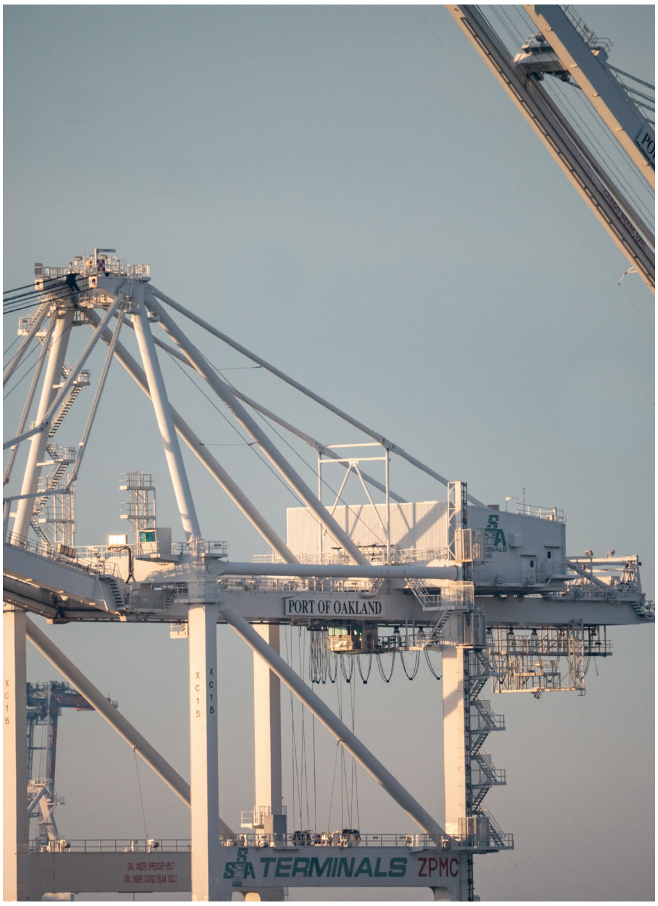



Fig 1. Package view of SPINE architecture

System was designed to be compatible with the ASSIST-IoT architecture based on multiple enablers, each one a microservice. SPINE pilot reuse the ASSIST-IoT Video Augmentation Enabler (VAE).

The SPINE system assumes that it can receive information (e.g., the URL of the video stream) on a video stream of the gantry cameras within the crane, either from the crane's existing systems or other sources – with local files as a possibility to simulate the video stream.

The SPINE solution is event-driven and treats the video stream of the crane cameras as a set of events to be processed by the Data Acquisition Layer. These events are then processed by the SPINE-adapted Video Augmentation Enabler, which leverages Machine Learning (ML) models for Object Detection, Tracking and Collision Estimation. These models are stored within a Model Repository in the cloud.




The results from the ML models are used to decide if an alarm should be generated and if so, the alarm is generated and sent into the interoperability layer, which ensures the alarms reach the expected endpoints – such as the SPINE cloud (where the dashboard for operators and long-term storage for statistics are located), ASSIST-IoT cloud or other endpoints.

**ML results are then shown in SPINE GUI, an user-friendly dashboard, which gives information to the operators about their work environment. Some screenshots of the dashboard are provided on Figure 2, 3 and 4 .**

The main page is the “Live Cameras” menu, which shows all the cameras available according to the crane selected, as well as the last triggered alarms (Figure 2) and the real-time alarms, when detected (Figure 3). If there is no dangerous situation detected, the dashboard shows a “OK” visual feedback (Figure 2).

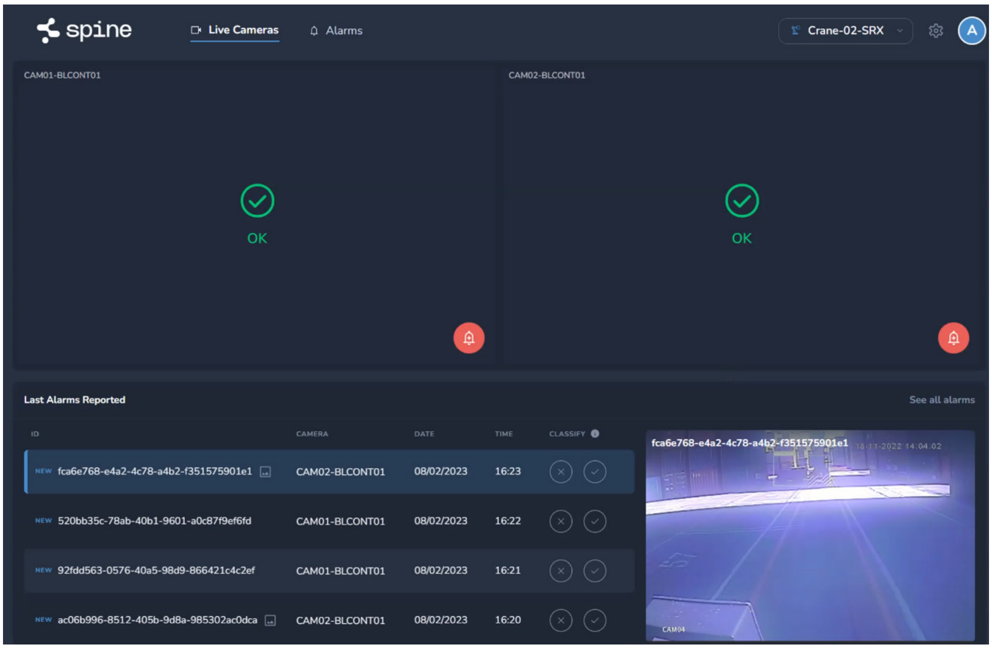



Fig 2. Live Cameras page

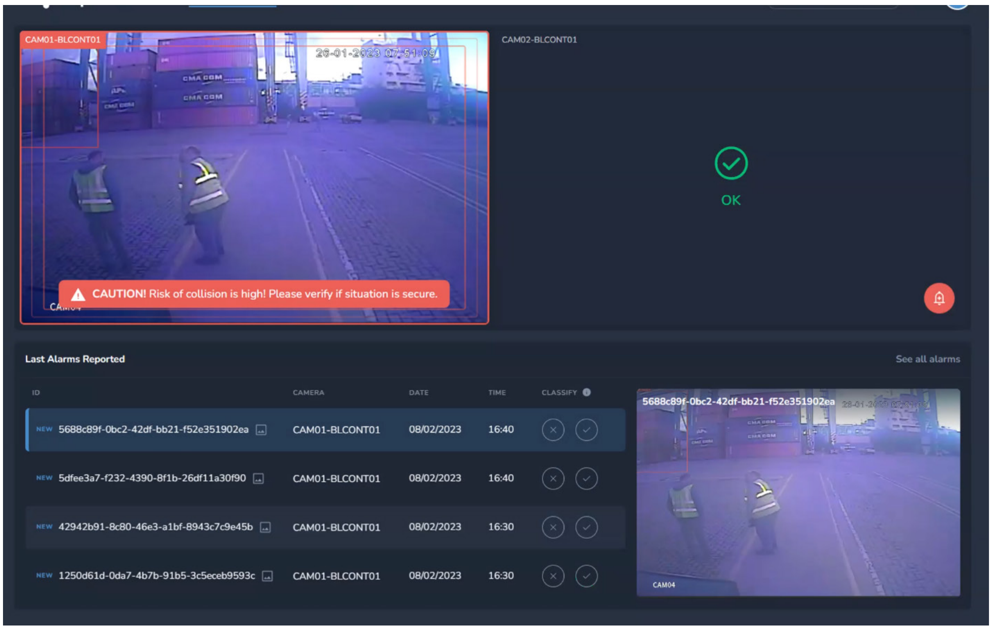



Fig 3. Package view of SPINE architecture

The List of Alarms section (Figure 4) is where the user can find all the alarms triggered on the platform and related statistics. Similar to the Last Alarms Reported view, the user can analyse and classify the alarms shown.

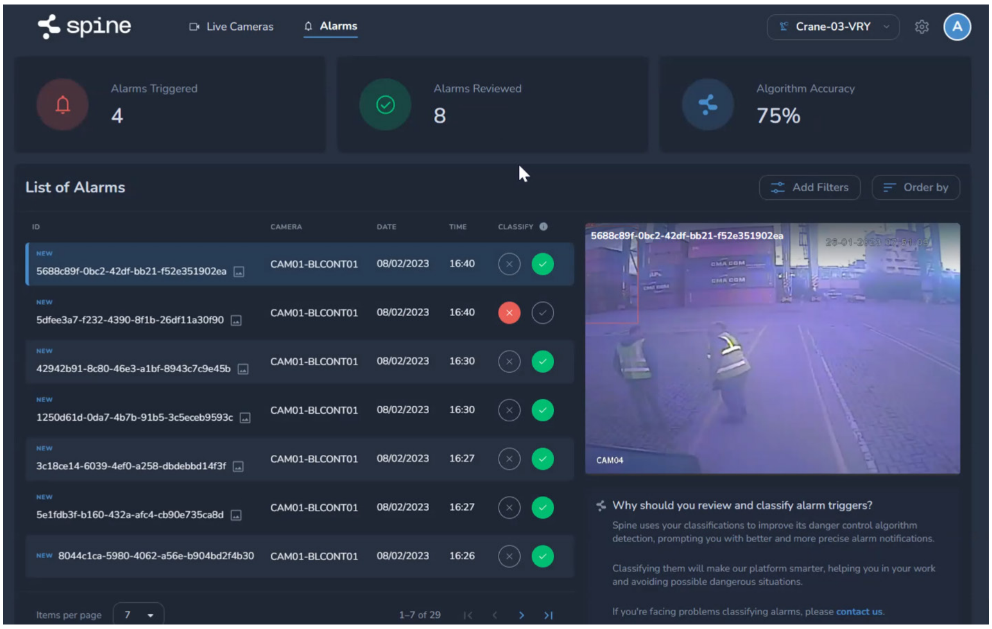



Fig 4. Alarms List page

The core of the SPINE Architecture is the custom-made Video Augmentation Enabler (VAE). Responsible for processing video streams from cameras within the cranes, the VAE must infer if potentially dangerous situations between the crane and other entities around the crane - such as people, vehicles or containers - may happen. To do such analysis, the VAE leverages multiple Computer Vision algorithms to detect objects, infer their distances and compute if a collision is likely to happen or not.

The VAE outputs an alarm if such a situation is likely, which will then be presented to the port manager and/or crane operator(s) through a dashboard interface.

Therefore, with the SPINE system, the crane Operator is expected to be able to:

1. see alarms of potentially dangerous situations in real-time.

2. see a list of the previous alarms to manually validate if they are true alarms or not, to improve the system's accuracy.

3. report an undetected dangerous situation that should have been detected but was not.

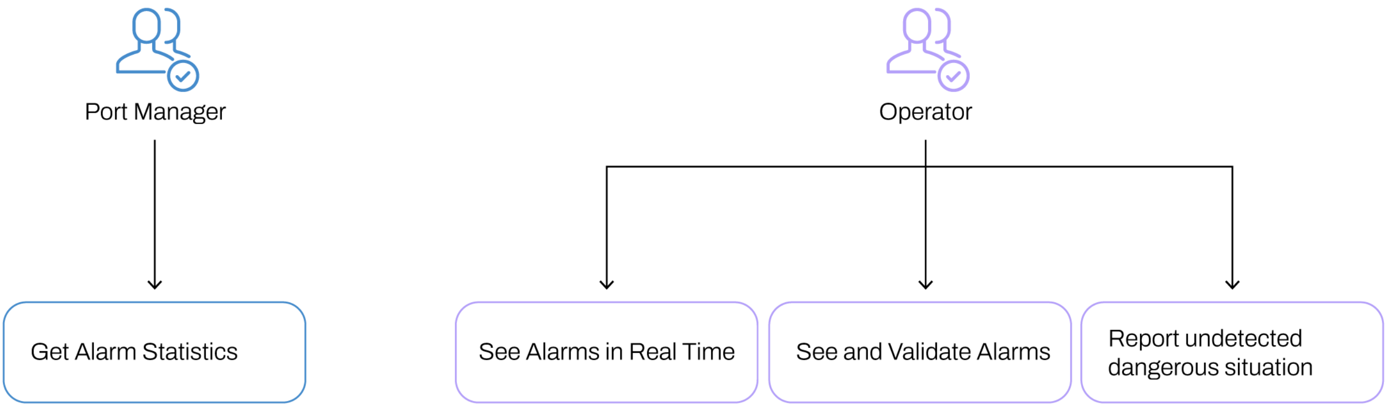



Fig 5. User cases

**In addition, statistics on the alarms could be provided to the port manager.**

# Benefits and Impact

## SPINE is considered to possess huge potential, firstly due to the way its system architecture was designed, modularly, allowing replicability and scalability, and secondly due to its adaptability, which allows for applications in several different scenarios and contexts in which safety is key.

The main benefits associated with the solution, therefore, rely on these aspects. Replicability and scalability are mandatory characteristics for a successful product. The ability to adjust the solution to different ports, of different sizes and with different demands can dictate its success. Additionally, adaptability is essential to also demonstrate the versatility of the solution, its capability to adjust to different scenarios which might require safety assurance and potential collision's management.

In all possible scenarios, the SPINE system can help prevent collisions or, when a collision is inevitable, record collision events, making it easier for the authorities to identify the collision origin. The benefits of the solution enable the improvement of several sectors which is previewed to result in a large scale and stronger impact.

**The impact of SPINE is, therefore, expected to be great and wide. Its replicability and scalability along with adaptability are expected to raise great interest in several areas while also expanding the already existing interest when it comes to port's transformation.**

# Conclusion

## The SPINE project, throughout its execution, was able to achieve all the requirements and goals it set out to do. It was possible to deliver a solution to predict potential dangerous situations within a port and notify crane operators on those situations.

While the developed solution has a good overall performance, improving the reliability and quality of detections is a natural future step, with multi sensor fusion as a clear path towards minimising inaccuracies.

The SPINE system hoped to fit all solutions but it became clear that the system greatly benefits from being personalised by the end-user in terms of the overall sensitivity it should present towards potentially dangerous situations and its notifications.

**The solution developed during this open call is a first step towards a Port Nervous System. The main targets for our solution are ports that want to modernise themselves through technologies such as edge computing and machine learning.**

# Editors

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