5GLOGINNOV

D1.1

5G-enabled logistics use cases

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List of abbreviations and acronyms

Abbreviation	Meaning
3GPP	3rd Generation Partnership Project
4G/5G	4th/5th Generation (of cellular networks)
ADAS	Advanced Driver Assistance System
ADR	Accord européen relatif au transport international des marchandises Dangereuses par Route (European agreement concerning the international carriage of dangerous goods by road)
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
ATP	Automated Tuck Platooning
BSS	Business Support System
CAD	Connected Automated Driving
CAM	Connected Automated Mobility
CAN	Controller Area Network (vehicular bus standard)
CCTV	Closed Circuit TeleVision
CMS	Container Management System
CNF	Cloud Native Functions
E2E	End-to-End
eFCD	Extended Floating Car Data
eMBB	Enhanced Mobile BroadBand
ETSI	European Telecommunications Standards Institute
FCD	Floating Car Data
FMS	Fleet Management System (vehicular communication standard)
FTED	Floating Truck and Emission Data
GHG	GreenHouse Gas
GLOSA	Green Light Optimal Speed Advisory
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPU	Graphics Processing Unit
HMI	Human-Machine Interface
IaaS	Infrastructure-as-a-Service
IoT	Internet of Things
IP	Internet Protocol
ISG	Industry Standardization Group
ITS	Intelligent Transportation Systems
KPI	Key Performance Indicator
LCM	Life Cycle Management

LCMM	Low Carbon Mobility Management
LL	Living Lab
LSP	Logistics Service Provider
LTE	Long-Term Evolution (4th generation of cellular networks)
M2M	Machine-to-Machine
MANO	MAnagement and Network Orchestration
MEC	Multi-access Edge Computing
MEP	MEC Platform
ML	Machine Learning
MNO	Mobile Network Operator
mMTC	Massive Machine-Type Communications
NFV	Network Functions Virtualization
NFVI	Network Functions Virtualization Infrastructure
NR	New Radio (5th generation of cellular networks)
NSA	Non-Standalone (5G network operation)
OBU	On-Board Unit
OEM	Original Equipment Manufacturer (often referred to car-makers)
OSS	Operations Support System
POI	Point of Interest
QoS	Quality of Service
RSU	Road-Side Unit
SA	Standalone (5G network operation)
SDK	Software Development Kit
SLA	Service Level Agreement
SME	Small-Medium Enterprise
TLF	Traffic Light Forecast
TMS	Traffic Management System
TOS	Terminal Operating System
UAV	Unmanned Aerial Vehicle
UC	Use Case
UHD	Ultra-High Definition (images)
URLLC	Ultra-Reliable Low Latency Communications
UWB	Ultra-Wide Band
V2X	Vehicle-to-anything (any ITS-enabled vehicle or infrastructure)
VIM	Virtual Infrastructure Manager
VM	Virtual Machine
VNF	Virtual Network Functions
VPN	Virtual Private Network
VR	Virtual Reality

VRU	Vulnerable Road Users
VSaaS	Video Surveillance-as-a-Service
WLAN	Wireless Local Area Network
WLTP	Worldwide-harmonized Light vehicles Test Procedure
WP	Work Package

EXECUTIVE SUMMARY

The purpose of this document is to draft the scope of use cases that will be implemented and demonstrated at the three Living Labs of the project.

The main objectives of this document are:

- To state and establish a common understanding of the ambition and scope of each LL.
- To determine partners and stakeholders involved in each use case.
- To identify the gaps that will be addressed (and how).
- To define the boundaries of the Open Call for innovative start-ups supporting the LLs.

The document includes an overview of 5G technology, describing the distinctive features/services and vertical applications that are particularly relevant for the logistics domain; such features/services are mapped to planned use cases through an application matrix showing how they contribute to their realization.

For each Living Lab, the document provides the description of the relevant pilot site, from the physical and business perspective (geographic location, connections, layout, cargo volumes, etc.), and illustrates the main motivations and objectives of associated use cases; such motivations and objectives cover operational aspects (e.g. increase of the overall efficiency, reduction of handling/transit times, preservation of assets, reduction of costs, etc.) as well as socio-environmental issues (e.g. reduction of emissions, safety of operating personnel, etc.). Then, each use case is thoroughly described through a structured gap analysis (illustrating the goals of the UC, the initial conditions, the major problems and the ways to overcome them, the final conditions, etc.) and an overview of its operation from the technological/functional point of view.

Finally, the document provides a brief overview of the Open Call for the selection of five innovative start-ups (prepared in WP4) aiming to develop 5G-based solutions in the framework of activities carried out at the three Living Labs, with a dedicated focus on their specific areas of interest.

1 INTRODUCTION

1.1 Project intro

5G-LOGINNOV will focus on seven 5G-PPP Thematics and support to the emergence of a European offer for new 5G core technologies in 11 families of use cases. 5G-LOGINNOV's main aim is to design an innovative framework addressing integration and validation of Connected Automated Driving/Mobility (CAD/CAM) technologies related to the industry 4.0 and port domains by creating new opportunities for LOGistics value chain INNOVation. 5G-LOGINNOV is supported by 5G technological blocks, including new generation of 5G terminals notably for future Connected and Automated Mobility, new types of Industrial Internet of Things 5G devices, data analytics, next generation traffic management and emerging 5G network architectures, for city ports to handle upcoming and future capacity, traffic, efficiency and environmental challenges. 5G-LOGINNOV will deploy and trial 11 families of use cases targeting beyond TRL7, including a GREEN TRUCK INITIATIVE using CAD/CAM & automatic trucks platooning based on 5G technological blocks. Thanks to the new advanced capabilities of 5G relating to wireless connectivity and core network agility, 5G-LOGINNOV ports will not only significantly optimize their operations but also minimize their environmental footprint to the city and the disturbance to the local population. 5G-LOGINNOV will be a catalyst for market opportunities build on 5G core technologies in the logistics and port operations domains, thus being a pillar of economic development and business innovation and promoting local innovative high-tech SMEs and start-ups. 5G-LOGINNOV will open SMEs' and start-ups' door to these new markets using its three Living Labs as facilitators and ambassadors for innovation in future European ports. 5G-LOGINNOV's promising innovations are key for the major deep-sea European ports in view of the mega-vessel era (Athens, Hamburg), and are also relevant for medium sized ports with limited investment funds (Koper) for 5G.

1.2 Purpose of the deliverable

Attainment of the objectives and explanation of deviations

The objectives related to this deliverable have been achieved in full and as scheduled.

1.3 Intended audience

This deliverable is the primary source of information for Living Lab coordinators and other technical profiles participating in WP1 and WP4; furthermore, being a public document, it provides the general audience with a detailed overview of the use cases that will be implemented and demonstrated at the three Living Labs of the project.

2 TECHNOLOGICAL BACKGROUND

2.1 5G Main Features and Services

5G refers to the fifth generation of wireless broadband cellular communications and network deployments aligning to 3GPP specifications and ETSI standards. The initial 5G standard and a Cloud-Native End-to-End network architecture allows 5G and 4G to work together. 5G, however, is ultra-fast and ultra-responsive compared to previous cellular connections, allowing mobile devices unimaginable connectivity and capabilities. Many of the advanced features critical to 5G success include network slicing and network function virtualization, which will be used by different applications and services and managed from the core.

This next-generation mobile network will deliver significantly increased operational performance (e.g. increased spectral efficiency, higher data rates, low latency, more connected devices), as well as superior user experience (near to fixed network but offering full mobility and coverage). 5G needs to cater for massive deployment of IoT (Internet of Things), while still offering acceptable levels of energy consumption, equipment cost and network deployment and operation cost. It needs to support a wide variety of applications and services. ITU-R defined three main 5G application scenarios (Figure 1):

- eMBB (Enhanced Mobile Broadband).
- URLLC (Ultra-Reliable Low Latency Communications).
- mMTC (Massive Machine-Type Communications)

Each of the three sets of use cases below appears to pull 5G in a different direction.

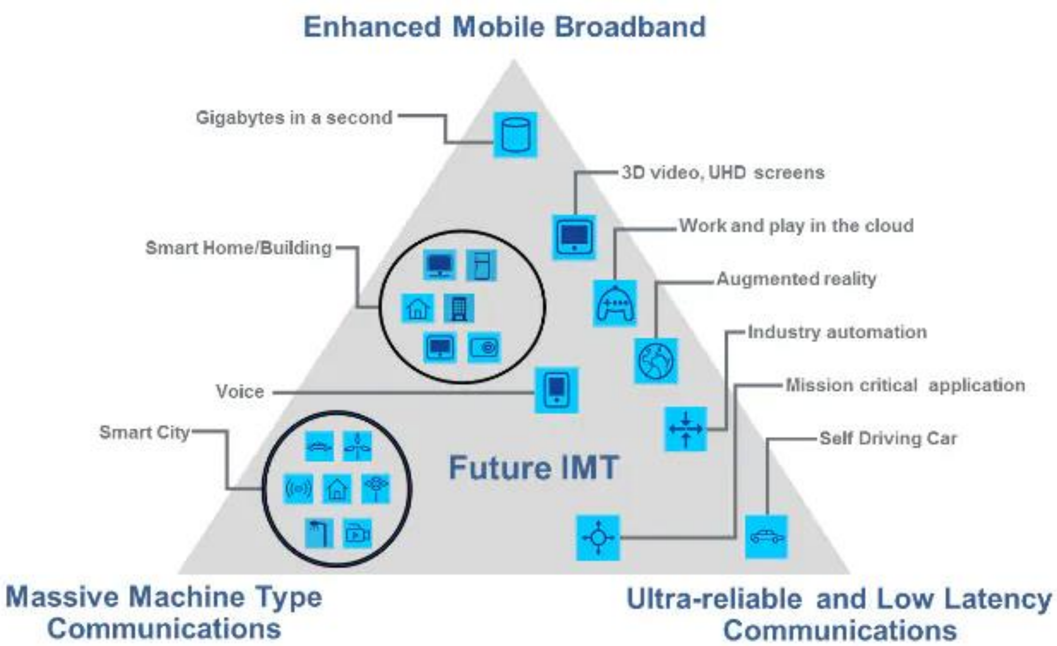


Figure 1. Main 5G usage scenarios

The initial phase of 5G Non-Standalone deployments focuses on eMBB, which provides greater data-bandwidth complemented by moderate latency improvements on both 5G NR and 4G LTE. This will help to develop today's mobile broadband use cases such as emerging Augmented Reality/Virtual Reality (AR/VR) media and applications, Ultra-HD or 360-degree streaming video and many more. eMBB is a natural evolution to existing 4G networks.

mMTC will facilitate the monitoring, control and automation in various sectors, including ports and logistics. From logistics to utilities, from homes to cities, from urban to rural, mMTC will connect lowpower sensors to enable the collection of telemetric data to be processed intelligently either by humans or exclusively by machines.

URLLC is the most futuristic of all three use-cases delivering intelligent automation which will become mainstream as Artificial Intelligence (AI) and Machine Learning (ML) reach technological maturity and widespread adoption. AI and ML are expected to reach their technological maturity through the low-latency wireless communications enabled by 5G.

2.1.1 Network Slicing

In 5G, heterogeneous services can coexist within the same network architecture by means of Network Slicing. According to ETSI (ETSI GR NGP 011), Network Slicing is an end-to-end paradigm initially discussed in the context of 5G to support new kind of applications that need absolute resource guarantees in terms of latencies, bandwidth, jitter, reliability and privacy. The goal is an ability to use common end-to-end infrastructure that can deliver diverse services with their corresponding assurance. From a mobile operator's point of view, a network slice is an independent end-to-end logical network that runs on a shared physical infrastructure, capable of providing an agreed service quality.

The technology enabling Network Slicing is transparent to business customers for whom 5G networks, in combination with Network Slicing, allow connectivity and data processing tailored to the specific business requirements. The customisable network capabilities include data speed, quality, latency, reliability, security, and services. These capabilities are typically provided based on a Service Level Agreement (SLA) between the mobile operator and the business customer. 5G mobile network will in turn enable network operators and service providers to host vertical industry segments by introducing new services and enhance business collaborations between providers and customers at large. From a technical perspective, network slicing opens the opportunity for the creation of a new ecosystem for delivering customized and cost-efficient services to vertical segments.

Network slice supports multi-tenancy for new set of services focusing on the use cases that do not necessarily fit into traditional virtual networking or VPN solutions. They require much higher degree of resource assurance as well as stricter guarantees of those resource availabilities. For example, low-latency communications for V2X, high-throughput for immersive multimedia applications, extremely reliable network for emergency response situations. There are several differentiating aspects among these use cases from traditional isolation techniques, such as (ETSI GR NGP 011):

- Once allocated, the resource may be under the control of the network slice service operator (or tenant) for autonomous control of the resources.
- Absolute guarantees should be met with, even under active contention of resources in other best-effort flows.
- Every flow (per stream QoS) should receive the assured treatment, i.e. two flows within the same slice should not compete with each other.

The complete architecture with all the actors is described in Figure 2. There are three entities interacting for the use of a network slice, namely:

- Tenant.
- Network Slice Provider.
- Network Slice Agent.

A tenant is a user of a network slice who creates a service with a particular network slice type. A network slice type distinguishes the kind of network resources needed to fulfil service requirements. A Network Slice Provider provides network slice as a service to tenant for control and operations of resources in the service. A Network Slice Agent is a network slice entity in infrastructure provider's domain. It understands processes and maps Network Slice Provider information within its domain.

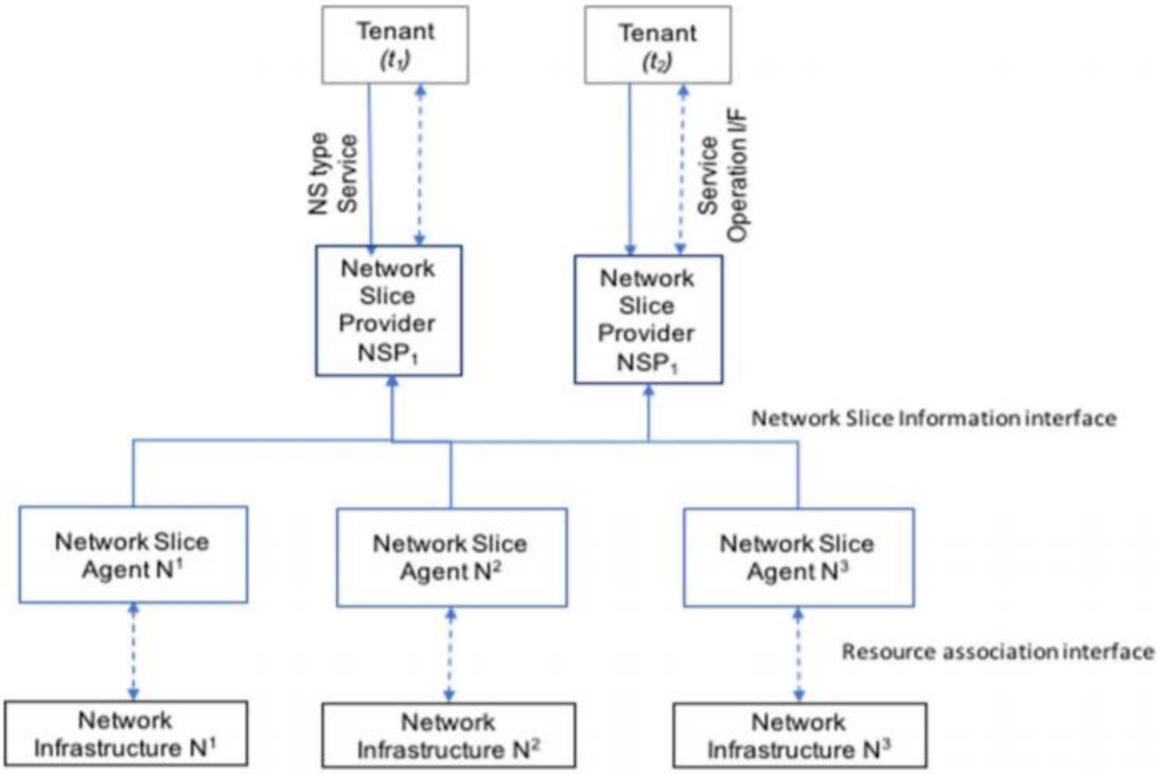


Figure 2. 5G Network Slicing Reference Framework

2.1.2 Mobile Edge Computing (MEC)

Edge computing is a key technology to meet end-to-end latency requirements introduced by new 5G services and to improve the efficiency of the whole network operation through the deployment of computing and storage resources at the edge of the network, closer to the mobile users. The exploitation of edge resources offers the possibility to execute computing tasks in a distributed manner directly at the edge of the network, reducing the traffic load on the core of the infrastructure and guaranteeing faster service responses. This approach allows high scaling in distributed Mobile Network Operators' (MNO) environments. Edge technologies are particularly suitable for all use cases with needs in direction of ultra-low latency and high availability of bandwidth in the mobile network.

The Multi-access Edge Computing (MEC) framework, defined in the context of the ETSI MEC Industry Standardization Group (ISG), provides an open and standardized environment for the efficient and seamless integration of edge applications from different vendors and providers across distributed platforms located at the edge of the network [ETSI19-MEC003]. The MEC framework identifies two main components in a typical MEC architecture, i.e. the "MEC Host" and the "MEC System". It manages the virtualized resources available at the edge nodes through a Virtual Infrastructure Manager (VIM) and it embeds a MEC platform (MEP) to facilitate the interactions among MEC applications and the steering of the mobile traffic flows to/from the target applications. In this context, [ETSI19-MEC10-2] specifies the interfaces for onboarding and lifecycle management of MEC applications, as well as standard data models for descriptors and software packages to distribute multi-vendor MEC applications.

The figure below illustrates the ETSI MEC reference architecture in a Network Functions Virtualization (NFV) environment.

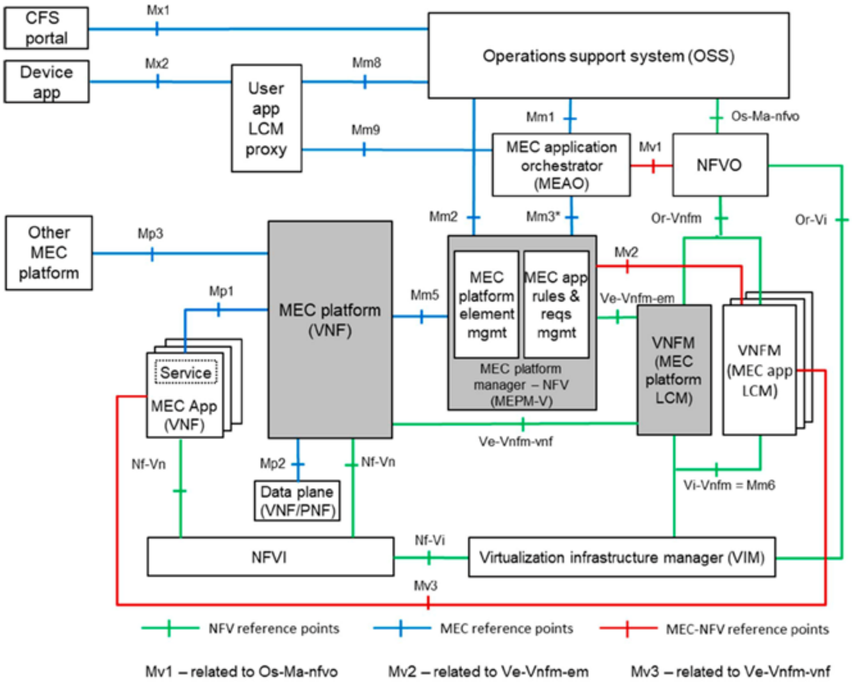


Figure 3. MEC Architecture Overview (source: ETSI GS MEC 003)

With respect to Edge Computing integration into 5G systems, 3GPP has defined a list of enabling functionalities that are briefly discussed in [TS 23.501], where a basic API for Application Function Influence on Traffic Routing is already specified.

2.1.3 NFV-MANO

NFV-MANO functions (Network Functions Virtualization - MAnagement and Network Orchestration) play an important role in delivering the business benefits envisioned by the Network Functions Virtualization Standardization Group (NFV ISG). These benefits are achieved through interworking with other functional components in the NFV framework, as well as external entities, such as Operations and Business Support Systems (OSS/BSS).

NFV-MANO alone cannot deliver all the NFV business benefits; it needs to integrate and interwork with other management entities for this purpose (e.g. OSS, BSS), using interfaces offered by those entities and offering its own interfaces to be used by external entities. In order for service providers to achieve the full benefit of NFV, NFV-MANO solutions should be considered holistically alongside OSS/BSS integration and management requirements. Simply extending existing OSS/BSS models to account for virtualisation will not be sufficient, because this approach will not support the new value-added capabilities and services provided by NFV (ETSI GS NFV-MAN 001).

In Athens and Koper LLs, a 5G-LOGINNOV architecture and its extensions will be used for automated deployment and life cycle management of network and services Virtual Network Functions components (VNF) for the addressed ports operations. The 5G-LOGINNOV architecture will enable on-demand and automatic deployment of VNF-based network and services components, high availability and resilience of operations of the most demanding logistics services, IoT-5G devices and mission critical communication services operated in port environment.

2.2 5G Applications in Logistics

The following chapters describe some 5G-related applications that are particularly useful in logistics domain, and thus will be exploited by the use cases of the project.

2.2.1 Precise Positioning

For nearly all use cases in 5G-LOGINNOV, precise positioning is required. Navigation with accuracy of 3-15 meters, as found in typical GPS systems, does not meet the actual requirements. Precise Positioning delivers cloud-based corrections that deliver accuracy of up to ten centimetres. The solution is scalable for an unlimited number of applications and IoT devices.

Precise Positioning is already available nationwide throughout the United States and Germany, with extended European coverage scheduled to come in 2020. The long-term target is to use the precise positioning solution from 5G standard components (3GPP Rel. 16).

The figure below illustrates a Deutsche Telekom/Swift solution for Precise Positioning services.

Figure 4. Skylark Precise Positioning Service

The illustrated solution includes the following components:
- Dual band GNSS antenna.
- Multi Frequency GNSS receiver.
- Mobile network access to the Skylark Corrections Service.
- Embedded control unit running Swift Starling software to calculate the exact position from satellite signals and correction data from the Cloud.

The GNSS correction signal will be provided 0.1 to 1 time per second, while the local calculation of the exact position can be up to 10 times per second. In the future, additional components (e.g. UWB - Ultra-Wide Band support for indoor measurements) could be integrated.

2.2.2 Traffic Management Applications

Traditional Traffic Management Systems (TMSs) are based on traffic detection systems which are counting the:
- Traffic volume (number of vehicles per time).
- Traffic density (number of vehicles per road segment).

Both measurement values are detected in fixed locations (space) counting the number of vehicles (road segment, time). They are linked to each other by the following relation known as fundamental diagram for traffic analysis as shown in Figure 5. It is necessary to bring both measurement values into a relationship and define the quality of a traffic state, usually free, dense or congested. This principle of data fusion towards categories of traffic state was used in the past to merge data from vehicles (Floating Cars) and e.g. loop or video camera data. For sustainable traffic information, data fusion becomes more complex, but the general Physics of Traffic data fusion methodology does not change.

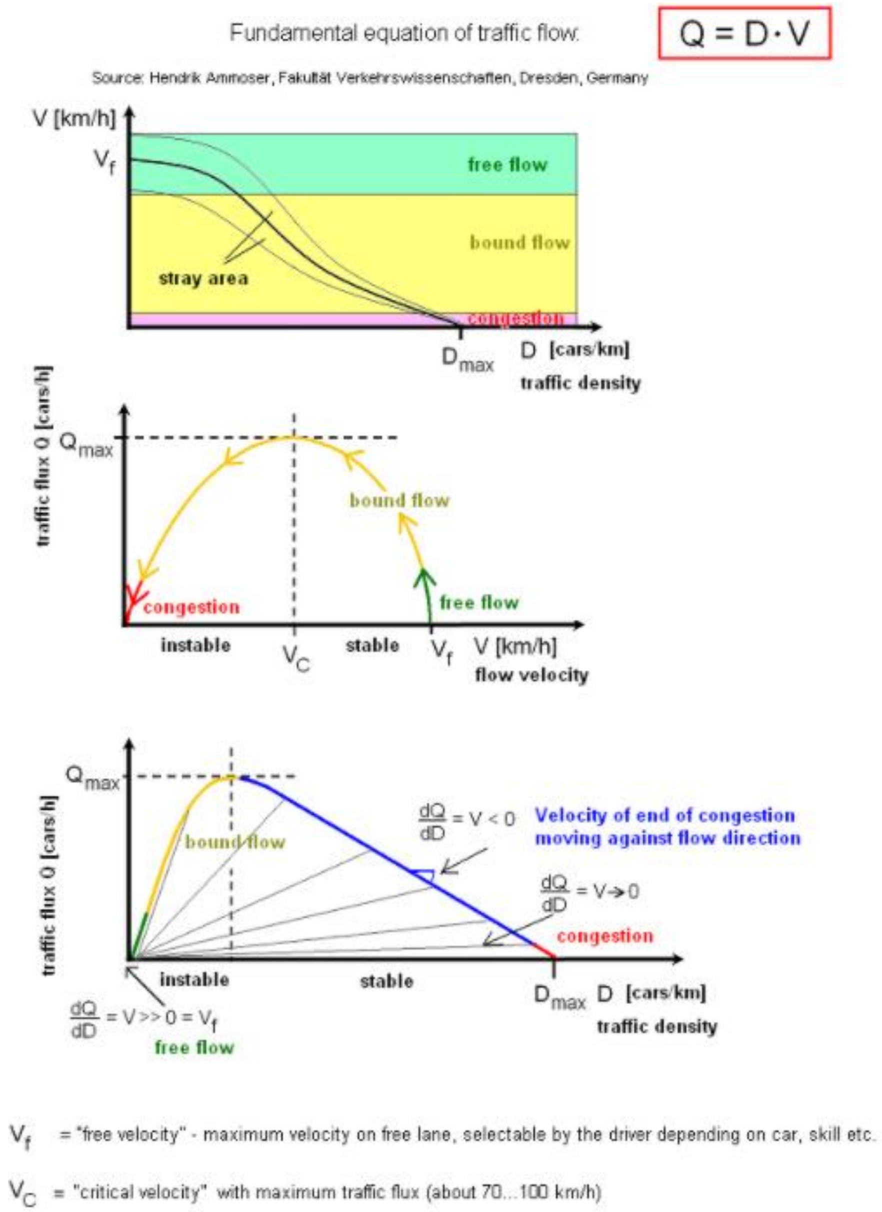


Figure 5. Fundamental diagram of traffic flow

The innovation offered by 5G within this methodology lies in the resilient inclusion of additional data sources. In the world of connected vehicles, the IoT devices inside the vehicle in motion (e.g. CAN-Bus) in combination with numerous sensors of 5G-smartphones (e.g. GNSS satellite receivers) generate a large amount of telemetry data collected from speed and acceleration profiles from Floating Cars, in this case from logistics fleets. By analysing microscopic trip data, according to the fundamental diagram of traffic flow, combined with nomadic device ISO-23795 standard [2], targeting fuel and emission detection of a given vehicle in motion, traffic management expands from traditional “accident prevention” to sustainable and Intelligent Transportation Systems (ITS).

Figure 6 illustrates how 5G comes into this scenario: by collecting extended floating truck data from relevant road segments generated by vehicle sensor sources (CAN-Bus, On-Board Units, IoT sensors, etc.) complemented with smartphone data, it becomes possible to enrich existing traffic detection systems, in especially those used in road networks of ports and hinterland logistics. These enriched data elements allow to identify much better the sensitive stray area of bound traffic states indicated in Figure 5, choosing the right traffic management strategy to avoid congestion.

Moreover, the enriched measurement sources enable traffic managers to balance traffic management strategies by converging detected traffic states, air pollution and fuel consumption. For this purpose, 5G-LOGINNOV plans to use three different IoT-device types, which are 5G-IoT On-Board Units (OBUs), smartphones and Car-PCs connected to CAN-Bus and external sensors. That is why 5G is needed: for any type of online decision support, traffic managers have to be sure that the collected data is reliable, scalable and exchanged with low latency and guaranteed service level agreements (see chapter 2.1.2).

Figure 6. Sustainable Traffic Management solution using 5G infrastructure

Data fusion will take place within the Mobile Edge Computing (MEC) Server, with the objective to evaluate traffic state information and driving manoeuvres examining their origin (external or individual). By consequently analysing the bound traffic states mapping inter-medium categories of critical traffic situations (see Figure 5) to hinterland-to-port corridors, traffic related decision support systems can react with the help of 5G in a much more efficient way than traditional systems. Thus, 5G technology and 5G infrastructure become important building blocks for Sustainable Traffic Management solutions, bringing equally together air quality and quality of traffic flow as Key Performance Indicators for policy makers designing sustainable “Ports of the Future”.

2.2.3 High-performance CCTV Surveillance Applications

With the potential to seamlessly connect a massive number of devices and handle huge volumes of data in near real-time, 5G networks will provide a platform for the growth of Industrial IoT and AI use cases. One such fast growing application in the physical security sector is 5G Closed Circuit Television (CCTV) cameras with AI capabilities.

The demand for video surveillance through CCTV cameras has accelerated over the years. With advancements in technology and exponential growth in the connected ecosystem, video surveillance systems have predominantly moved to IP-based networks. This has resulted in a massive growth in video data traffic, and in turn created the need for advanced network infrastructure, which can handle such monumental volume of transmission feeds from different sources. Video surveillance networks are initially deployed through wired infrastructure, predominantly over fibre-optic cables due to the requirement of higher bandwidth. However, fibre network installation requires high capital investment and has a coverage limitation, especially in remote locations. On the other hand, mobile wireless connectivity (particularly 4G LTE) is a superior alternative due to its extensive coverage, flexibility, and ease of deployment while installing video surveillance systems at a larger scale. However, as more cameras and recorders are increasingly getting connected to the internet and adoption of higher definition CCTV cameras continue to raise, 4G LTE networks are getting more congested and overburdened.

The ongoing proliferation of 5G networks is helping to overcome these challenges as well as bringing in new opportunities for the development of video surveillance market. 5G network undoubtedly provides a more reliable, higher bandwidth, and low latency connectivity for remote video surveillance solutions as compared to its predecessor wireless networks as well as fibre-based network.

5G CCTV (IP) cameras, leveraging artificial intelligence-based solutions (like people detection, face recognition, object recognition, event recognition, intelligent image processing, remote asset management, behavioural detection, and analytics), are leading to the transformation of video surveillance into an active threat detection system. Along with AI, machine learning and deep learning algorithms can also be leveraged to develop advanced video analytics solutions and further improve the intelligence of video surveillance systems. In 5G-LOGINNOV, the video analytics solution will be capable of detecting people, objects or events of interest by analysing and monitoring live video streams or recorded images from the surveillance cameras. Key advantages and potential use cases of 5G CCTV with artificial intelligence-based video surveillance system include high reliability, high scalability, higher resolution video, remote coverage, and high efficiency.

Video Surveillance-as-a-Service (VSaaS)

5G networks provide ultra-fast transmission speeds, enabling users to quickly upload the video surveillance footage from different sources into a centralized cloud platform, rather than storing it in local systems. These video footages can be later accessed easily on-demand by users from remote locations. VSaaS offers an advanced cloud-based video management service capable of viewing, playback, and monitoring of surveillance footage, also enabling near real-time analysis using artificial intelligence.

Multi-access Edge Computing (MEC) pre-processing for VSaaS

Rising security concerns regarding the transfer of sensitive video surveillance data to the cloud, MEC is enabling the processing of video data within the edge of AI-enabled 5G CCTV networks. Instead of sending all video surveillance data to the cloud, MEC reduces security risks by processing the data locally and transferring filtered data to the cloud. This approach helps enterprises to significantly lower cloud storage cost and improve bandwidth utilization efficiency. Moreover, MEC also improves the responsiveness of video surveillance systems by reducing the latency involved in transmitting or receiving data to or from cloud-based backend servers.

2.2.4 Real-Time Tracking & Enhanced Visibility

Portable 5G-connected trackers that monitor in real time the location and condition of the trucks/goods throughout the entire (or part of the) service chain can provide significant advances in port operations. 5G connected trucks, i.e. mobile 5G-IoT devices, would gain the ability to deliver live, with low latency, information to systems including geolocation, CAN-Bus data, custom and other relevant on-board sensor data, etc. With this data in hand, logistics companies and port operators will be able to provide live status updates, understand where potential delays may come in, optimize their truck/fleet routes, and forecast the exact moment the package (e.g. container) or vehicle will arrive at its destination. In 5G-LOGINNOV, real time tracking and enhanced in-truck visibility based on the deployed on-board sensors will be the foundation for the implementation of several use cases.

2.2.5 Maintenance Support

5G technology provides a flexible, reliable and predictable environment (coupled with low latency transmissions and faster data rates) that will allow the materialization of benefits from predictive maintenance services. Generic sensors will record data and will share them with analytics tools, which can detect potential malfunctions and less efficient operations within assets. Within the unique operational environment of port facilities, 5G will make predictive maintenance a common and necessary practice for reducing operating costs, costs associated with asset downtime, and extend the (mobile and stationary) equipment lifespan. In 5G-LOGINNOV predictive maintenance will aid port operations by tracking in real-time the performance/status of equipment on a day-to-day basis (obtained by a diverse set of sensors equipped, e.g. on trucks, lifts, cranes, etc.) with aim to potentially anticipate possible breakdowns before they occur, reduce downtime for repairs, optimally allocate storage capacity based on necessary spare/repair parts, and by increasing the overall service life of yard vehicles.

2.3 5G Services/Application Matrix

The following table summarizes the usage of the above-described 5G services and applications within the context of the use cases that will be demonstrated in 5G-LOGINNOV Living Labs.

5G Service/Application	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9	UC 10	UC 11
Network Slicing	X										
MEC	X			X	X	X		X	X	X	X
NFV-MANO	X		X	X	X	X	X				
Precise Positioning					X			X	X	X	X
Traffic Management Applications								X	X	X	X
High-performance CCTV Surveillance Applications (including VSaaS)				X	X	X					
Real-Time Tracking & Enhanced Visibility		X	X					X	X	X	X
Maintenance Support					X		X				

Table 1. 5G Services/Application matrix

2.3.1 Living Lab 1 - Athens

The envisioned use cases in Athens LL will exploit several functions of 5G technology to address demanding logistics and Industry 4.0 scenarios in port operations. Optimizing real-time operations requires time constrained and precise updates over a set of participating assets (e.g. trucks, cranes, lifts), that address different phases of interconnected port operations. At Piraeus port, real-time traffic regulation and coordination over a fleet of 5G connected trucks will be realized through low-latency transmissions and enhanced localization services, while also telemetry data from a set of diverse on-truck sensors will be utilized. Such operations, as will be illustrated by UC2/UC3, will exploit the low latency 5G network to optimize in real-time the truck routes/selection (and potentially other dependent services) in port operations which have direct impact on several work chains at Piraeus. To further facilitate automation in port operations, a MANO platform will be developed to enable on the fly service orchestration and service life cycle management at scale, exploiting core 5G technologies and NFV, where pioneering 5G-IoT devices will be designed and developed. Particularly, on average, a mother vessel at Piraeus needs 3000 stevedore moves for operations completion. Seal-presence check currently requires one person and about 30 seconds to complete. Reducing this time by e.g. 3 seconds per container, results to 9000 seconds (or 2.5 hours) reduction of vessel stay at the port and removes the need for human presence at an area with high safety risks. In this case, taking advantage of 5G technology and low latency transmissions (coupled with far-edge computing services on-board the proposed 5G-IoT device and MANO) will have a direct effect on the unloading (and other) processes for vessels in port operations. Additionally, eMBB service will be exploited to provide greater data-bandwidth for consuming 4K surveillance video streams from several sites at PCT, and enhanced video analytics techniques based on Artificial Intelligence/Machine Learning (AI/ML) models at the far edge (incorporated into the proposed 5G-IoT device) will be implemented, to meet the needs at the LL premises related to port control, logistics and remote automation (UC4, UC5). Finally, real-time asset monitoring (e.g. per truck CAN-Bus and other sensor data), coupled with analytics tools and ML for predictive maintenance, will be implemented through UC7, which will exploit 5G low latency transmissions to monitor in real time the performance/status of assets (e.g. trucks), in order to reduce operational costs, improve operational efficiency and extend the life cycle of port equipment.

Overall, Athens Living Lab targets implementation of novel 5G technologies (MANO-based services and orchestration, pioneering far-edge computing as a service, computer vision, AI/ML video analytics) and cutting-edge prototypes into an operational port environment.

2.3.2 Living Lab 2 - Hamburg

For Hamburg LL, use cases 8 and 9 are aimed at collecting Floating Truck & Emission data (FTED) by 5G IoT devices, on-board units and nomadic devices, whereas use case 11 will use this data for sustainable traffic management purposes. Analysing FTED data according to the ISO-23795 standard [2] leads to microscopic emission models per vehicle for the air pollutants CO_2, NO_x, PM and noise, all directly linked to acceleration and energy performance index (API, EPI). But applying the ISO-23795 standard for carbon footprint monitoring, requires stable data transmission and precise positioning, even more when using ISO-23795 for NO_x, PM and noise where Newtonian Physics turned out to be non-linear relative to fuel consumption detection per floating car. Additionally, use cases 8, 9 and 11 include Real-Time Tracking & Enhanced Visibility features for traffic managers by monitoring FTED speed profiles and congested road segments, services which once again require stable data transmission and precise positioning (5G prerequisite).

Green Light Optimal Speed Advisory (GLOSA) helps drivers to avoid harsh braking, which is one of the main causes for increased fuel consumption and CO_2 emissions. In 5G-LOGINNOV, it is planned to use GLOSA for truck platoons and to showcase a mid-term migration path for using GLOSA in Automated Truck Platoons based on 5G technology. From 5G projects and publication [3], it is well-known that Vehicle-to-Infrastructure (cellular V2X) for vehicle platooning has End-to-End (E2E) latency requirements of 20ms time frames and up to 350m minimum ranges, prerequisites, which can only be achieved with the URLLC functionalities of the 5G network. Performance requirements for advanced driving including collision avoidance (10ms E2E latency) and cooperative lane change (25ms E2E latency) have the same low latency communication characteristics and cannot implemented without 5G mobile networks. In 5G-LOGINNOV, GLOSA based Truck Platoons will demonstrate a migration path towards higher SAE levels of Automation starting with basic functionalities including 5G test cases and test runs foreseen in use case 10, GLOSA based Automated Truck Platoons.

2.3.3 Living Lab 3 - Koper

For the orchestration, showcased in UC1, NFV-MANO was selected as the orchestrator as it provides means to efficiently provision, deploy and manage life-cycle of 5G network infrastructure and Industrial IoT services. NFV-MANO supports OpenStack/Kubernetes and some public cloud providers and can be used on private or public mobile network systems, as both are required for reliable port operation. Furthermore, NFV-MANO also supports network slicing, which is another requirement for efficient port logistic operation, as it can provide different network capabilities in terms of performance and QoS/QoE per different user segment (e.g. real-time communication, IoT, M2M, UHD video streaming in real-time). To enable more advanced port logistic services, such as automation control of container management system or real-time AI-powered video surveillance, 5G MEC components will be established along with high-performance CCTV applications (as showcased in UC5/UC6). Such applications (e.g. body worn camera, drone-assisted video streaming) will significantly benefit from low-latency provided by 5G mobile network and its MEC enhancements while the complexity of the system is abstracted through the orchestration system powered by NFV-MANO.

3 LIVING LAB SPECIFICATIONS

From the overall Living Lab design, the objectives and their related use cases can be grouped as in the schematic scenario shown in Figure 7. Whereas Hamburg has a focus on hinterland use cases, Athens and Koper will pilot their use cases inside the operational area and responsibility of the local Port Authority.

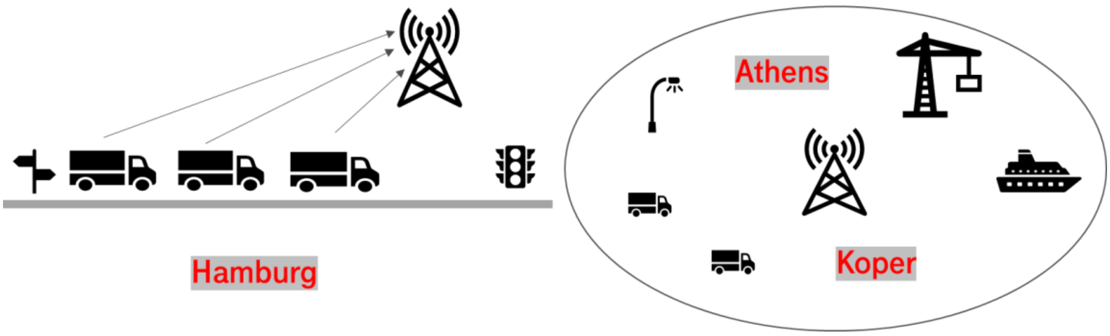


Figure 7. 5G-LOGINNOV port and hinterland use cases and cities to pilot them

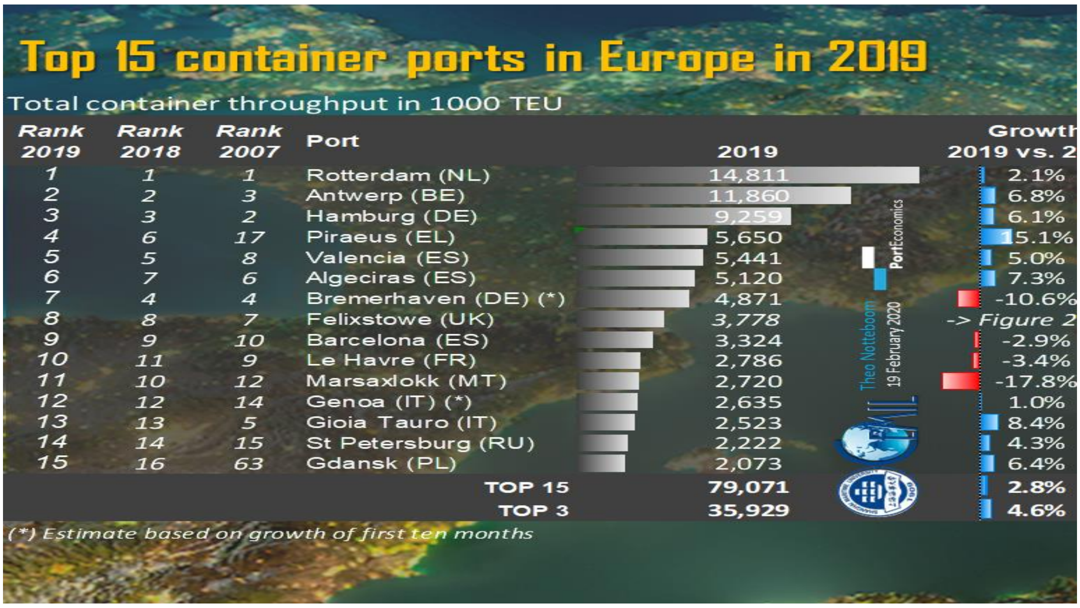
The following chapters define the scope of each Living Lab and thoroughly describe the relevant use cases.

3.1 Living Lab 1 - Athens

Pilot Site Description

Piraeus Container Terminal (PCT S.A.), is a large dynamic company with promising prospects for the future, wholly owned by COSCO Shipping Ports Limited (former COSCO Pacific Limited "CPL"), located at Piraeus, in Athens, Greece.

The Company's main activities are the provision of loading/unloading and storage services for import and export containers handled via the Port of Piraeus, including cargoes which use Piraeus only as an intermediary station of transport (transhipment cargo). The strategic location of Piraeus makes it an ideal port to be used as a hub for destinations in the Central and Eastern Mediterranean, as well as the Black Sea. The continuous development of the port in both yard equipment and innovative technological solutions has raised it to rank 4 among the busiest European Ports of 2019 in terms of container throughput and is expected to rise even more on the same ladder in the upcoming years.



Top 15 container ports in Europe in 2019

Total container throughput in 1000 TEU

Rank 2019	Rank 2018	Rank 2007	Port	2019	Growth 2019 vs. 2
1	1	1	Rotterdam (NL)	14,811	2.1%
2	2	3	Antwerp (BE)	11,860	6.8%
3	3	2	Hamburg (DE)	9,259	6.1%
4	6	17	Piraeus (EL)	5,650	15.1%
5	5	8	Valencia (ES)	5,441	5.0%
6	7	6	Algeciras (ES)	5,120	7.3%
7	4	4	Bremerhaven (DE) (*)	4,871	-10.6%
8	8	7	Felixstowe (UK)	3,778	-> Figure 2
9	9	10	Barcelona (ES)	3,324	-2.9%
10	11	9	Le Havre (FR)	2,786	-3.4%
11	10	12	Marsaxlokk (MT)	2,720	-17.8%
12	12	14	Genoa (IT) (*)	2,635	1.0%
13	13	5	Gioia Tauro (IT)	2,523	8.4%
14	14	15	St Petersburg (RU)	2,222	4.3%
15	16	63	Gdansk (PL)	2,073	6.4%
			TOP 15	79,071	2.8%
			TOP 3	35,929	4.6%

(*) Estimate based on growth of first ten months

Figure 8. Top European Container Ports

The Company's primary goals are to offer high quality services to ocean carriers, to the Greek importers/exporters and the freight forwarders; to attract ocean carriers to use Piraeus as their transhipment hub in the area; to fully utilize the port's connection with the railway network; to promote the value of its infrastructure (port facility, warehouse, multiple vessel calls from Far East and China), in order to attract big multinational companies to use Piraeus as their hub for Southeast Europe, Africa and Black Sea.

Yard equipment availability plays a significant role in modern container ports not only on operational efficiency but also on matching container traffic forecasts with port throughput capacity. Container traffic in PCT has been increasing significantly over the last decade reaching from 685.000 TEUs in 2010 (when PCT assumed the management of the port) to 5.650.000 TEUs in 2019. With the completion of Pier III, the throughput capacity of the port will reach 6,8M TEUs and container traffic is expected to increase. Quay side length is already fully utilized making the addition of quay cranes practically impossible. Moreover, given the fact that there are already 170 trucks operating in PCT's container yard, leaves little space for an increase on the number of trucks, thus making the increase of truck availability an important factor for future growth. Finally, storing and managing bulky spare parts required for equipment maintenance takes up significant space of the port that could be used more efficiently. Figure 9 depicts the three functional piers at PCT.

Figure 9. Athens PCT piers overview

Motivations and Objectives of the Living Lab

5G-LOGINNOV will address several key aspects of day-to-day port operations at PCT through 5G and the logistics sector. The current local fleet size (about 170 operational trucks daily), in addition to incoming external trucks, imposes significant challenges in port operations that in turn affect various work chains in Piraeus. Efficiently managing and coordinating the movement of yard trucks within the port is of vital importance, as the majority of operations heavily rely on internal yard trucks for the horizontal movement of containers between stacking areas and loading/unloading areas for vessels and rail.

Unfortunately, current network deployments and localization services lack several key elements for optimally allocating container jobs to yard trucks (given the availability pool), where more often than not, the selected trucks are not the ones closest to the container. This results in (unnecessary) longer travel duration for trucks, increased fuel consumption (and relative CO_2 and NO_x emissions) and traffic jam incidents, which have a direct impact in productivity levels and operational costs (e.g. in life-cycle of tyres, with annual cost exceeding 4 MEuro at Piraeus, currently). The enhanced localisation services and low latency transmissions will constitute the key element blocks for the optimal assignment of container jobs to 5G-connected yard trucks, realized though the envisioned use cases that will be implemented through 5G-LOGINNOV.

Edge computing is a pioneering technology that enables the evolution to 5G and beyond architectures, designed to put applications and data closer to devices and their users (targeting diverse market verticals), in order to overcome the intrinsic problems of the traditional cloud, such as high latency and the lack of security. Far-edge computing will be exploited by 5G-LOGINNOV in Athens Living Lab to address two critical use cases:

- UC4 concerns the safety of employees and other personnel within the premises of PCT. Frequent incidents involving boom collisions, gantry collisions or stack collisions along with the presence of stevedoring personnel in the area make the risk for serious bodily injuries considerable. A far-edge (low latency) computing approach will be adopted, integrated into a pioneering 5G-IoT device, for deterring human presence in areas not allowed, based for instance on innovative machine learning techniques. The realization of this use case will minimize the risk of serious bodily injuries by triggering alerts to responsible personnel and/or voluminous video streams (when necessary) form associated 4K cameras to the MANO platform that will be developed in 5G-LOGINNOV.
- UC5 follows a similar technological approach targeting remote automation of port operations and logistics support focusing on detecting the presence/absence of container seals. Currently the identification of presence or absence of container seals occurs manually, i.e. by an appointed employee, raising safety concerns, sub-optimal use of human resources in yard equipment and port operations, and increased manual effort (e.g. manual database update, etc.). The envisioned use case employs a similar far-edge computing (5G-IoT) device operating at port machinery (such as lifts, forklifts, terminal tractors, etc.), utilizing a 4K video stream and e.g. computer vision techniques, to automate and manage end-to-end the life cycle of the service for detecting container seals. 5G transmissions will relay the inference of the model to the MANO platform targeting the logistics sector and Industry 4.0 scenarios.

Finally, a key concern at Athens LL is storing and managing bulky assets (such as spare/repair parts) that occupy significant space of the port, especially at PCT operating close to maximum annual capacity. 5G-LOGINNOV will implement a predictive maintenance (algorithmic) tool (based on insights from the COREALIS project) to analyse telemetry data (e.g. CAN-Bus and other on-truck sensor data) collected from the fleet of 5G-connected trucks to potentially predict possible breakdowns, reduce downtime for repairs and optimise stock of spare parts, increase the service life of yard vehicles and optimise operational efficiency through minimisation of breakdowns (as identified by the COREALIS project).

Overall, 5G-LOGINNOV at Athens LL will optimise port operations through a diverse set of use cases, including the optimal assignment of container jobs based on localisation (and other) data of internal trucks, improvement of personnel safety through analytics of 4K video streams, predictive maintenance of yard equipment and reduction of the environmental footprint in port operations. This will be achieved by the deployment of a 5G network and installation of 5G access points on yard trucks connected to the engine CAN-Bus and truck sensors, the deployment of the envisioned 5G-IoT devices as well as the deployment of 4K surveillance cameras on the quay side and the rail terminal. Data collected will be transmitted over the 5G network to an orchestrator platform and distributed to a number of existing systems and platforms. The results achieved can be replicated to any maritime or inland terminal as well as container depots that base their operation on trucks and high-stacking cranes.

Expected benefits are:

- Reduction of traffic congestion in the port of Piraeus.
- Redistribution of traffic in the port, based on real-time truck location.
- Improvement of operational efficiency of the port of Piraeus.
- Reduction of operations cost.
- Reduction of the environmental footprint of port operations.

The main objectives of the Athens Living Lab are summarised in the following table.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O1	• Minimise percentage of yard equipment assets idling for more than one shift.	• Development and deployment of optimal yard truck selection service of UC3, and predictive maintenance service of UC7 at Athens LL.
#O1	• Traffic redistribution in port operations based on real-time truck localization data.	• Development and deployment of device management platform ecosystem of UC2 at Athens LL.
#O1	• Improve utilisation of the port warehouses and storage spaces by at least 15%.	• Development and deployment of predictive maintenance service of UC7.
#O1	• Optimise the use of human resources in yard equipment port operations.	• Development and deployment of UC4 surveillance cameras and video analytics, and UC5 automation for ports: port control, logistics and remote automation.
#O2	• Reduce percentage of empty container runs by 15%.	• Development and deployment of device management platform ecosystem service of UC2 at Athens LL.
#O2	• Reduce vessel operation completion times by at least 5%.	• Development and deployment of UC5 automation for ports: port control, logistics and remote automation.
#O2	• Reduce total cost of spare parts and tyres annually by at least 10%.	• Development and deployment of predictive maintenance service of UC7.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O4	• Extrapolation of the potential CO_2/NO_X savings based on the real traffic volume to the port terminals. • Reduce emissions produced by trucks delivering/picking up containers at least 15%.	• Development and deployment of optimal selection of yard trucks services of UC3 and device management platform ecosystem service of UC2 at Athens LL.
#O5	• Attract at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in 5G, IoT, renewable energy & circular economy for improving port environmental footprint per pilot. • Provide a start-up innovation funding scheme for 5 short-listed SMEs in the respective city in order to design and implement in a TRL2-3 level the proposed technologies.	• Extension of planned use cases through the integration of innovative solutions brought by the winners of an Open Call dedicated to start-ups and SMEs (WP4). • The target value of (at least) 10 applicants is set at project level; there is no predefined scheme for the deployment of selected (5) applications across the different LLs (it depends on the reference LL declared by each application).
#O7	• Support the 5G next generation network architecture in order to deploy the logistics and CAD innovative advanced use cases. • 5G-based cellular communications system will be provided by the national Mobile Network Operator to meet the needs of port operations and address the use case requirements.	• Deployment and validation of the 5G network and services in Athens LL. Support for the operation of all use cases.
#O7	• Enhanced monitoring and predictive maintenance of port assets by collecting telemetry data from different sensors equipped on yard trucks in port operations.	• Development and deployment of 5G connected trucks and services (as mobile 5G-IoT devices) to support UC2, UC3, UC7.
#O7	• Novel surveillance technologies and mechanisms (pioneering portable 5G-IoT device, AI/ML based video analytics) with MANO orchestration support.	• Development and deployment of novel 5G-IoT devices to support UC4 and UC5 in Athens LL.
#O7	• Promote 5G-LOGINNOV project at the World Port Conference, ITS Congresses, 5G, IoT conferences and international events.	• Project presentation (international, conferences). Supported by all use cases.

Table 2. Objectives of the Athens Living Lab

These objectives will be pursued within the following use cases:
- UC2 - Device Management Platform Ecosystem.
- UC3 - Optimal selection of yard trucks.
- UC4 - Optimal Surveillance Cameras and Video Analytics.
- UC5 - Automation for Ports: Port Control, Logistics and Remote Automation.

- UC7 - Predictive Maintenance.

A prototype solution will be developed at the ICCS 5G testbed realizing specific UCs (cf. 3.1.3 and 3.1.4), and then migrated to the Living Lab setup in coordination with PCT and Vodafone. In more detail the software and hardware components of the ICCS testbed include:

1. Software:
    a. OpenAirInterface (https://www.openairinterface.org/) for the 4G/5G protocol stack.
    b. OpenSourceMano (https://osm.etsi.org/) service orchestration.
    c. Machine Learning model to be defined by the ICCS developer team.
2. Hardware
    a. (2x) PowerEdge R840 Rack Server → 4G EPC, 5GC, OSM, Openstack.
    b. (4x) Precision 7920 Tower Workstation → Edge Computing, eNB, gNB, 5G-IoT.
    c. SDR Platforms:
        i. Ettus USRP N310 (4 Channels, 10 MHZ - 6 GHZ, 10 GIGE) - https://www.ettus.com/all-products/usrp-n310/.
        ii. Ettus USRP B210 (2 Channels, 70Mhz - 6Ghz, USB3) - https://www.ettus.com/all-products/ub210-kit/.
    d. Multi-band Antennas (698 MHz - 6 GHz).
    e. GPU- Jetson AGX Xavier Developer Kit (https://developer.nvidia.com/embedded/jetson-agx-xavier-developer-kit).

3.1.1 UC2 - Device Management Platform Ecosystem

Description

At the port multiple trucks arrive and depart continuously. Each truck driver can be aware of another trucks position by using a mobile app that displays location of all trucks on the port. Traditionally trucks are fitted with GPS devices that transmit data over GPRS networks. A remote server is used to receive device's GPS position. Each data transmit is based on the following simplified flow:

- Device CPU reads the GPS location.
- The device modem opens a connection.
- Location data are transmitted to the platform.
- Data are processed and pushed to mobile devices or another server for further processing.

The above flow contains a time delay between the time of the actual location and the time is visualized to the user. This process includes the following time costs:

- Device signal acquisition.
- Data post from device to server.
- Data processing on the server.
- Data transferred from the server to the device.

This use case aims to leverage the 5G low latency in order to reduce the data transit time. On top of this, the device will be configured to run as a streaming device with no network negotiation times (open/close transmit sockets etc.).

Gap Analysis

UC goals	• Optimal (near-) real time position update of each truck to the rest truck drivers.
Initial conditions (before 5G-LOGINNOV)	• Devices transmit location data over GPRS and end users (truck drivers) receive data over 4G networks.

Major problems identified	• Device negotiation time, GPRS data transmission incurs time cost.
Final (foreseen) conditions (after 5G-LOGINNOV)	• System upgrade from GPRS to 5G. • Zero negotiation time. • Streaming of location data. • Less time difference between actual position and user observation.
Gap between initial and final conditions	• Current deployment is based on GPRS.
Measurement of these gaps	• 5G deployment, 5G enabled devices, 5G enabled mobile phones.

Table 3. UC2 (Athens) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
ICCS	Project partner	Living Lab Leader
Vodafone	Project partner	Provider of 5G Communications System
PCT	Project partner	Port Operator

Table 4. UC2 (Athens) - Involved Partners and Stakeholders

Use Case Operation

Each truck participating in the pilot will be fitted with a 5G-enabled GNSS location tracker. The configuration of this device will allow the device modem to keep open a 5G network connection and transmit data without negotiation as a streaming method. Data received from the server will be pushed to a 5G enabled mobile phone running fleet monitor application. Truck drivers will be able to monitor the position of each truck at (-near) real time updates. The operational flow of the use case is illustrated in Figure 10.

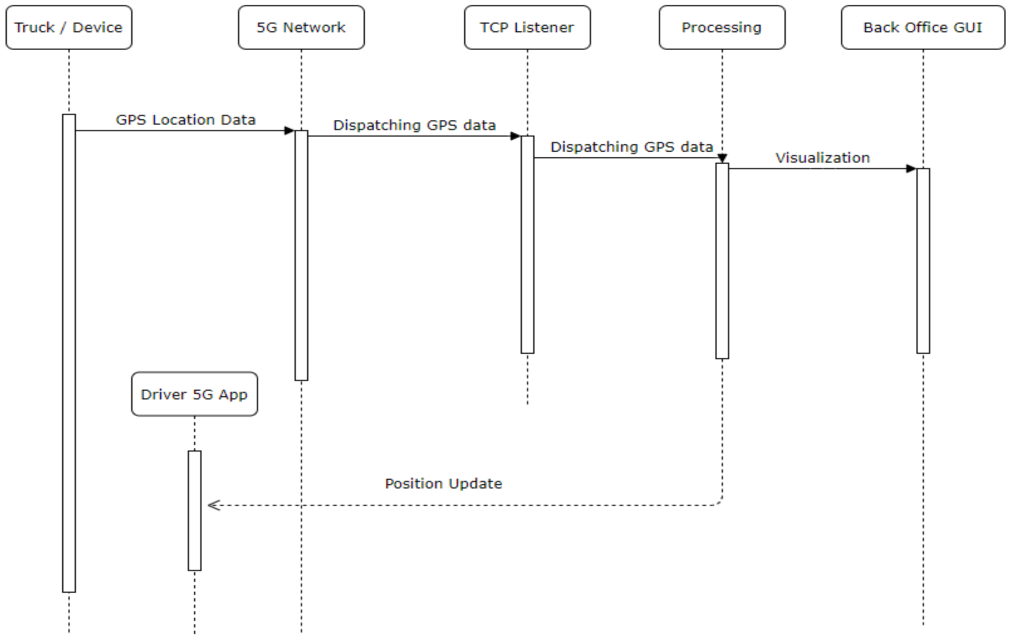


Figure 10. UC2 (Athens) - Operational Flow

3.1.2 UC3 - Optimal selection of yard trucks

Description

The port heavily relies on internal yard trucks for the horizontal movement of containers between stacking areas and loading/unloading areas for vessels and rail. Use case 3 will upgrade the current system at PCT that assigns container jobs to trucks, with 5G technology. The in-place system was developed based on insights from the INTE-TRANSIT project 5187/2C-MED12-05 (Figure 11). The algorithm utilizes two data sources: a) GNSS coordinates transmitted over WiFi or 4G from yard trucks to the MANO orchestrated platform and b) data from sensors installed on trucks indicating the current freight carried by each vehicle. However, localization data transmissions over WiFi, combined with the current accuracy of the GNSS system and the average trucks' speed of 35 kph, results in inaccurate localization info and thus sub-optimal truck selection for container jobs. This results in unnecessarily longer travel duration for yard trucks and potentially additional manoeuvres in high traffic areas causing additional delays and traffic jams within Piraeus port. 5G connectivity and low latency transmissions will enable significantly faster responses from the fleet of 5G connected trucks. This use case will equip yard trucks with access points connected to the vehicle's data sources (CAN-Bus/GNSS and other sensor data), and a 5G interface for communications. Each truck will transmit in real-time over the low latency 5G network the accumulated sensor/telemetry data to the application platform where the job assignment algorithm will optimally allocate yard trucks to container jobs, in real-time.

Gap Analysis

UC goals	• Optimal (near-)real time assignment of container jobs to yard trucks.

Initial conditions (before 5G-LOGINNOV)	• About 170 trucks are part of the system. • GPS data are transmitted over WiFi or 4G. • A location-based assignment algorithm (deployed based on insights from the INTE-TRANSIT project 5187/2C-MED12-05) is used for allocating trucks to container jobs based on the received GPS info.
Major problems identified	• Reliability in WiFi connections. • Imprecise GNSS system information. • High latency in data exchanges.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Operational 5G network at the port premises. • 5G access points installation on yard trucks. • Interconnection of installed 5G access points with on-truck data sources (CAN-Bus, GPS, container presence sensors, etc.). • Enhanced location-based assignment algorithm, enhanced localization service, low latency transmissions.
Gap between initial and final conditions	• Current deployment is based on WiFi and 4G.
Measurement of these gaps	• 5G network deployment. • 5G connected trucks.

Table 5. UC3 (Athens) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
ICCS	Project partner	Living Lab Leader
Vodafone	Project partner	Provider of 5G Communications System
PCT	Project partner	Port Operator

Table 6. UC3 (Athens) - Involved Partners and Stakeholders

Use Case Operation

For the development and deployment of UC3, several steps must be realized. The initial step concerns the deployment of the 5G network at the Athens LL premises. Next follows the procurement and installation of 5G Access Points (APs) on the respective trucks: these APs will be connected to the yard trucks on-board data sources (telemetry data), such as: CAN-Bus, sensors for container presence, Terminal Operating System (TOS) terminals and GNSS data. The accumulated statistics/data will be transmitted with low latency over the 5G network to the MANO orchestrated platform, where the job assignment algorithm resides. Given the aggregated telemetry data from all available 5G connected trucks, the algorithm will optimally assign in real-time container jobs to trucks. The high-level operational flow of the use case is depicted in Figure 12.

Figure 11. UC3 (Athens) - Layout

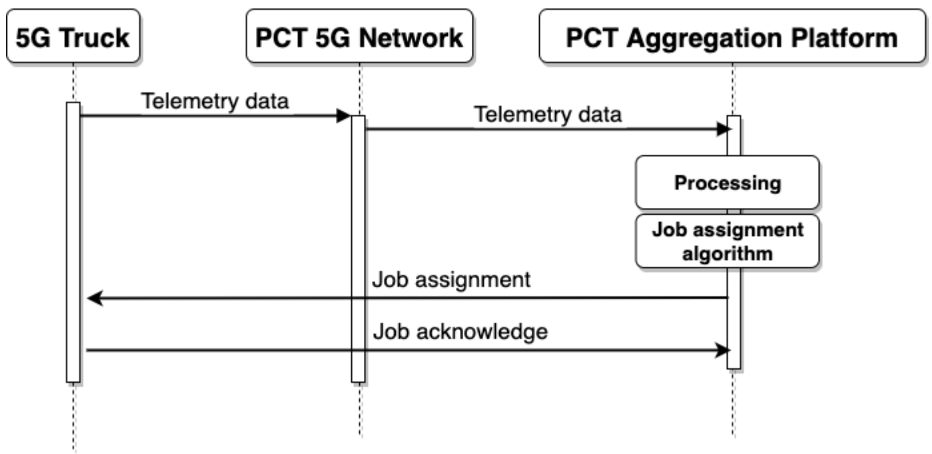


Figure 12. UC3 (Athens) - Operational Flow

3.1.3 UC4 - Optimal Surveillance Cameras and Video Analytics

Description

Use case 4 is aimed at determining human presence in areas where they are not allowed (e.g. railways, areas with heavy crane operations, etc.) and minimizing the risk for serious bodily injuries. To this end, several 4K surveillance cameras will be deployed at selected areas of interest, providing a real-time video stream to the Terminal Operations Monitoring Platform taking advantage of the eMBB service of the 5G network. Each camera will be directly connected to a generic 5G-IoT device, which will additionally be equipped with an on-board GPU to perform locally video analytics tasks (e.g. Jetson AGX Xavier Developer Kit), and a 5G interface for communication. The video analytics model will be based e.g. on Machine Learning (ML) techniques, to detect human presence in high-risk areas, and the device will employ the low latency 5G network to transmit the inference of the algorithm to the MANO platform.

The use case will be implemented through two development levels of increasing requirements:

1. The inference/result of the video analytics model (human presence detected) is transmitted to the control platform, alerting the responsible personnel for the relevant risk area, who in turn informs the Security Shift located at the Operations Centre to perform the necessary actions and minimise the risk of injury.
2. Service Life Cycle Management (LCM): in case of no event detection, the streamed video of the live feed is constrained (e.g. low video resolution), whereas in the opposite scenario (human presence detected) the video stream is upgraded to 4K resolution.

Gap Analysis

UC goals	• Minimizing risk for bodily injuries in specified areas. • Real-time video surveillance with portable and mobile capabilities.
Initial conditions (before 5G-LOGINNOV)	• Surveillance video is currently streamed over fibre. • Number of cameras currently installed >200.
Major problems identified	• Currently, there is no support system (or service) in place for human presence detection. • Fibre coverage is limited and fixed.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Development of a novel 5G-IoT device. • The deployed service: "Far edge computing orchestration for video analytics and Life Cycle Management (LCM)". Outcome: real time detection of human presence in specific areas. • Automatic service orchestration and deployment at scale.
Gap between initial and final conditions	• 5G deployment at PCT. • MANO platform. • Design and development of the proposed 5G-IoT device. • Video analytics approach enhanced with advanced mechanisms for human presence detection (e.g. AI/ML model).
Measurement of these gaps	• 5G deployment. • Design, development and deployment of the proposed 5G-IoT device at relevant areas at PCT. • MANO platform. • Integration options for the developed ICCS prototype at PCT.

Table 7. UC4 (Athens) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
ICCS	Project partner	Living Lab Leader
Vodafone	Project partner	Provider of 5G Communications System

Organization	Relation with 5G-LOGINNOV	Role
PCT	Project partner	Port Operator

Table 8. UC4 (Athens) - Involved Partners and Stakeholders

Use Case Operation

The development of UC4 will initially take place at the ICCS 5G testbed, where a novel 5G-IoT device will be designed and built, enabling far-edge computing as a service. The proposed system will be based on widely deployed open-source platforms enabling on-the-fly service deployment, management and orchestration (e.g. OpenSourceMano, OpenStack), and 5G connectivity (e.g. OpenAirInterface) to deliver a MANO-enabled 5G IoT platform. An indicative list of the layered components for deployment at the ICCS testbed is depicted in Figure 13 (normal operation) and Figure 14 (alarm operation). The enhanced video analytics model on-board the 5G-IoT device necessary for detecting human presence will be defined, trained and tested/evaluated at ICCS premises, whereas the camera and GPU specifications will also be defined according to the ML model requirements. The next steps involve preparations for migrating the developed prototype at PCT premises for further training and testing. Next, several areas of interest according to the Port's needs will be specified, deploying several instances of the proposed device, utilizing the eMBB service at PCT. Figure 15 illustrates a high-level overview of the operational flow of the use case.

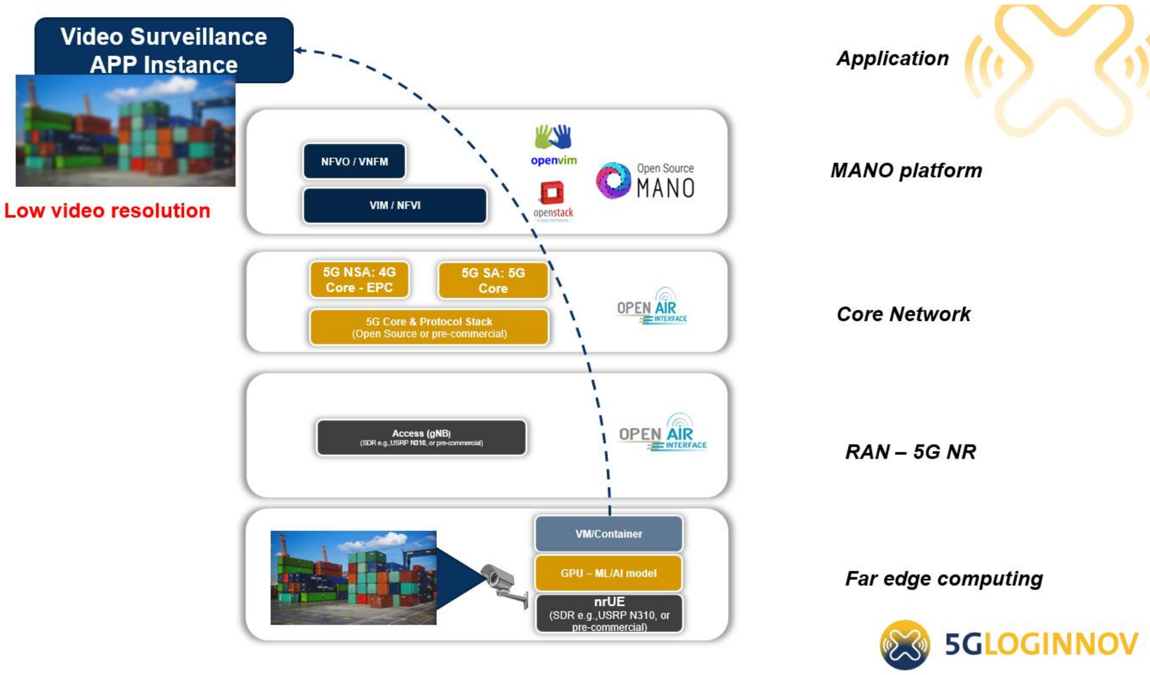


Figure 13. UC4 (Athens) - Layout, normal operation

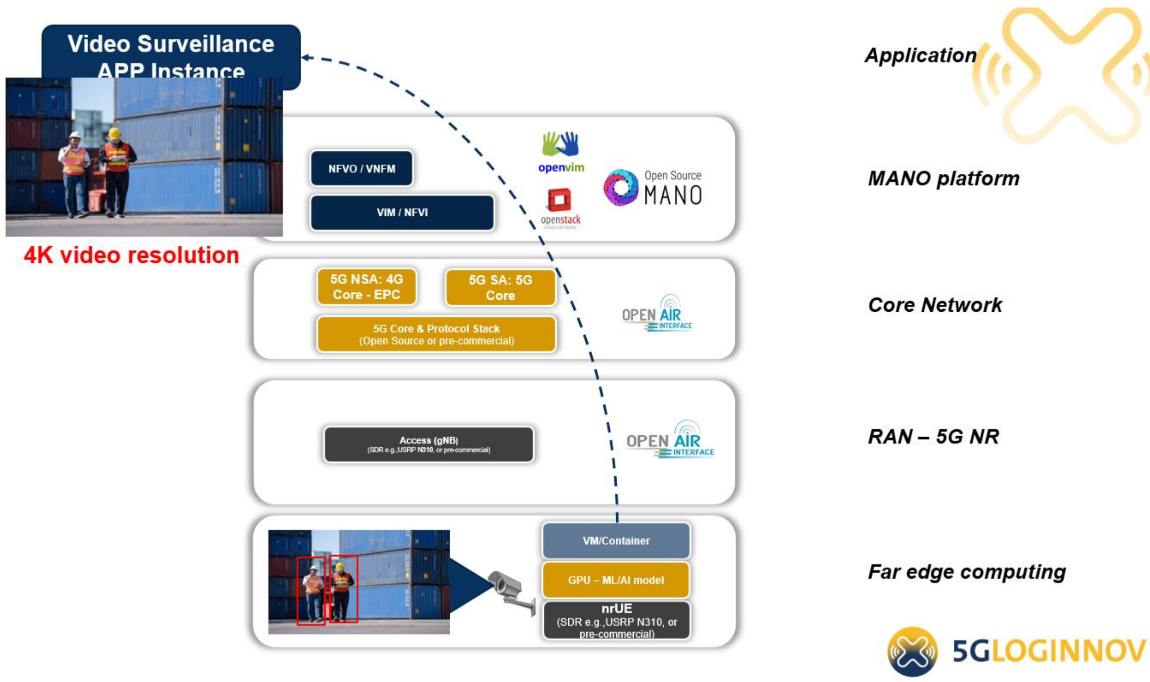


Figure 14. UC4 (Athens) - Layout, alarm operation

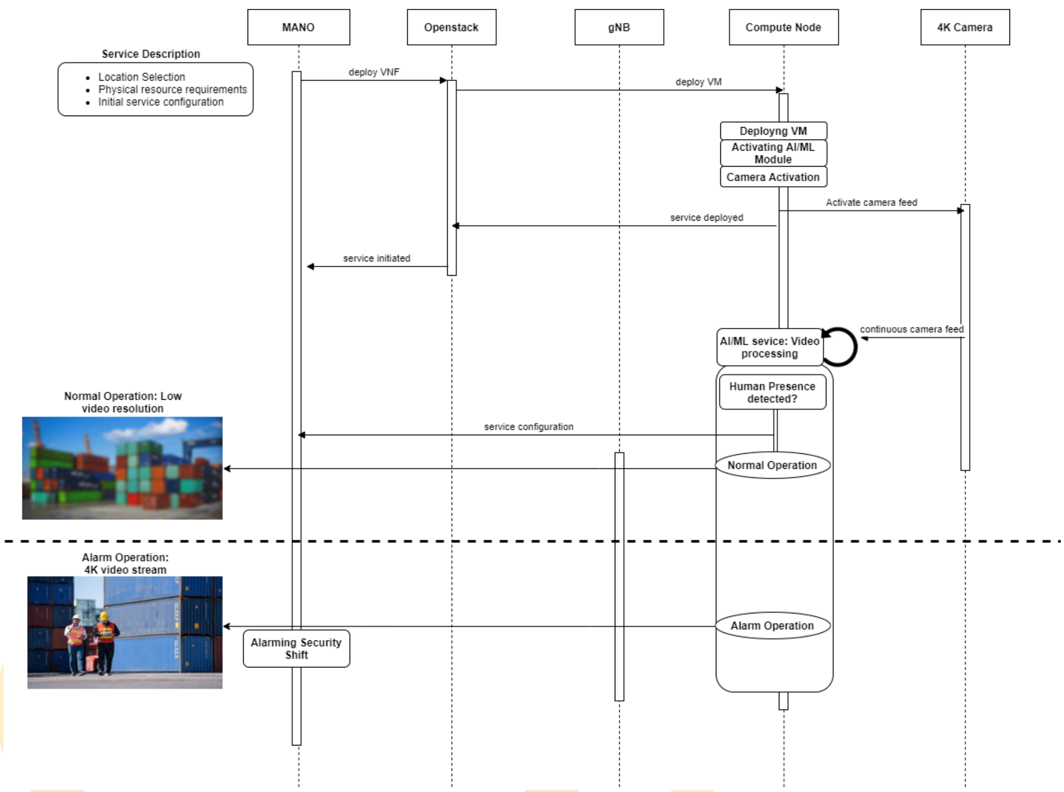


Figure 15. UC4 (Athens) - Operational Flow

3.1.4 UC5 - Automation for Ports: Port Control, Logistics and Remote Automation

Description

Use case 5 is focused on port control, logistics and remote automation, and aims at detecting the presence/absence of container seals without intervention from human personnel. To this purpose, operating port machinery (such as lifts, forklifts, terminal tractors, etc.) will be equipped with industrial 4K cameras for capturing Ultra-High Definition (UHD) images and/or video streams that will be transmitted to the MANO platform utilizing the broadband 5G network at PCT. Each camera will be directly connected to a novel 5G-IoT device that will additionally be equipped with an on-board GPU (e.g. Jetson AGX Xavier Developer Kit), to perform locally, based on computer vision techniques, image/video processing tasks that detect the presence or absence of container seals. The inference of the model (i.e. seal present/absent) will be transmitted to the MANO platform in real time over the 5G network.

The use case will be implemented through different development levels of various requirements:
1. The inference/result of the model (container seal presence/absence) is transmitted to the control platform, alerting the responsible personnel for the result.
2. The result is automatically stored in the PCT database for subsequent analytics and visualization.
3. Live 4K streams of the operation from different deployments of the proposed 5G-IoT device are transmitted to the MANO platform over 5G, for further inspection.

Gap Analysis

UC goals	• Automated support for detecting the presence/absence of container seals.
Initial conditions (before 5G-LOGINNOV)	• Manual inspection for detecting the presence of container seals.
Major problems identified	• Currently, there is no support system (or service) in place for container seal presence detection.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Development of a novel 5G-IoT device. • Automated support for container seal presence/absence in daily workloads (enabled as a far-edge computing service). • Automatic service orchestration and deployment at scale.
Gap between initial and final conditions	• 5G deployment at PCT. • MANO Platform. • Design and development of the proposed 5G-IoT device. • Video analytics approach enhanced with advanced mechanisms for container seal detection (e.g. computer vision).
Measurement of these gaps	• Operational 5G network deployment. • Design, development and deployment of the proposed 5G-IoT device at relevant areas of the LL. • MANO platform. • Integration options for the developed ICCS prototype at PCT.

Table 9. UC5 (Athens) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
ICCS	Project partner	Living Lab Leader
Vodafone	Project partner	Provider of 5G Communications System
PCT	Project partner	Port Operator

Table 10. UC5 (Athens) - Involved Partners and Stakeholders

Use Case Operation

A prototype 5G-IoT device will be designed and developed at the ICCS 5G testbed for the realization of use case 5. Similar to UC4, the proposed device will be built over opensource platforms for the management and orchestration of the service (e.g. OpenSourceMano) and for 5G connectivity (e.g. OpenAirInterface), enabling far-edge computing as a service, orchestrated at scale. The indicative layered components of the service (at the ICCS testbed) are illustrated in Figure 16. Initially, the advanced video analytics model (hosted on the 5G-IoT device) will be defined, trained and tested at ICCS, for detecting the presence/absence of container seals, where the GPU and camera specifications necessary for the relevant video/image processing tasks will be defined. The next steps include the migration of the device/service at PCT premises for further testing. Finally, the areas of interest for activating/enabling the service (at several deployment sites) will be defined according to the LL needs, taking advantage of the broadband 5G network at PCT. Figure 17 illustrates a high-level overview for the operational flow of the use case.

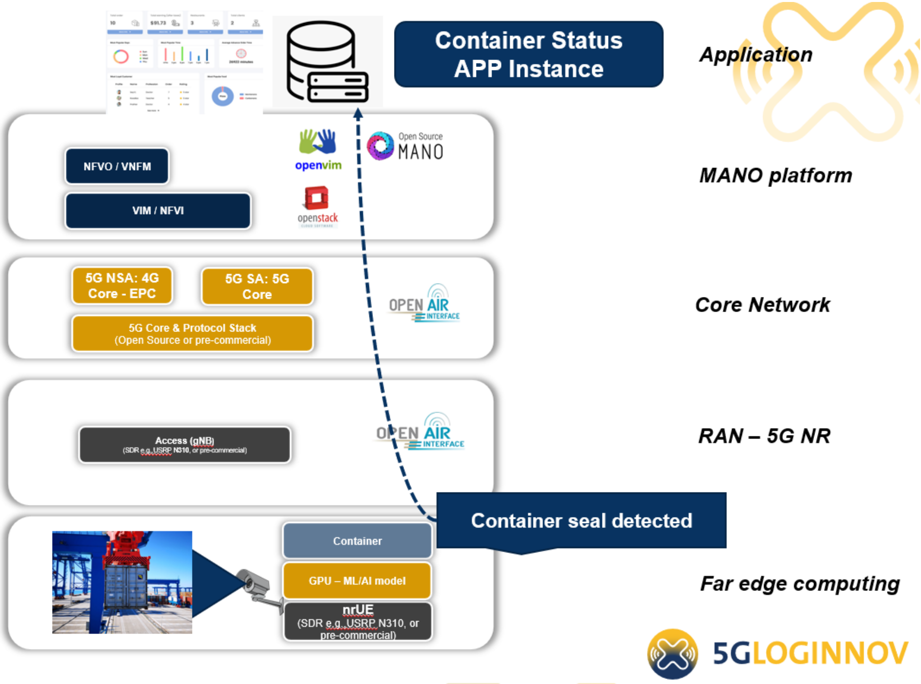


Figure 16. UC5 (Athens) - Layout

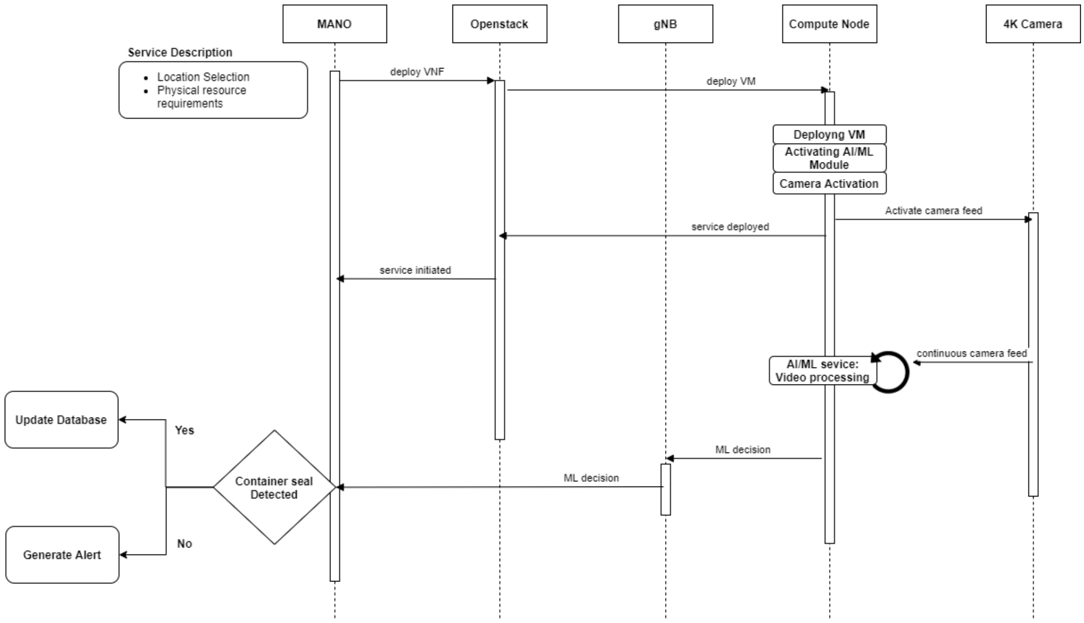


Figure 17. UC5 (Athens) - Operational Flow

3.1.5 UC7 - Predictive Maintenance

Description

Predictive maintenance is a significant contributor to increasing operational efficiency and reducing unplanned downtime of expensive equipment by identifying and solving problems before they occur. In PCT, the maintenance of yard vehicles is currently performed with regularly scheduled manual checks; thus, a lot of issues are identified at breakdown. Within UC7, 5G access points will be installed aboard yard vehicles and will be connected to existing data sources (e.g. CAN-Bus, sensors for container presence, TOS terminals, etc.); the 5G access points will collect in real-time telemetry data and will forward them to the MANO orchestrated platform over the 5G network (low latency) via the relative API, where the AI logic for the predictive maintenance service will reside (Figure 18). The proposed tool will capture historical and recent status data for the assets in question, by taking advantage of 5G technology that provides a flexible, reliable and predictable environment to remotely keep track of the connected assets on a real time basis.

Gap Analysis

UC goals	• Reducing port operational costs through predictive maintenance.
Initial conditions (before 5G-LOGINNOV)	• Manual inspections on trucks at scheduled intervals. • About 170 trucks are part of the system. • WiFi or 4G APs installed on trucks. • APs collect and transmit telemetry data (e.g. CAN-Bus) to the control platform.
Major problems identified	• No service is in place for predictive maintenance of yard trucks (no ML/AI solution available). • Problems are identified at breakdown.
Final (foreseen) conditions (after 5G-LOGINNOV)	• A predictive maintenance service integrated with the PREDICTOR tool developed through the COREALIS project 768994/MG-7.3-2017, taking advantage of the CAN-Bus (and other) data for the realization of the service.

	• Potential benefits (as identified in COREALIS project) include: reduction in maintenance costs, reduction in yard vehicle breakdowns, reduced downtime for repairs, reduced stock of spare parts, increased service life of yard vehicles, improved yard vehicle operator safety, optimisation of operational efficiency through minimisation of breakdowns.
Gap between initial and final conditions	• Installation of 5G access points on yard trucks. • Interconnection of the 5G APs with on-truck data sources. • MANO platform for aggregating telemetry data over the fleet of 5G connected trucks. • Modify the predictor tool developed at COREALIS project in 5G-LOGINNOV (based on ML/AI appropriate models) according to the LL needs.
Measurement of these gaps	• Operational 5G network deployment. • MANO platform. • Predictive maintenance ML/AI algorithm.

Table 11. UC7 (Athens) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
ICCS	Project partner	Living Lab Leader
Vodafone	Project partner	Provider of 5G Communications System
PCT	Project partner	Port Operator

Table 12. UC7 (Athens) - Involved Partners and Stakeholders

Use Case Operation

The development and deployment of use case 7 encompasses several steps. The first step concerns the deployment of the 5G network at the premises of PCT and the installation of 5G Access Points (APs) on yard trucks. The APs will be connected with on-truck sensors, e.g. CAN-Bus and other sensor data, which will be transmitted in real time to the MANO platform. The accumulated data over the fleet of 5G connected trucks will be used by the predictor tool developed through the COREALIS project 768994/MG-7.3-2017 (tailored to the needs of the use case), hosted at the MANO platform, for predictive maintenance services, visualization and analytics. The high-level operational flow of the use case is depicted in Figure 19.

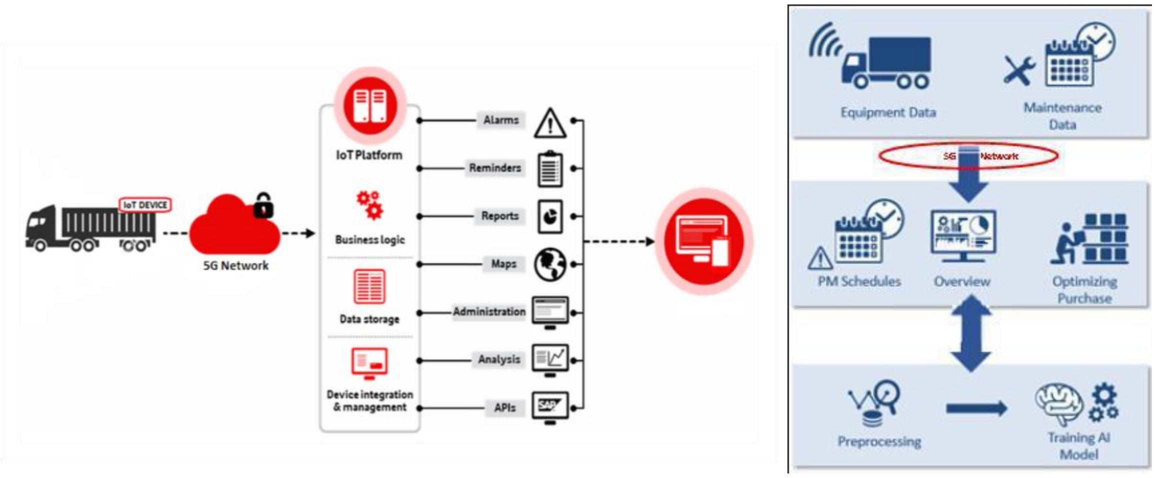


Figure 18. UC7 (Athens) - Layout

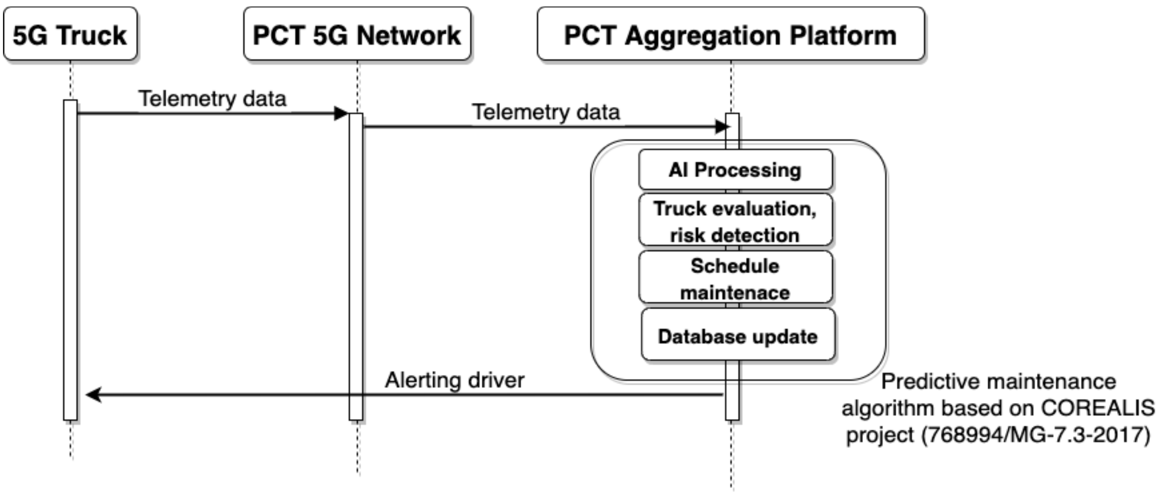


Figure 19. UC7 (Athens) - Operational Flow

3.2 Living Lab 2 - Hamburg

Pilot Site Description

With around 10 million containers, the Port of Hamburg is ranked No.3 in Europe. The disadvantage of the 70 km Elbe restricting access to the Northern Sea is compensated by the excellent rail network in the port and hinterland, of special importance for inter- and multimodal transport and logistics. Due to special situation as a city port, several terminals for container handling are spread across different parts of the city, which makes an efficient hand-over and automation within the intermodal transport chain (port internal transfers) of great importance for Hamburg's long-term competitiveness. Being part of the city's ITS Policy Strategy 2030 to optimize the transport chain, the inclusion of port transport logistics and hinterland connections was therefore crucial for the City of Hamburg policy makers (https://www.hamburg.com/business/its/11747566/strategy/).

Figure 20. Aerial view of Hamburg Port (Cruise Terminals)

For the ITS World Congress, which is scheduled in October 2021, Hamburg launched a test field for automated driving to optimize the access of trucks to the port terminals. The test field is available to all OEMs and mobility service providers for Car2X data exchange and other C-ITS functions. A total number of 26 traffic lights is currently available for Connected Automated Driving (CAD) test runs. The test field is located in the heart of the city close to the ferry boat terminals (see Figure 21).

Figure 21. Connected and automated driving test field (TAVF) in the city centre of Hamburg

The arms of the Elbe spread the grounds of the handling terminals and show the storage areas for containers delivered by ship. If a port basin has no connection to a rail network, a freight forwarder intending to use rail freight is forced to transport the containers from a port basin to the freight yard by so-called repositioning, which is frequently needed in case of transfer of containers from depot to terminal, to customs inspections, etc. Repositioning of containers by a Logistics Service Provider (LSP) and its trucks occurs up to 100 times per day inside port and public roads. Following challenges exist in repositioning containers:

- Trucker: alignment between intermodal operator and various terminals.
- Trucker: booking of (limited) available time slots at various terminals.
- Trucker: waiting time at terminals and due to traffic.
- Intermodal Operator: complexity of managing various partners and overall alignment of cut-off times.
- Intermodal Operator: significant cost factor in low-margin business of hinterland transportation.
- Terminal: non-aligned booking of time slots by various trucker.

Re-positioning shows the sensitivity of connecting the inner-port area with the out-of-port area, especially when public roads are mixed up by passenger vehicles, vulnerable pedestrians and heavy-duty trucks for just-in-time delivery to the vessel waiting for the container. For a city port such as is Hamburg, the deployment of C-ITS and automated driving are innovative strategies to increase the capacity of the limited road network. The implementation of 5G use cases in this context fully supports the main pillars of Hamburg's ITS policy objectives.

Besides ITS, the environmental pressure is another driver for innovation for the two-million city of Hamburg, ranked number two in Germany with regards to the number of citizens. Air pollution caused by trucks is crucial for the authorities in Hamburg and diesel ban was introduced together with other measures after emissions exceeded the regulations for environmental protection and clean air policy, as agreed in the Aarhus convention 1998. Adopted in German Ordinance on Air Quality Standards and Emission Ceilings, the Federal Government transposed the Aarhus EU directive into national legislation. Accordingly, the limit value for particulate matter was set at 50 µg/m³, which may be exceeded on a maximum of 35 days a year. The average annual value for nitrogen dioxide was set at 40 µg/m³. The EU directive obliges cities and municipalities to draw up action plans for air pollution control. These plans have formed the basis for the implementation of 48 Low Emission Zones (LEZ) with limited access for vehicles with high emissions so far. Hamburg has two restricted road segments where the annual average was exceeded, and diesel banned from entry.

In order to comply with the clean air regulations, the city wants to implement ITS solutions balancing the need for improving air quality with the economic interests of logistics service provider to deliver their goods in time and budget. Therefore, sustainable traffic management based on 5G and Connected and Automated Cooperative Mobility became a key pillar of Hamburg's 2030 ITS policy targets. The four use cases planned within 5G-LOGINNOV reflect this need for clean air projects including innovative traffic management and GLOSA-based Automated Truck Platooning.

Motivations and Objectives of the Living Lab

Climate change presents enormous challenges to everyone, especially to the transport sector, which is responsible of 20% GHG emissions in Germany alone. As logistics contributes significantly to these emissions, tools to monitor carbon footprint on company and trip level are needed to reduce emission on operation level. For this purpose, cause & effect of carbon footprint occurring during a trip are very important, and reliability of the measurement tools is a must to improve and reduce carbon footprint.

Hamburg Living Lab will demonstrate the potential of leveraging positive environmental impact by using 5G for sustainable traffic management, and will develop and implement a methodology to capture the effect of the traffic infrastructure on regional emissions, thus making them comparable by quantifying relevant factors (driver profile, vehicle profile, loading, etc.) in the context of Traffic Management System (TMS) measures. To this purpose, the following interactions with system elements of traffic management will be demonstrated:

- For UC8 and UC9, emission data from floating vehicles/trucks will be made available in a cloud-based centre to enable situation monitoring on emissions.
- For UC10, the current and predicted traffic light signalling will be made available from traffic centres to vehicles, in order to allow an optimised trajectory planning for automated vehicle manoeuvring across intersections, saving energy and emissions.
- For UC11, data received in UC8/9 and other data typically used in environmental traffic management will be used to trigger traffic management measures (strategies) in traffic control (e.g. changing traffic light framework programs, setting speed limits or providing instructions and directives to vehicles). For this use case, data from vehicles and traffic light status/predictions are based on real data linkage, while traffic management measures (i.e. real changes in signal control or speed limits/advice to broad public) are demonstrated as a concept.

These features will be implemented through a cloud-based Virtual Traffic Management Centre, as shown in the following figure.

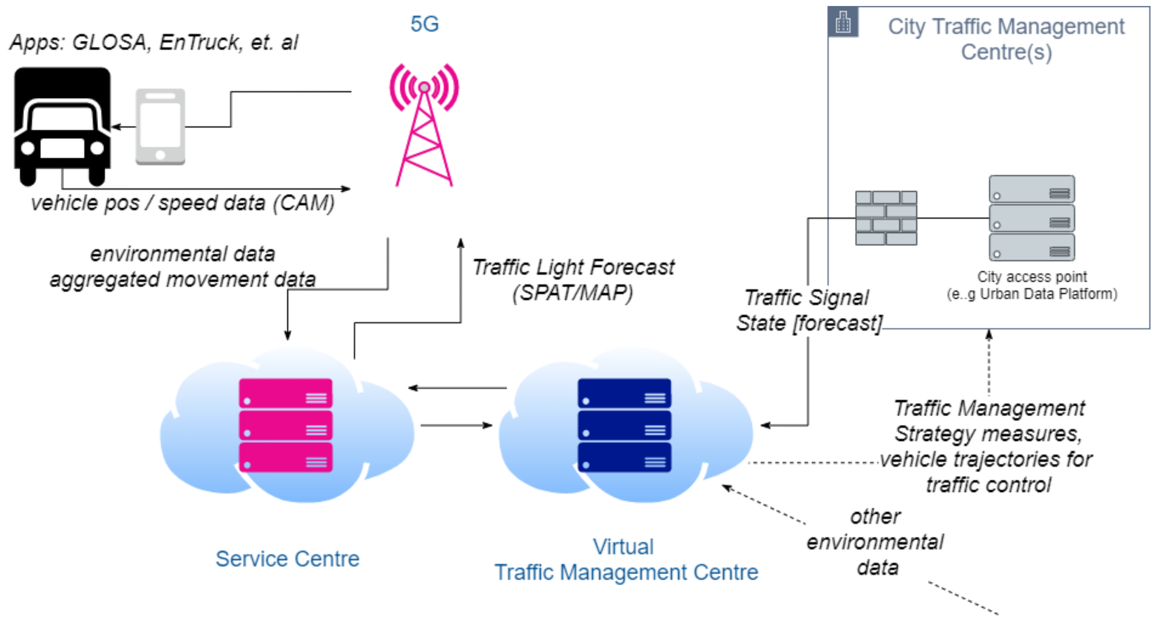


Figure 22. Virtual Traffic Management Centre in Hamburg LL

For the calculation of emissions, the Living Lab will adopt a methodology called LCMM (Low Carbon Mobility Management), which was developed and piloted in the last decade by T-Systems, together with several Logistics Service Providers (LSPs) in Europe and China [4]. From an automotive engineering standpoint, energy demand of any vehicle in motion is summarized in Figure 23, as well-known in engineering literature. The basic idea behind LCMM consists of reducing the large set of parameters in Figure 23 to a minimum set of dynamic (primary) variables and a maximum set of static (secondary) vehicle parameters. Based on logistics pilot projects of the last years, it became evident that the satellite receiver of a nomadic device (mobile phone) is optimal to measure fuel demand and carbon footprint, by assuming that the vehicle parameters are constant (secondary) whereas speed, acceleration and slope are dynamic (primary) and available per second. Comparing real trip satellite data (from the mobile phone) to well-known inertia forces (e.g. reference driving cycle WLTP) leads to an overall simplification of the problem, which in turn requires as little vehicle data access as possible and promotes its widespread use.

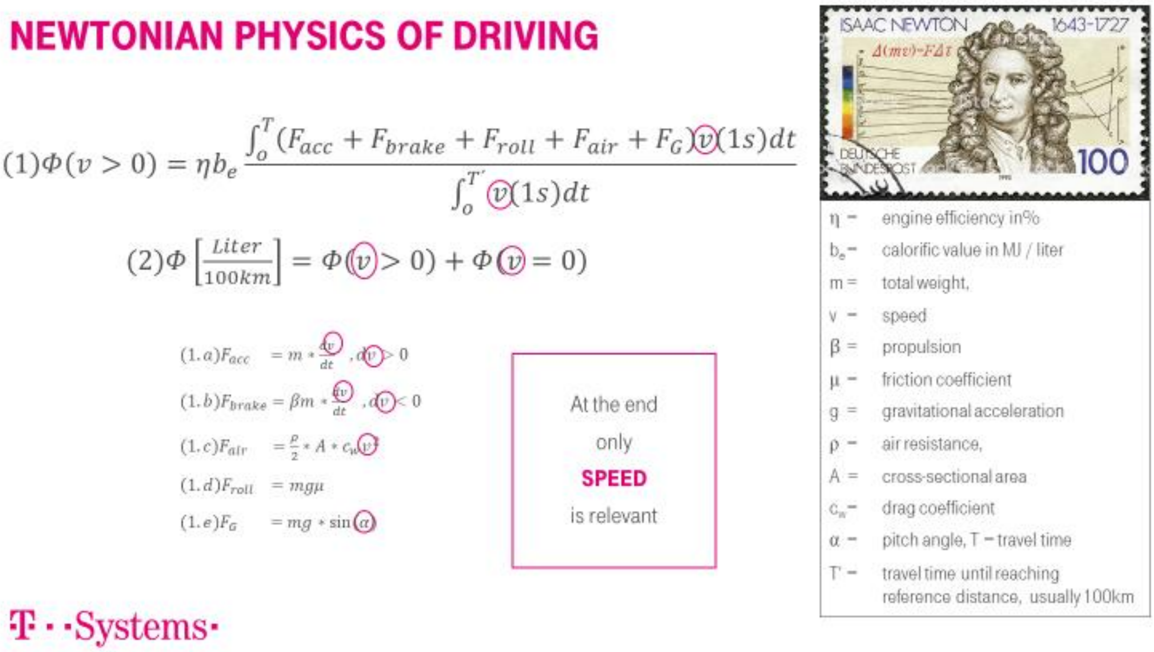


Figure 23. Newtonian Physics describing energy demand of a vehicle in motion

In intelligent traffic control, traffic flow and speed characteristics have been so far considered at "macro" level (i.e. "average speed" or "average emission" by vehicle class), while it is proven that vehicle dynamics on "micro" scale (stop/accelerate/decelerate) are most relevant for emission peaks or energy consumption. Up to now, the lack of effective communication and services brought two major limitations, making impossible to:

1. Know about the current/micro-scale real trajectory profiles for these parameters, which can even differ when the vehicle load is different (especially on trucks).
2. Be able to influence and contribute to optimise a single vehicle behaviour in a cooperative manner,

The Hamburg Living Lab will address the first limitation through the integration of Entruck[1] data and 5G communication, which will automate the analysis and quantification of micro-scale dynamics according to the context (vehicle, load, driver, infrastructure, TMS situation, etc.) and return them to the control centre as a live image. By displaying the historical data on a digital map, a preview of the driving task to be performed and emission forecast for the further route to the destination (port,

[1] Entruck is an open telematics and telemetry platform that enables detailed analytics regarding fuel efficiency and wear, based on mobility data of commercial vehicles.

loading/unloading point) can be called up under the TMS status switched on there, either individually for each vehicle or for pulks/platoons.

The second limitation will be addressed by introducing a Traffic Light Forecast (TLF) service by the Traffic Management or Service Centre with standardised messages, and by using it in vehicle applications such as Green Light Optimal Speed Advisory (GLOSA); this chain will enable a cooperative micro-manoeuvre behaviour of vehicles, avoiding unnecessary energy spending and reducing pollutants to a considerable degree. The GLOSA app will use the TLF service (which provides signal switching time information) to determine the optimal speed towards the next intersection, thus avoiding energy consuming manoeuvres.

Furthermore, current vehicle trajectories (such as speed or position) can be handed back in the return low-latency channel; such data, when available in near-to-real-time mode to the traffic control system, will enable the cooperative intersection control action of intersection, thus bringing further energy savings. This feature, out of the scope of 5G-LOGINNOV, will be possibly developed in the framework of future activities in Cooperative Intelligent Transport Systems (C-ITS).

In light of the above, the main objectives of the Hamburg Living Lab are summarised in the following table.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O3	• Real-time emission data from truck sensors will be transferred to Road-Side Units (RSUs) and traffic controllers calculating the optimum speed for the automated truck platoon in the logistics corridor avoiding stop & go incident of the truck platoon. • Facilitate the quantification of port decisions impact for mid-/long-term through Key Performance Indicators (KPIs): investments, stakeholder satisfaction, accessibility, modal split, CO_2 emissions, air quality, green energy, market share, employment; CT KPIs: truck turn time, yard inventory of containers, outbound trucks in port >1 hour, crane idle hours, (un)avoidable delay, (un)scheduled maintenance.	• 5G-LOGINNOV Floating Truck & Emission Data. Measured fuel savings of all participants of the truck platoon or trucks alone while driving with 5G GLOSA (LCMM/Entruck detect fuel proportional to CO_2/NO_X (WP1, WP2, WP3). • Family of use cases: 8-9.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O4	• Time slot allocation of truck platoon driving connected and automated in the logistics trial corridor and the connected optimized traffic light signalling. • Extrapolation of the potential CO_2/NO_X savings based on the real traffic volume to the port terminals. • Reduce emissions produced by trucks delivering/picking up containers (at least 15%). • Reduce noise generated by trucks delivering/picking up containers (at least 10%). • Reduce waiting time for inland containers transported via rail or barge (at least 10%). • Improve the modal split ratio in favour of rail and inland waterways (more than 10%).	• 5G-LOGINNOV 5G GLOSA & Automated Truck Platooning implemented and dynamic control loop for environment sensitive traffic management actions (WP1, WP2, WP3). 5G-related URLLC is a prerequisite for collision warning of Vulnerable Road Users (VRU) and Truck Platoon drivers • Family of use cases: 10-11.
#O5	• Attract at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in 5G, IoT, renewable energy & circular economy for improving port environmental footprint per pilot. • Provide a start-up innovation funding scheme for 5 short-listed SMEs in the respective city in order to design and implement in a TRL2-3 level the proposed technologies.	• Extension of planned use cases through the integration of innovative solutions brought by the winners of an Open Call dedicated to start-ups and SMEs (WP4). • The target value of (at least) 10 applicants is set at project level; there is no predefined scheme for the deployment of selected (5) applications across the different LLs (it depends on the reference LL declared by each application).

Table 13. Objectives of the Hamburg Living Lab

These objectives will be pursued within the following four use cases:

- UC8/9 - Floating Truck & Emission Data (FTED).
- UC10 - 5G GLOSA & Automated Truck Platooning (ATP)-under 5G-LOGINNOV Green initiative.
- UC11 - Dynamic Control Loop for Environment Sensitive Traffic Management Actions (DCET).

The following figure illustrates the general layout of Hamburg Living Lab.

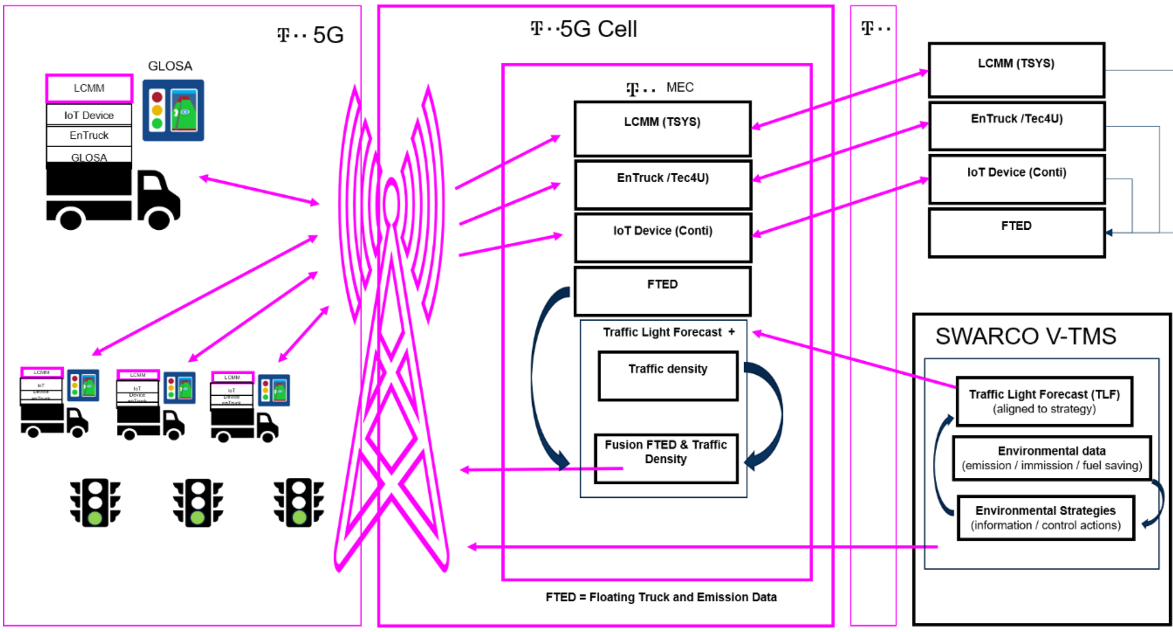


Figure 24. Hamburg Living Lab - General Layout

3.2.1 UC8/9 - Floating Truck & Emission Data (FTED)

Description

The automatic detection and evaluation of driving manoeuvres (based on real data from individual vehicles), their resulting effect on emissions and the related influence of infrastructure are key when it comes to the demonstration and proof of the effectiveness of a dynamic traffic management. The large number of vehicles in an urban environment requires a bidirectional communication infrastructure with a high bandwidth and a low latency. Therefore, 5G is a “must” requirement to ensure a secure and reliable communication strategy.

This enables live classification of micro driving manoeuvres of the individual vehicles into characteristic cases (e.g. braking, active acceleration, constant speed) and to link them to the static infrastructure features (curve, uphill, downhill); in parallel, the dynamic traffic control system provides additional mobility data as traffic lights, lane and speed displays, which will be defined and used as specific Points of Interest (POIs).

Based on the variation and changes of the driving manoeuvres, in relation of the current valid TMS status and the static and dynamic boundary conditions, the resulting emission behaviour is determined, assigned and evaluated. This is done by using the LCMM methodology that has been calibrated by Entruck analytics based on real driving and consumption profiles.

The results are stored live and in parallel with the underlying raw vehicle data on a digital map, that illustrates the effects of dynamic traffic management measures on individual vehicles in form of various driving situations and their specific manoeuvre/consumption diagram.

A further relevant component for this approach is the 5G Precise Positioning technology, enabling lane-exact position of vehicles and the detailed mapping of the static infrastructure conditions (3D profile, gradient, gradient curve radii) along the route corridors. For this purpose, the corridors will be segmented into partial routes and form the basis of the digital map on which the relationships between the influencing factors (vehicle, load, driver, route as well as TMS and consumption/emissions profile) are stored for analysis and prediction.

In addition, the information bases and data, as well as results of the control strategies, will be available for the other use cases 10 and 11, where the findings from UC8/9 will be translated into promising approaches for a dynamic traffic management to meet/optimize higher-level emission and extended requirements of the participants from the port and logistics sector, as well as with the environmental and traffic management authorities in the test area.

The identified solution features:

- 5G real-time truck & emission data collected by LCMM, Entruck and Continental IoT device by using 5G Precise Positioning technology.
- Improve the LCMM standard by Entruck (e.g. tire pressure, engine, etc.).
- Characterisation of infrastructures and emissions based on real vehicle data and behaviour.
- Real-time analysis of manoeuvres and direct provision of results.
- Calibration of external services (LCMM) based on speed profiles.

Gap Analysis

UC goals	• Floating Truck and Emission Data.
Initial conditions (before 5G-LOGINNOV)	• Traffic Management Systems work with static traffic data from stationary detectors.
Major problems identified	• No micro manoeuvre/trajectory data from trucks/vehicles available in intelligent traffic management. • No knowledge about emission situation in relation to vehicle dynamics known.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Dynamic traffic management can utilise real-time floating truck data: ◦ Position/speed/arrival times known for traffic control. ◦ Pollutant & energy consumption known for environmental traffic management.
Gap between initial and final conditions	• Vehicles with no telematics data (no LCMM-APP, IoT devices, Entruck).
Measurement of these gaps	• Introducing data from the vehicle to TMS, GLOSA.

Table 14. UC8/9 (Hamburg) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
T-Systems	Project partner	Living Lab Leader
Swarco	Project partner	Traffic Management System supplier
Continental	Project partner	IoT device supplier
Tec4U	Project partner	Mobile data analytics

Table 15. UC8/9 (Hamburg) - Involved Partners and Stakeholders

Use Case Operation

For the development and deployment of UC8/9, several steps must be realized. The initial step is the selection of an adequate fleet for installing the onboard units planned for FTED data collection. The general system layout of UC8/9 is illustrated in Figure 25.

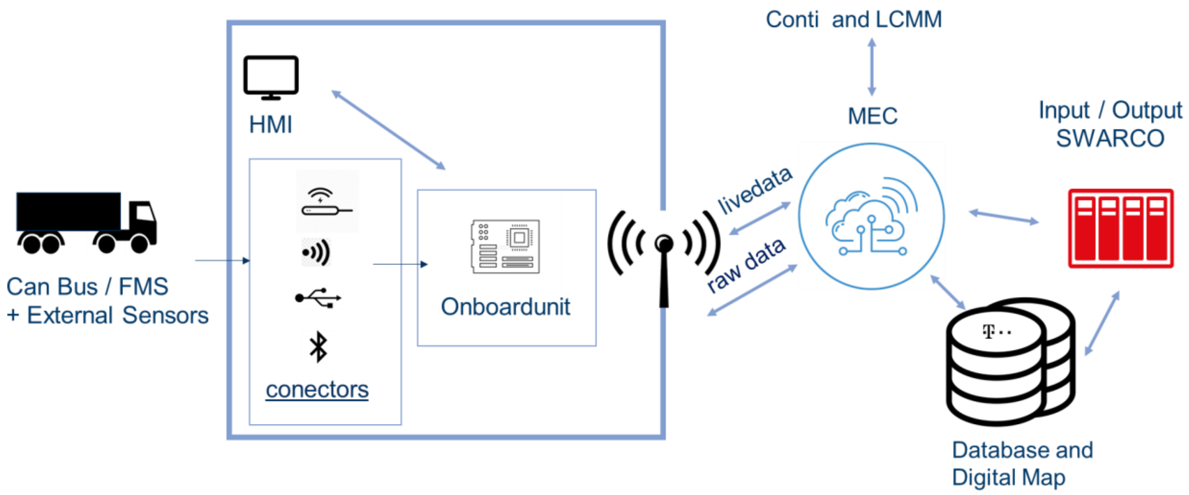


Figure 25. UC8/9 (Hamburg) - Layout

It is planned to start with LCMM test data collection, and then to expand the fleet to logistics service providers, with a focus on covering logistics corridors inside the City of Hamburg. The fleet will be operated according to the principles of Floating Car Data and analyse road segment with regards to traffic quality, stop & go and standstill starting.

In the initial phase, 5 vehicles equipped with LCMM will collect trip data for preliminary analysis. After the initial phase, the LCMM equipment of the fleet will be extended by installing Entruck onboard units and the Conti-IoT-Box. Finally, the data collection will be done on three level of data depth and collection method to illustrate different media and hardware requirements. The equipped vehicles will perform test drives along the autonomous driving test field in Hamburg to collect Floating Car Data (FCD) and provide it to the MEC by using a 5G network.

Additionally, a 5G enabled MEC server infrastructure will be implemented to support SWARCO TMS decision support and GLOSA ATP solution described in UC10 and UC11. The operational flow is illustrated in Figure 26.

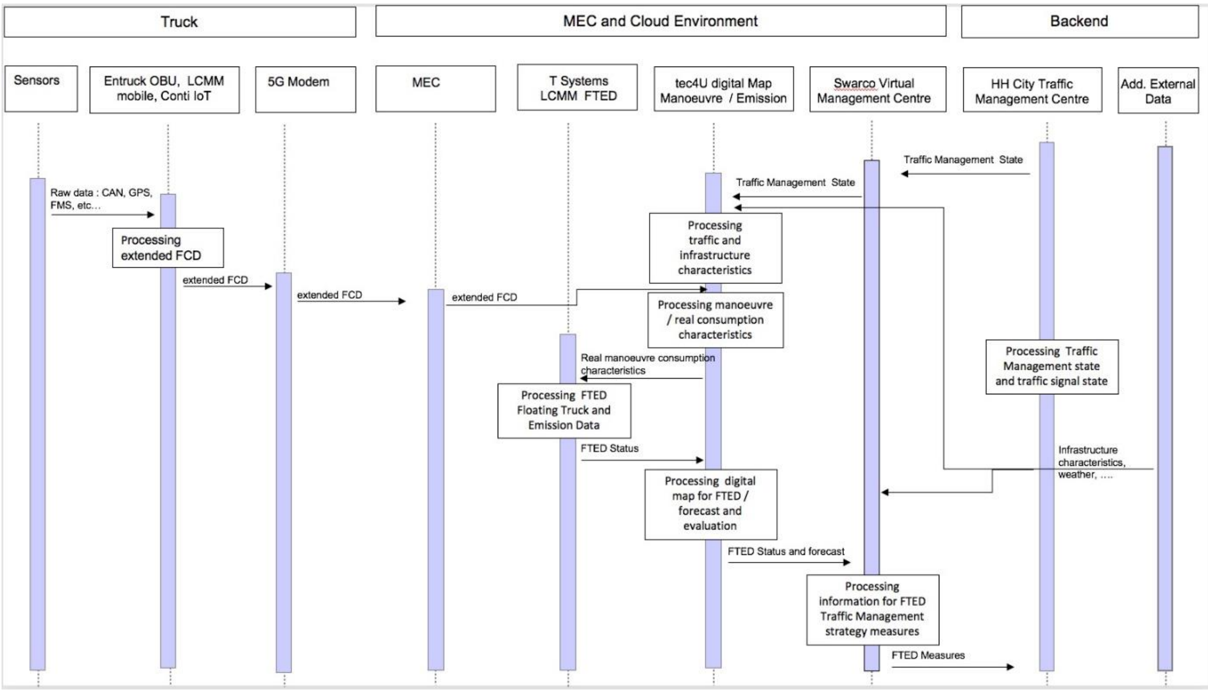


Figure 26. UC8/9 (Hamburg) - Operational Flow

The bi-directional 5G-enabled communication described above includes, but is not limited to:

- Standardized dataset for all common vehicle types.
- Continuously data recording (min. 2 per second).
- Transmission of live information for TMS project targets (pre-processed) and raw data for quality assurance and digital map creation.
- Data rate approx. 350 Mb/month for raw data transmission and forwarder-specific driver interactions.
- Additional project-specific data volume for the transmission of (pre-processed) data for LCMM, TMS live data and TMS communication.

3.2.2 UC10 - 5G GLOSA & Automated Truck Platooning (ATP)-under 5G-LOGINNOV Green initiative

Description

The basis for proving and demonstrating the effectiveness of GLOSA in interaction with ATP is, in addition to a safe and target-oriented communication strategy and environment, the automatic recognition and evaluation of the emission impact of driving manoeuvres, and the related influence of the infrastructure, TMS systems and TMS GLOSA measures. The driving manoeuvres are classified into characteristic cases (braking, accelerating, constant speed) and linked to the static infrastructure characteristics (curve, uphill, downhill); in parallel, the dynamic traffic control systems (traffic lights, lane and speed displays) are recorded/localised (and located as specific GLOSA POIs) and the specific information need/available content is queried and structured.

Based on the changes in driving manoeuvres (when TMS/GLOSA measures, the status of the traffic situation and the knowledge of other boundary conditions are known), the changes in emission behaviour are determined, assigned and evaluated, based on the driving profile change. To determine the emission behaviour, the LCMM methodology is calibrated by means of Entruck data, using real driving and consumption profiles; thanks to this approach, the effect can be recorded for individual vehicles, using the different driving situations (traffic light green phase, green wave to traffic light red phase), and evaluated using an adapted routine from UC8/9. In the fundamental diagram, this means an extreme consideration, since the manoeuvre components of acceleration and deceleration are close to zero in the ideal case, in favour of the constant driving component. The reflection on real traffic conditions will be evaluated based on field data and in a specific GLOSA simulation for the development of control strategies, applied to the potential estimation and planning of possible logistics corridors.

The fundamental building blocks for this approach are the exact (lane-level) positioning of the vehicles and the TMS systems, as well as the exact mapping of the static infrastructure conditions (3D profile, gradient, gradient curve radii), needed to predict driving resistances, traffic situation and arrival times of the platoon at the traffic control system (which influences the control time) or to transfer the necessary boundary parameters for the control strategy adaptation of the ATP in a suitable way. In this respect, the possibilities of strategies for coupling the ATP to the TMS facility must also be taken into account and secured, by means of a continuous exchange of information between vehicles and TMS facility, especially when dealing with unexpected traffic disturbances (dangerous situations).

Furthermore, the results and control strategies will be integrated into UC11, where these findings, based on the knowledge gained from UC8/9, will be translated into promising approaches for dynamic traffic management to meet/optimise higher-level emission and extended requirements of the participants from the port and logistics sector, as well as with the environmental and traffic management authorities in the test area.

Gap Analysis

UC goals	• Establishing 5G real-time connection between Automated Truck Platoons and traffic control.
Initial conditions (before 5G-LOGINNOV)	• No knowledge from Traffic Management Systems to support driving dynamics optimisation.
Major problems identified	• Focus of traditional GLOSA on single-vehicle speed advise. • Non-dynamic TMS, missing upstream of information from the truck/platoon. • High latency of information exchange and imprecise GNSS information.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Dynamic traffic management with real-time floating data with high reliability and low latency. • Precise position information through 5G.
Gap between initial and final conditions	• Vehicles with no telematics data (no LCMM-APP, 5G-IoT devices, Entruck). In-vehicle systems and technical conditions that enable ATP.
Measurement of these gaps	• Introducing data from the vehicle to TMS, GLOSA.

Table 16. UC10 (Hamburg) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
T-Systems	Project partner	Living Lab Leader
Swarco	Project partner	Traffic Management System supplier

Organization	Relation with 5G-LOGINNOV	Role
Continental	Project partner	IoT device supplier
Tec4U	Project partner	Mobile data analytics
City of Hamburg	External support	Data supplier of traffic light data
Truck drivers (users)	External support	End users/service consumers in the vehicle

Table 17. UC10 (Hamburg) - Involved Partners and Stakeholders

Use Case Operation

The basis for the proof and demonstration of the effectiveness of GLOSA in interaction with ATP is, in addition to a secure and targeted communication strategy and environment, the automatic recognition and evaluation of the emission effect of optimisation/modification of driving manoeuvres by the possibilities of TMS-GLOSA measures.

For this purpose, the automatic recognition and evaluation of the emission effect of driving manoeuvres and the associated influence of infrastructure (developed by UC8/9) will be set in relation to the TMS-based data as traffic light green phase, green wave to traffic light and red phase and evaluated with a specific GLOSA routine.

The specific GLOSA information is sent to the vehicles under the ATP boundary conditions, which allow the driver/ATP to select the optimum speed to reach the active traffic control system (traffic lights). In particular, the lead distance required for the consumption-optimised speed setting must be determined under the given infrastructure conditions and the ATP conditions (number of vehicles and differences in vehicle characteristics/drivetrain). In addition, specific sections of the route with the appropriate technical equipment are defined on which the test vehicles interact, and the digital map is extended accordingly.

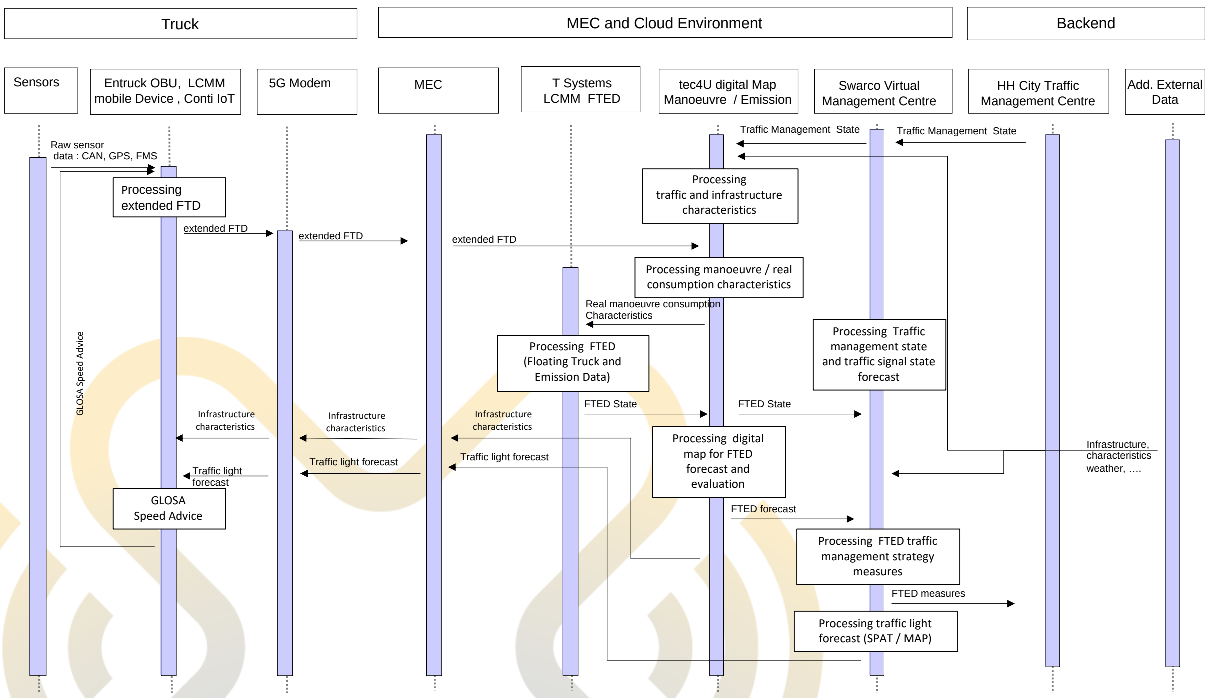


Figure 27. UC10 (Hamburg) - Operational Flow

The vehicle data is collected and transmitted in analogy to UC8/9. The resulting fundamental diagram, i.e. driving manoeuvre/consumption/emission diagram, is an extreme consideration, as the manoeuvre components acceleration and deceleration ideally approach zero in favour of the constant driving component. The observation of the real traffic conditions is evaluated on the basis of field data and in a specific GLOSA simulation for the development of control strategies, and applied to the potential estimation and planning of possible logistics corridors. In this context, the possibilities of strategies for coupling the ATP to the TMS system are also to be considered and secured by a continuous information exchange between vehicles and TMS system, especially in case of unexpected traffic disturbances (dangerous situations). This includes the reliance on 5G URLLC for time-critical collision warning (<10 ms) of truck platoon drivers and Vulnerable Road Users (VRU).

3.2.3 UC11 - Dynamic Control Loop for Environment Sensitive Traffic Management Actions (DCET)

Description

The SWARCO Virtual Traffic Management System (SWARCO V-TMS) is located in the SWARCO-Cloud and can be used for different application areas, e.g. to inform different road user groups about the city air quality, as well as to collect, analyse, take decisions and act managing the traffic related to the port and Hamburg City, in order to decrease the air pollution resulting from motorized traffic.

Environment Sensitive Traffic Management (Figure 28) is a control loop involving:

1. Vehicle dynamics (driving parameters) and vehicle (engine) characteristics.
2. Evaluation of the vehicle dynamics and computation of emissions caused by the dynamics.
3. Consideration of weather and air conditions, pollutant measurements for modelling immission of current and future time.
4. Consideration of the immission and the overall traffic situation (now and future) to:
    a. Select defined traffic management strategies.
    b. Activate bundles of actions.
5. Activating traffic management strategies, involving:
    a. Changing traffic light control parameters.
    b. Changing speed limits or access regulations (re-routing, restriction of engine types, speed limits etc).
    c. Modifying cooperative control interaction.
    d. Spreading traveller information (inform about restrictions, encourage mode shift or other mobility behaviour changes).
6. Resulting impacts on vehicle dynamics/mobility behaviour/engine types running in the pollutant zone.

The use case 11 of the Hamburg Living Lab includes steps 1, 2, 5.c and 6 of the described circle. Steps 3 to 5.b are demonstrated conceptually by a strategy manager in the virtual traffic management centre (i.e. no real implementation in field), since those steps are not in the focus of 5G-related communication.

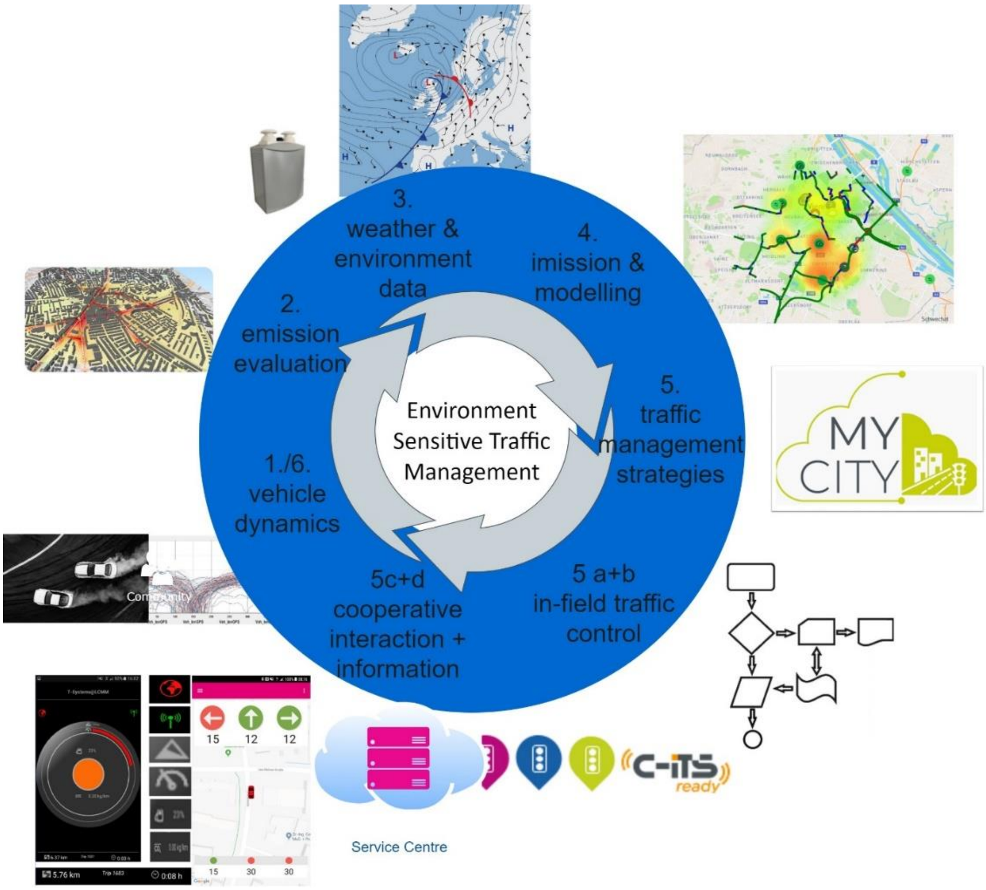


Figure 28. UC11 (Hamburg) - Environmental Sensitive Traffic Management circle

The main objectives of this use case are:

- Dynamic traffic management with real-time floating truck data.
- Synchronisation of TMS measures through the analysis of driving manoeuvres.

The identified solution features:

- Definition of logistics corridors in close cooperation with stakeholders from the port and logistics community and with the environmental agencies and the traffic management authorities.
- Exchange of complex V2X information via 5G making use of the 5G inherent precise positioning as well as of the eMBB, URLLC and mMTC functionalities of the mobile network.
- Green light priority and speed advisory of a truck platoon in port-city's automated test field.

Gap Analysis

UC goals	• Floating Truck and Emission Data.
Initial conditions (before 5G-LOGINNOV)	• Traffic Management Systems work with static traffic data from stationary detectors.
Major problems identified	• Non-dynamic TMS, missing upstream of information from the truck.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Dynamic traffic management with real-time floating truck data. • Synchronizing TMS measures by analysing driving manoeuvres.

Gap between initial and final conditions	• Vehicles with no telematics data (no LCMM-APP, IoT devices, Entruck).
Measurement of these gaps	• Introducing data from the vehicle to TMS, GLOSA.

Table 18. UC11 (Hamburg) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
T-Systems	Project partner	Living Lab Leader
SWARCO	Project partner	Traffic Management System supplier
Continental	Project partner	IoT device supplier
Tec4U	Project partner	Mobile data analytics
City of Hamburg	External support	Potential future operator of demonstrated strategy management

Table 19. UC11 (Hamburg) - Involved Partners and Stakeholders

Use Case Operation

The use case is planned to be operated in the following 3 phases:

- Phase 1: definition of logistic corridors in cooperation with all relevant stakeholders.
- Phase 2: real-time tests with data from Entruck, LCMM GPS and Continental with small sample fleets (>2).
- Phase 3: demo operation according to project schedule.

Starting from phase 2, the Virtual Traffic Management Centre gets from the other Living Lab partners highly accurate and precise environmental data, merged in a common format. Using this highly actuated data from the field (within the SWARCO environmental management platform), the Virtual Traffic Management System (V-TMS) takes decisions and develops strategies in order to change the management of the motorized traffic flow for the benefit of air quality, e.g. by changing the traffic light management strategy and traffic light switching; furthermore, V-TMS may provide MNOs with traffic light information, which can be offered to the road users of the GLOSA service. The operational sequence of UC11 is illustrated in Figure 29. Through the implementation of such sophisticated strategies and the provision of accurate data, the SWARCO V-TMS has a big impact on the environmental sensitive traffic management.

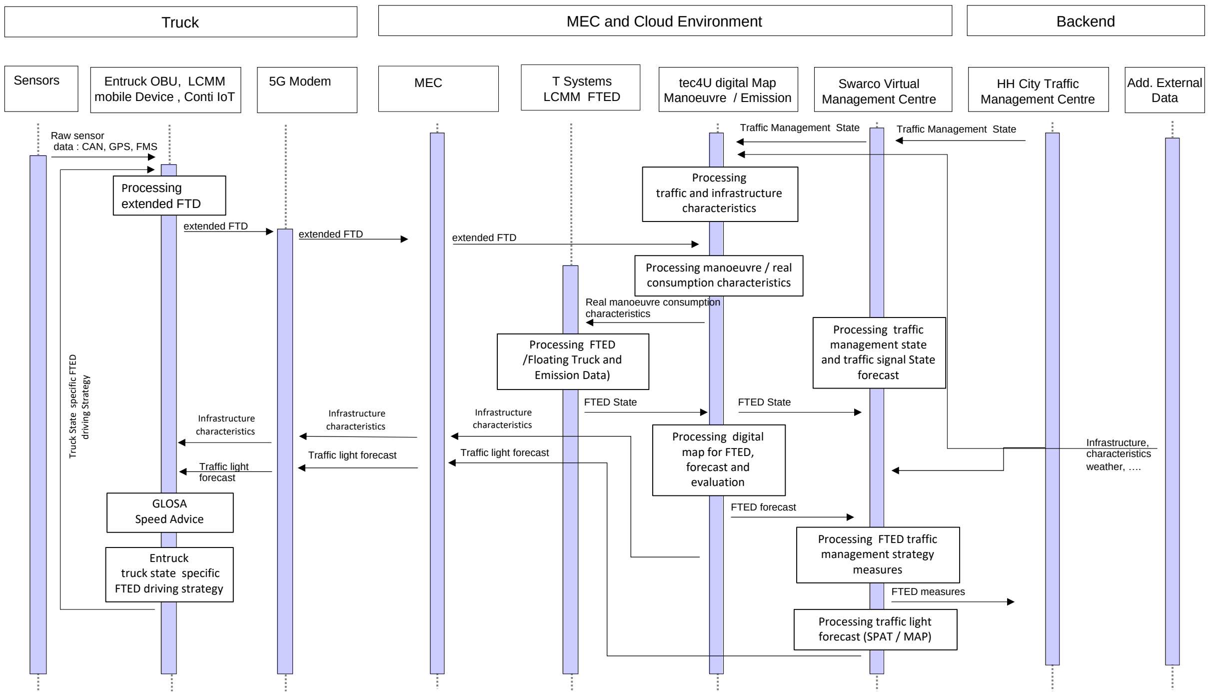


Figure 29. UC11 (Hamburg) - Operational Flow

The data collected within UC11 operations contain the following elements:

- Vehicle-Central “upstream” elements: vehicle sensors provide trajectory data from vehicle movement and additional powertrain information if applicable. The data are processed on the vehicle, where Extended Floating Car Data (eFCD) information is created (e.g. in the modules Entruck OBU, LCMM mobile, Conti IoT). Using 5G communication and MEC infrastructure, the Extended Floating Car Data are transferred to the MEC/cloud systems. Using further analytics or additional data, the vehicle driving characteristics are processed to:
    - Probe data describing traffic characteristics (to be used in traffic management/situational awareness).
    - Energy consumption and emission information based on real time driving characteristics.

  This elaborated MEC/cloud information is further used in the (virtual) traffic management centre (see description above). Traffic measurement bundles would be triggered and traffic management would alter the roadside control/traffic rule/traveller information.
- Vehicle-Central “downstream” elements: city traffic management and control provides current control settings (e.g. traffic light status). The Virtual Traffic Management Centre produces traffic light forecast (and further information), which is provided to the MEC/cloud system for the UC10 - 5G GLOSA & Automated Truck Platooning (ATP)-under 5G-LOGINNOV Green initiative.

3.3 Living Lab 3 - Koper

Pilot Site Description

Port of Koper is one of the most dynamic ports in Europe and one of the front runners of innovation. Located in the area of Koper municipality, it is the only Slovenian multi-purpose port connecting central Europe with access to the Adriatic and Mediterranean, and its activity influences the development of the region, Slovenian economy, and logistics in this part of Europe.

Figure 30. Aerial views of Koper Port

The core business of the port comprises the transhipment and warehousing of a variety of goods and a range of complementary services, providing customers with comprehensive logistics support. In 2008, Luka Koper concluded with the State a 35-year Concession Agreement for the performance of port activity, management, development and regular maintenance of the port infrastructure in the area of the Koper cargo port. Transhipment and warehousing are carried out at 12 specialised port terminals. The terminals are organised according to the goods/cargo they receive. Each terminal has its own characteristics, depending on its goods-specific work process, technological procedures and technology. Luka Koper operates all terminals in the Port of Koper and invests in new port capacities and development of the entire port area.

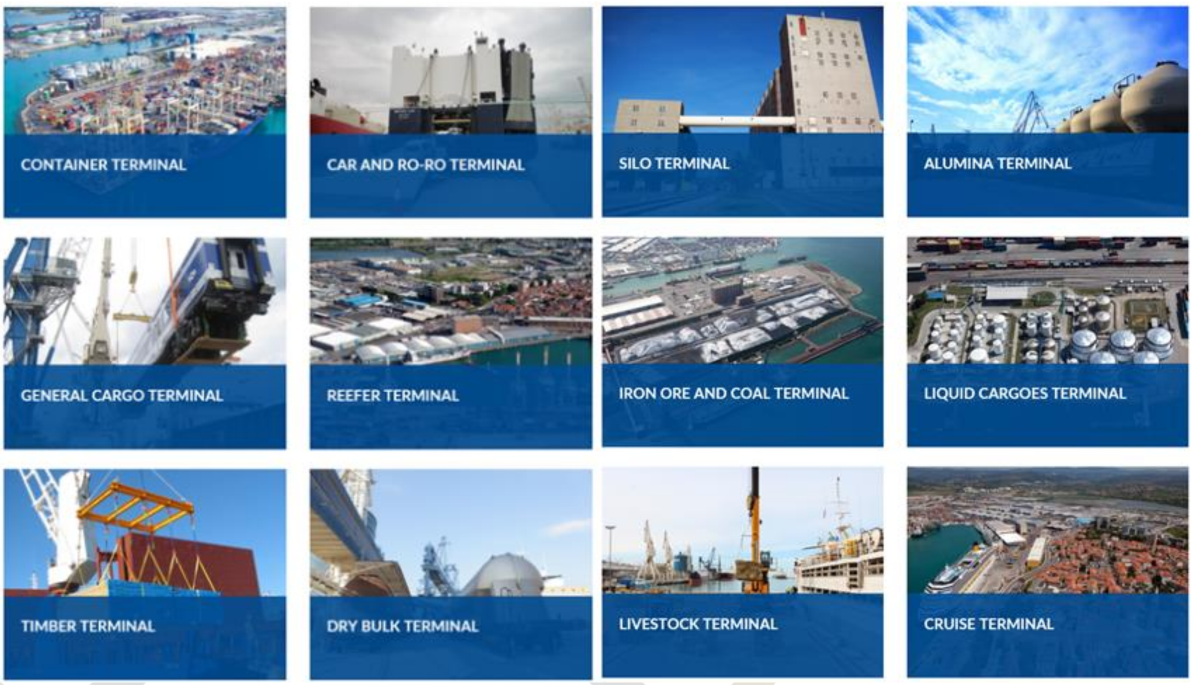


Figure 31. Koper Port Terminals

The port area consists of 274 hectares of land, with 50.7 hectares of warehouses and 109 hectares of open-air storage areas. 28 berths are located on 3,282 metres of the shoreline along 179 hectares of the sea. In terms of logistic activities, the services include:

- Loading/unloading of ships, trucks, and rail wagons, embarkation/disembarkation of passengers, storage, delivery, ship berthing.
- Services provided by the collection and distribution centre for all types of cargo.
- Services on goods (sorting, palletising, sampling, protection, labelling, weighing, cleaning and other services).
- Integrated logistics solutions.

In 2019, net sales amounted to EUR 229 million, and the Luka Koper allocated the amount of EUR 40 million to investments, mainly intended for transhipment equipment, the new port entrance and the construction of a new berth.

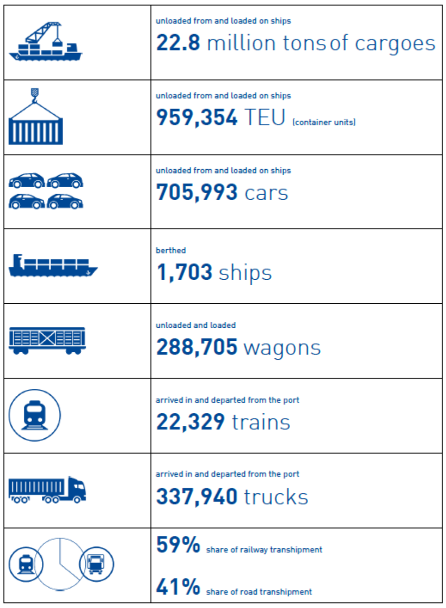


Figure 32. Koper Port in numbers (2019)

Port of Koper performs its core port activity of transhipment and warehousing for its hinterland. The Slovenian market amounts to less than a third of total throughput which has been increasing from year to year, in particular in the traditional and most important hinterland markets of Austria, Hungary, Slovakia, the Czech Republic, Italy, and also Croatia, Serbia and Romania, Germany and Poland.

Luka Koper also offers its services to overseas markets, where marketing and promotional activities present the port as the ideal entry and exit point for the mentioned hinterland markets. Regular activities are mainly performed in countries of the Mediterranean, and the Middle and Far East.

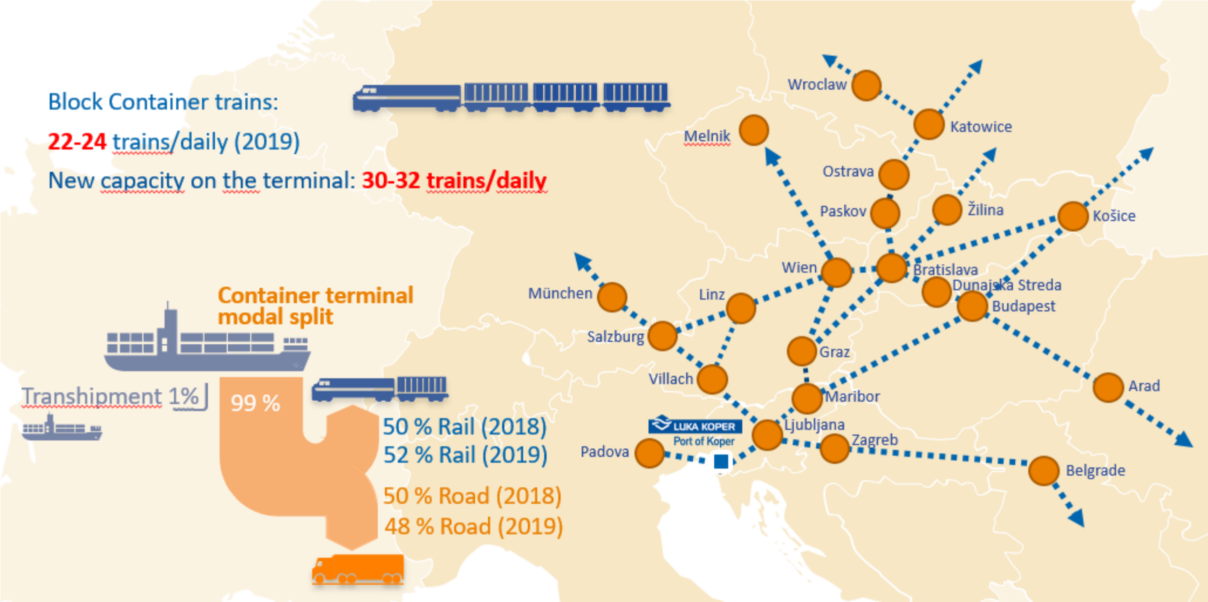


Figure 33. Koper Port railway connections

The Koper Living Lab is directly linked to the Port of Koper and its logistic services, which is operated by Luka Koper Company. The main applications and services that will be supported are based on Industry 4.0 scenarios and include use cases related to port control, logistics and remote automation. More specifically, the following 5G-enabled logistics support scenarios will be implemented at the Container Terminal area:

- Operating port STS crane will be equipped with industrial cameras for capturing and transfer of UHD streams to the Container Management System (CMS) for identification of container markers and detection of possible structural damage of containers using advanced video analytics based on AI/ML techniques. In addition, transfer of remotely gathered information will be enabled and made available to other port support systems, e.g. Terminal Operating System (TOS).
- Secondly, port equipment monitoring and remote metering will be performed for scenarios supporting operating machines monitoring (such as terminal tractors) by means of capturing and transfer of the key information (consumption, positions and other related metering) to the targeted port support system.
- Finally, a resilient 5G-based operational network scenario will be implemented to provide alternative 5G network capabilities to the established operational WLAN network, supporting data transfer redundancy between the operational port infrastructure and the operation centre.

The results that will be achieved in Koper LL can be replicated to any sea or inland port as well as terminals that base their operations on container throughput.

Motivations and Objectives of the Living Lab

The Koper Living Lab targets implementation of novel 5G technologies (MANO-based services and network orchestration, Industrial IoT, AI/ML based video analytics, drone-based security monitoring etc.) and cutting-edge prototypes tailored to be operated in port environment. This represents not only operational but also development challenge, particularly with regards to possible immaturity of some of its 5G components and consequently a possibility to disrupt/affect the established operations of the port. To overcome deployment and operational challenges of the current 5G technologies in port environment, the implementation of the Living Lab infrastructure is planned as a controlled and independently operating subsystem, and the interconnection points with the operational infrastructure (e.g. integration of 5G mobile network with the operational port network) will be carried out using proven and verified equipment. Also, 5G capabilities and services under test (e.g. eMBB, mMTC, MEC, the use of drones) represent an add-on to the existing port infrastructure and complement the overall service portfolio, not substituting any of its vital parts. Technical teams responsible for operation of existing port infrastructure will be involved in planning, deployment and integration activities in order to ensure minimum or no negative effects of the newly introduced technology into the established port environment and to get operational insight into novel 5G technologies.

The deployment of the 5G mobile network in the Port of Koper will rely on the availability of commercial 5G products, especially those related to the support of eMBB and mMTC features. The deployment plan already takes this into consideration, and the use of products and components that are either already commercially available or announced is planned. However, in case of delays in the commercial rollout on the part of 5G vendors and consequently unavailability of some components/ features, these will be replaced with the most suitable prototypes and open-source implementations already available in the 5G ecosystem.

The Port of Koper, even though located in the territory of the Republic of Slovenia, carries a status of an autonomous security zone, for which some specific security and regulatory constraints apply. The partners involved in the activities linked to and taking place in the Port of Koper will take these constraints into consideration and will work closely together and under guidance of the Port of Koper representatives to ensure compliance and execution of any required formal procedures within the context of the project timeline.

Concerning the use of drones and video streaming cameras in the seaport such as Port of Koper, the national legislation and regulations of the Republic of Slovenia as well as specific provisions for the port zone will be considered to make sure that all formal requirements are met. The Port of Koper will be in charge of investigating, planning and execution of any necessary provisions and will involve other LL partners as necessary.

The main objectives of the Koper Living Lab are summarised in the following table.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O5	• Attract at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in 5G, IoT, renewable energy & circular economy for improving port environmental footprint per pilot. • Provide a start-up innovation funding scheme for 5 short-listed SMEs in the respective city in order to design and implement in a TRL2-3 level the proposed technologies.	• Extension of planned use cases through the integration of innovative solutions brought by the winners of an Open Call dedicated to start-ups and SMEs (WP4). • The target value of (at least) 10 applicants is set at project level; there is no predefined scheme for the deployment of selected (5) applications across the different LLs (it depends on the reference LL declared by each application).
#O7	• Private 5G-based mobile services provided by the national MNO (Mobile Network Operator), tailored to the needs of port operation, will be provisioned and operated over the public MNO infrastructure. • Dedicated private mobile system that will be built as standalone and self-operated 5G network and services platform infrastructure.	• Deployment and validation of the 5G network and services in LL Koper to support operation of the UC1, UC5 and UC6.

Objective	Measurable objectives & indicators	Validation/Measurable outcomes
#O7	• Enhancing functionalities of the 5G IoT GW to support 5G Non-Standalone and Standalone capabilities (NSA/SA), MANO orchestration and capturing of vertical and horizontal network and services KPIs, with support of E2E 5G monitoring capabilities.	• Deployment and validation of 5G IoT platform in the LL Koper to support operation of the UC5 and UC6.
#O7	• Enhancing 5G IoT backend system elements with new NFV functionalities and MANO orchestration support.	• Deployment and validation of the 5G IoT backend system components in LL Koper to support operation of the UC1.
#O7	• Proprietary computer vision SDK, multiplatform, to rapid prototyping in a large variety of sectors, including Advanced Driver Assistance System (ADAS), security, inspection and HMI.	• Development and deployment of the SDK in LL Koper to support operation of the UC5 and UC6.
#O7	• Annotation model to describe content of image sequences, in the form of: spatiotemporal entities, called Elements. Thus, VCD contains lists of Elements being: Objects, Events, Actions, Context or Relations, etc.	• Development and deployment of the annotated model in LL Koper to support operation of the UC5 and UC6.
#O7	• Novel surveillance technologies and mechanisms (drone-based, wearable cameras, AI/ML based video analytics).	• Development and deployment of the mission-critical and security related uses case (UC6) in LL Koper.
#O7	• Enhancing equipment monitoring through the collection of telemetry data from vehicles involved in port operations.	• Development and deployment of IoT devices on vehicles in LL Koper, to support UC5.

Table 20. Objectives of the Koper Living Lab

These objectives will be pursued within the following use cases:
- UC1 - Management and Network Orchestration platform (MANO).
- UC5 - Automation for Ports: Port Control, Logistics and Remote Automation.
- UC6 - Mission Critical Communications in Ports.

3.3.1 UC1 - Management and Network Orchestration platform (MANO)

Description

Use case 1 will primarily address 5G-LOGINNOV MANO architecture (ETSI MAnagement and Network Orchestration) and its cloud extensions that will be used for demonstration of automated deployment and life cycle management of a network and applications operated in a 5G-enabled port environment targeting on Industrial IoT applications.

Novel virtualization and cloud-based principles such as VNF (Virtual Network Functions) and CNF (Cloud Native Functions), as well as industry-proven infrastructures (e.g. Kubernetes and OpenStack), will be used as baseline technology to build private 5G system in Koper LL. The open-source MANO orchestrator integrated with Kubernetes and OpenStack mechanisms will enable on-demand provisioning of Private 5G mobile network and 5G IoT services, it will assure the expected network and application performance metrics and KPIs, and finally it will enable onboarding, deployment automation and other required functions such as scalability, high availability and resilience of the operated services and applications. These mechanisms present essential capabilities that are required to run the most demanding logistics, Industry 4.0 and mission critical use cases in future European ports.

Gap Analysis

UC goals	• Demonstrating automated deployment and life cycle management of network and services deployment in the 5G-enabled port environment.
Initial conditions (before 5G-LOGINNOV)	• WiFi and optical infrastructure is in place to support port operation and logistics services.
Major problems identified	• Commercial and private 5G mobile infrastructure tailored to port operations needs is not available. • Security and legislation conditions need to be fulfilled for using public and private mobile systems in the case of port operation. • 5G network and services platform supporting VNF- and CNF-enabled components not available. • 5G IoT platform is not in place. • 5G IoT/M2M devices are missing.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Network and services orchestration platform will be tested in port environment and tailored to the needs of port operation. • 5G IoT platform will be integrated into the MANO orchestration environment and tested in port environment. • Automated deployment of VNF- and CNF-enabled services and life cycle management for port operation will be tested in port environment.
Gap between initial and final conditions	• Commercial 5G services, private 5G system, 5G IoT system, MANO orchestration.
Measurement of these gaps	• Operational commercial 5G mobile system will be available. • Operational portable 5G mobile system will be available. • Operational MANO orchestration platform will be available. • 5G IoT platform will be available. • 5G IoT devices/GW will be available.

Table 21. UC1 (Koper) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
Luka Koper	Project partner	Port Operator, Trial Leader
Telekom Slovenije	Project partner	Provider of a commercial 5G system, 5G Architecture Task Leader

Organization	Relation with 5G-LOGINNOV	Role
Internet Institute	Project partner	Provider of private 5G system, MANO orchestration platform and 5G IoT platform, Living Lab Leader

Table 22. UC1 (Koper) - Involved Partners and Stakeholders

Use Case Operation

To support UC1 services and application needs, two mobile systems will be deployed and operated on the premises of the Koper LL (Figure 34):

- Private mobile services provided by the national MNO (Mobile Network Operator) that will be provisioned and operated over the public MNO infrastructure.
- Dedicated private mobile system that will be built as standalone and self-operated 5G network and services platform infrastructure (Figure 35).

Combined private mobile services assured by the national MNO and the private 5G infrastructure will enable various scenarios and 5G operational modes to be tested and demonstrated on a single 5G port facility, including support for various vertical industries (transport and logistics, mission critical port operation) and private 5G standalone network operation for private security and port services. Hybrid private-public 5G network operations will also be supported with the demonstrated features, such as 5G slicing, MANO, NFVI (Network Functions Virtualization Infrastructure) and multi-IaaS (Infrastructure-as-a-Service) scenarios.

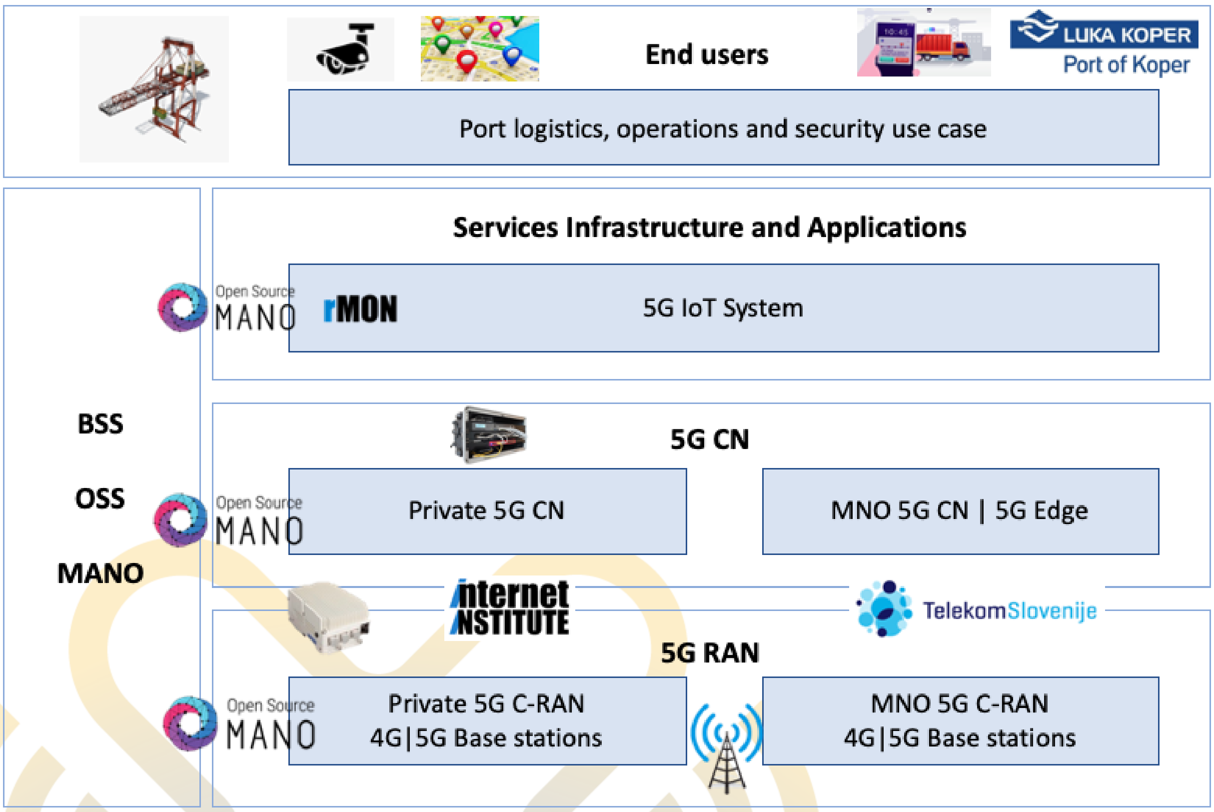


Figure 34. UC1 (Koper) - Layout, network and services

Figure 35 illustrates the architecture and planned technologies used for the design and deployment of the private 5G system. In the solution design, an open hardware approach will be followed, using cloud and industry proven technologies.

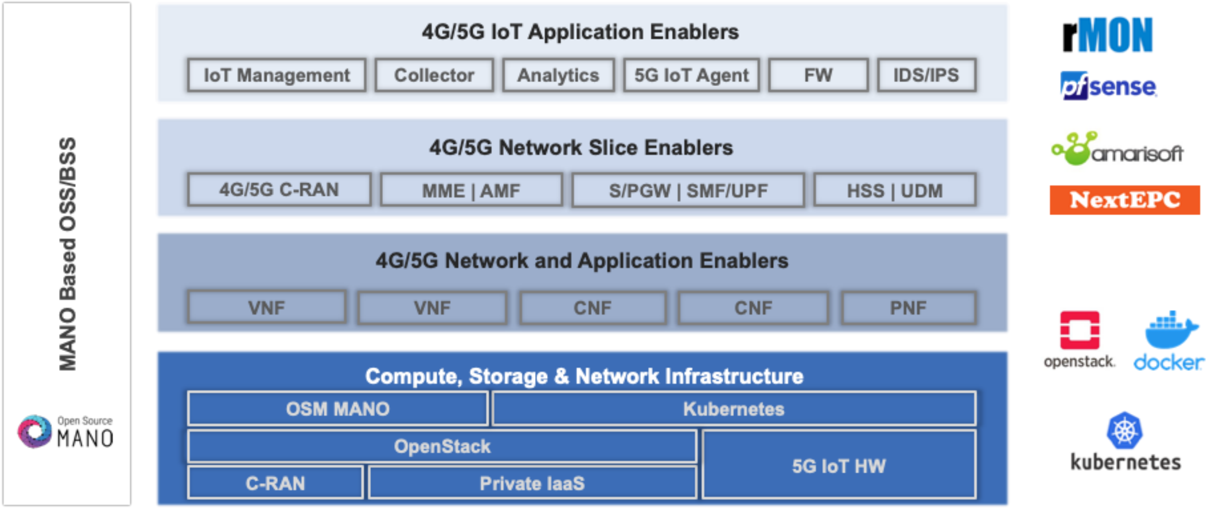


Figure 35. UC1 (Koper) - Layout, private 5G system

For the development and deployment of UC1, an iterative approach will be followed. In the first step, the baseline 5G network and cloud infrastructure will be designed and deployed on the premises of the Koper LL. To support strict port security requirements, commercial MNO infrastructure will be extended with MEC capabilities that will assure smart routing of the port-related network services and applications traffic directly to the operations support systems of the Koper LL. In addition to commercial MNO services, the private 5G mobile network with dedicated cloud infrastructure will be built and tailored to the needs of port operation and targeted UCs.

In parallel, the required activities for the design and development of CNF and MANO-enabled 5G IoT platform will take place. IoT system provided by ININ will be extended with 5G and cloud-native principles and other mechanisms required to support onboarding and automated deployment of the 5G-enabled IoT services (5G IoT System) into the MANO-controlled cloud environment. 5G IoT system components will be prepared as cloud-native functions (CNF) and extended with the support of MANO-based orchestration on top of Kubernetes and OpenStack infrastructure.

Therefore, to assure the 5G IoT system deployment in the Koper LL, the currently monolithically-built server elements will be split and prepared as distributed and modular application components. The relevant 5G IoT system deployment diagram, including component interdependency and interactions, is presented in Figure 36. The diagram will be used to develop the required MANO descriptors used by the orchestrator for the system deployment automation.

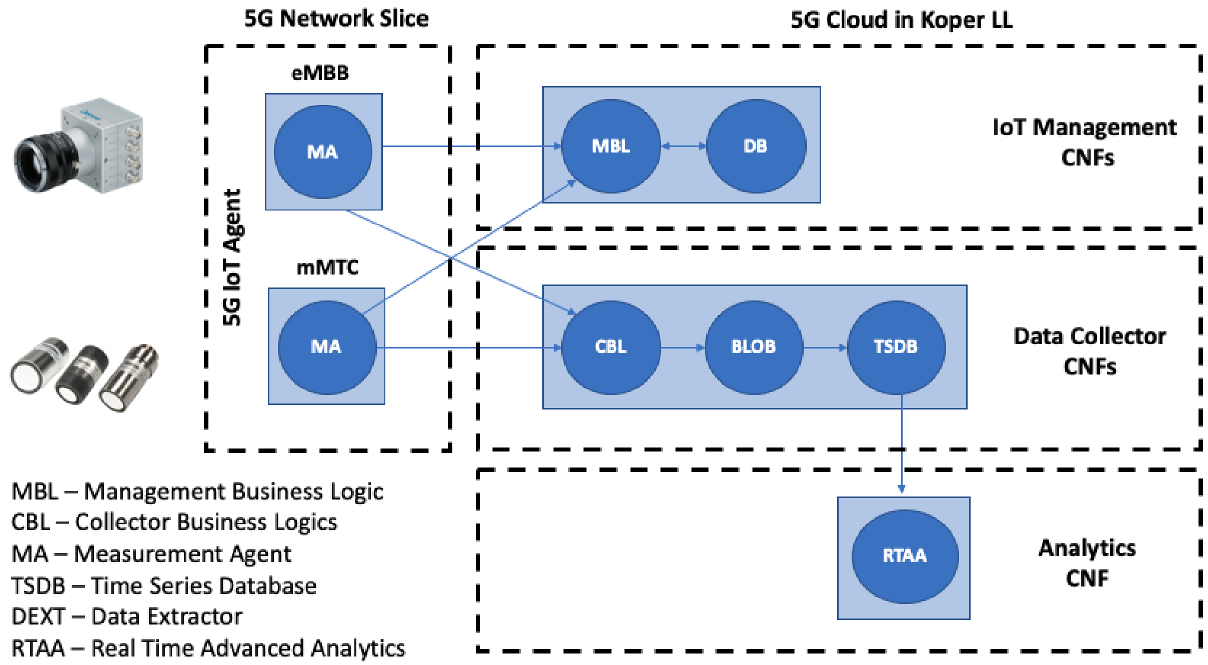


Figure 36. UC1 (Koper) - 5G IoT System Components

In the next step, the developed components will be onboarded into the Koper LL MANO repository; based on prepared descriptors, the MANO orchestrator will assure deployment automation of the 5G IoT system in the Koper LL environment. Successful deployment of the system will enable evaluation of its operation following the targeted KPIs and the prepared UC1 test scenarios, in order to confirm the following high-level operational requirements:

- 5G IoT system deployment automation.
- Scalability of the 5G IoT system components.
- Agility and resilience of the system operations.

The deployed 5G mobile network and cloud infrastructure capabilities will be used also to support other use cases (UC5 and UC6) that will be operated, verified and showcased in the Koper LL environment.

3.3.2 UC5 - Automation for Ports: Port Control, Logistics and Remote Automation

Description

Use case 5 will primarily target Industry 4.0 related port operation with a focus on scenarios related to port control, logistics and remote automation. More specifically, a logistics and port operation support scenario will be implemented where operating port machinery (STS crane) will be equipped with industrial cameras for capturing and transfer of 4K UHD streams in real-time over the 5G network to the video analytics system for identification of container markers and detection of structural damage of containers using advanced AI/ML based video processing techniques. In addition, the transfer of remotely collected information will be enabled and made available to other port operations systems.

Secondly, port equipment monitoring and remote telemetry (supported by the 5G mMTC) will be performed for operating machines (e.g. terminal tractors), by means of capturing and transferring of the key information (e.g. consumption, positions and other related telemetry information) to the port operation support system.

Finally, a resilient 5G-based operational network scenario will be realized to provide alternative 5G-enabled connectivity capabilities to the established operational WLAN network, supporting data transfer redundancy between the operational port infrastructure and port operations centres.

The deployed 5G network, cloud and Industrial IoT infrastructure from national MNO and the private 5G mobile system capabilities from UC1 will be used as the baseline communication system in UC5.

Gap Analysis

UC goals	• Deployment of port control, logistics and remote automation capabilities over the 5G infrastructure.
Initial conditions (before 5G-LOGINNOV)	• Fixed and WiFi-enabled communications. • Terminal Operating System (TOS). • Container Management System (CMS) – e.g. port operations system TINO.
Major problems identified	• WiFi network reliability and resilience for the critical port operation services. • Commercial 5G mobile infrastructure tailored to port operations needs is not available. • Security and legislation conditions need to be fulfilled for using commercial and private mobile systems in the case of port operation procedures.
Final (foreseen) conditions (after 5G-LOGINNOV)	• Port STS crane will be equipped with industrial cameras for transferring images to video analytics system and exposure/availability of information to other port operations systems. • System for identification of container markers and detection of structural damage will be tested in port environment. • System for operating machine telemetry will be tested in port environment. • 5G support for data-based network and service redundancy between operational port infrastructure/equipment and operations centre will be tested in port environment.
Gap between initial and final conditions	• Commercial 5G system, private 5G system, security and legislation procedures, system for container markers and structural damage detection, system for operating machine telemetry transmission.
Measurement of these gaps	• Operational commercial 5G mobile system will be available. • An operational private 5G mobile system will be available. • System for gathering port machinery telemetry will be available. • System for container markers detection on port crane will be available.

Table 23. UC5 (Koper) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
Luka Koper	Project partner	Port Operator, Trial Leader
Telekom Slovenije	Project partner	Provider of commercial 5G system
Internet Institute	Project partner	Provider of private 5G system, MANO orchestration platform and 5G IoT platform, Living Lab Leader
Vicomtech	Project partner	Provider of artificial vision technologies for container markers identification and structured damage detection
Continental	Project partner	Provider of port machinery telemetry

Table 24. UC5 (Koper) - Involved Partners and Stakeholders

Use Case Operation

To support use case operation, two concurrent scenarios will be supported. In the case of logistics and port operation support scenario, operating port STS crane will be equipped with industrial cameras for capturing and transfer of UHD streams to the cloud-based video analytics system (Figure 37). Each targeted STC crane will have up to 5 cameras installed and connected to 5G network, so 5 different angled images will be received from each container in real-time. Captured video streams from cameras will be transferred in real time over the deployed 5G network in the LL Koper to the video analytics platform, where streaming management module will identify and prepare video streams to be processed by the markers' detection and damages' detection modules (Figure 38).

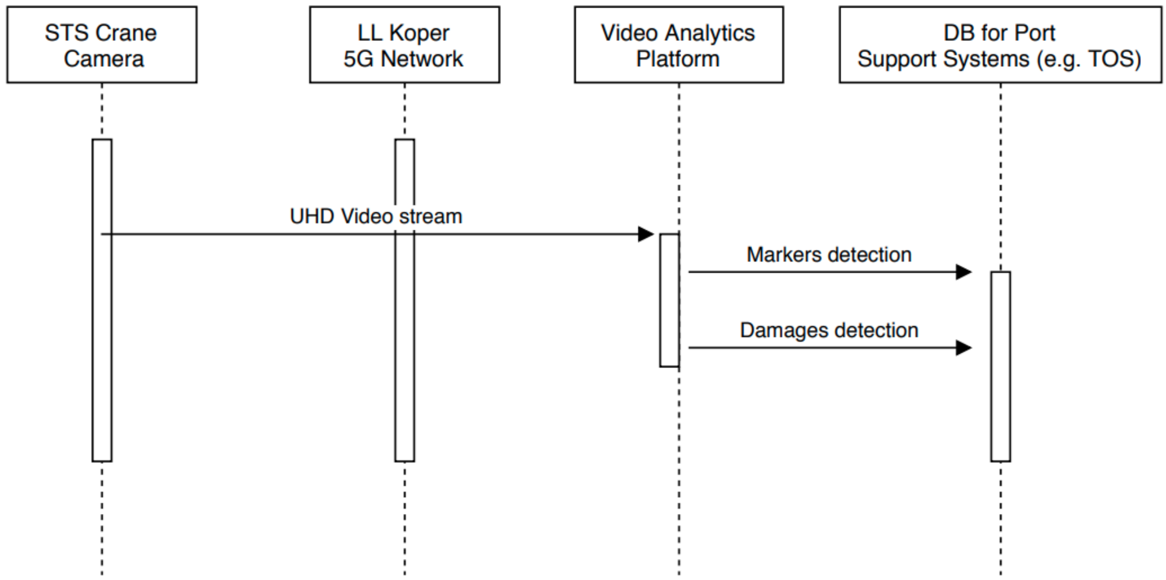


Figure 37. UC5 (Koper) - Operational Flow

Markers' detection module will first identify the area containing text in the image; second, an Optical Character Recognition (OCR) will identify which characters are part of the text, and third, to differentiate the marker from the other texts in the container, a semantic layer will be included. Damages' detection module will detect if the container is damaged, and where the damage is present

(5 streams per container will be available). To automate detection process, Deep Learning (DL) models will be applied to detect damages in the containers. These models will be trained with real images extracted from the scenario, where damages will be annotated in order to be considered for the detection.

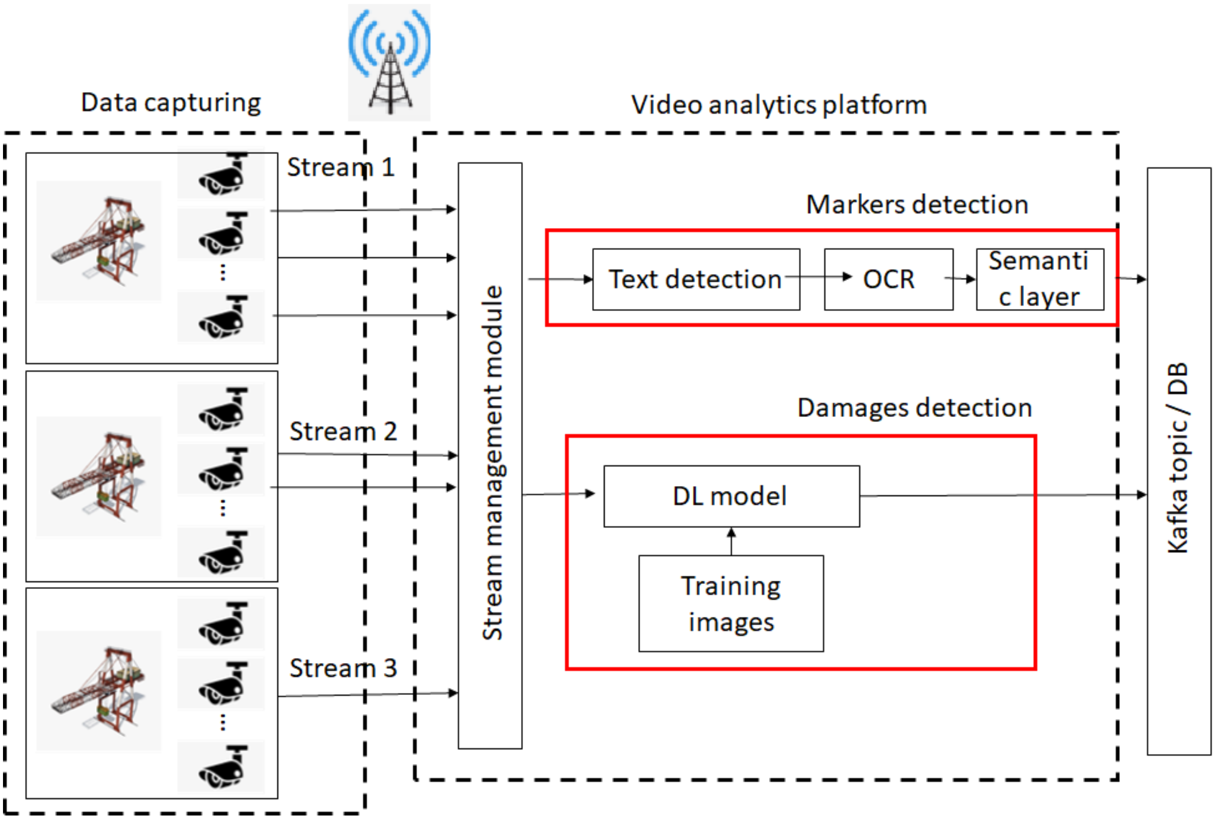


Figure 38. UC5 (Koper) - Block Diagram

Results of the video analytics platform process will be stored in database (e.g. Kafka) and will be made available to other port operating support systems in the LL Koper, e.g. TOS and CMS.

As part of the use case, telemetry data will be collected from some of the vehicles (e.g. terminal tractors) that operate within LL Koper. This information will be collected from the vehicle CAN-Bus, using the 5G-enabled IoT Device, and transmitted via the 5G network, to the backend installed within the internal IT infrastructure.

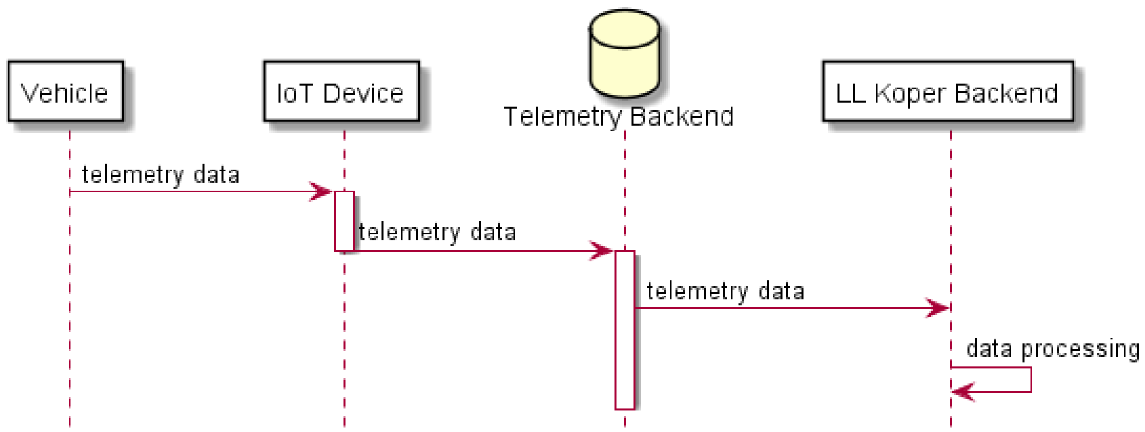


Figure 39. UC5 (Koper) - Telemetry Data Collection Sequence Diagram

The telemetry data gathered by the IoT device is dependent on the type of vehicle/equipment being monitored. Typical data to be collected include:

- Vehicle position
- Battery level
- Fuel level and consumption
- Oil level
- Tire pressure

Results of the telemetry data gathered by the device will be analysed and computed, stored in local database, and will be available to be used by other port operating support systems in the LL Koper.

3.3.3 UC6 - Mission Critical Communications in Ports

Description

As part of the use case 6, several activities related to the port security operation will be introduced to the LL Koper. A real-time video surveillance will be implemented using 5G-enabled body-worn cameras carried by security personnel to support their regular and mission critical operations and to provide additional personnel security. Portable video surveillance cameras with night vision capabilities (fixed cameras covering a specific area with relocations as necessary) will be connected to the 5G network and will be used to monitor specific port area (e.g. railway entrance) for the specific security services. In addition, automated and coordinated drone-based surveillance will be implemented for extended ad-hoc video surveillance support, where 5G network will be used to transfer video streams in real time into the port Security Operation Centre. To complement video-based security operations an automated detection of objects, vehicles and personnel movement in a specific port area will be targeted using ML and AI based video analytics. And lastly, private security operations management and support, featuring services to enable security operations, including personnel/team status monitoring, positioning and triage operations support with dedicated mobile applications will be evaluated.

In the use case 6, deployed 5G technologies from UC1 will be used as a baseline communication enabler, as such reliability and resilience of the multi-faceted real-time video surveillance will be targeted for mission-critical needs using commercial and private 5G network services.

Gap Analysis

UC goals	• Real-time video surveillance with portable and mobile capabilities. • Private security operations management and support. • Network reliability and resilience using public and standalone/portable 5G networks.
Initial conditions (before 5G-LOGINNOV)	• Stationary security cameras are in place using fixed connectivity. • Video analytics is not available.
Major problems identified	• Portable and mobile (body worn cameras, drone streaming) video surveillance. • Reliability of WiFi connectivity for mobile streaming video. • Privacy concerns/legislative framework related to real time video streaming needs to be investigated. • Operational/legislative procedures for drone operation need to be defined.

Final (foreseen) conditions (after 5G-LOGINNOV)	• Real-time video surveillance will be enhanced using body-worn cameras and drone-based video streaming. • Private security operation management and support will be enhanced. • Video surveillance will be enhanced with advanced analytics/mechanisms for detecting human presence in areas with safety risk. • Video surveillance will be enhanced with advanced analytics/mechanisms for counting and classifying vehicles at the entrance to the port.
Gap between initial and final conditions	• Body-worn cameras solutions supporting 5G, drone-based streaming supporting 5G, advanced video analytics platform, dedicated application for security management operation.
Measurement of these gaps	• Real-time video surveillance using body-worn cameras, portable video surveillance cameras and drone-based surveillance is available. • Team status monitoring application supporting team positioning and triage operation support system is evaluated. • Commercial and dedicated 5G infrastructure supporting port security operation is available.

Table 25. UC6 (Koper) - Gap Analysis

Involved Partners and Stakeholders

Organization	Relation with 5G-LOGINNOV	Role
Luka Koper	Project partner	Port Operator, Trial Leader
Telekom Slovenije	Project partner	Provider of commercial 5G system, 5G Architecture Task Leader
Internet Institute	Project partner	Provider of private 5G system, MANO orchestration platform and 5G IoT platform, Living Lab Leader
Vicomtech	Project partner	Provider of advanced video analytics

Table 26. UC6 (Koper) - Involved Partners and Stakeholders

Use Case Operation

To support use case deployment and operation in the LL Koper, several activities will be performed targeting different port operational systems and services:

- Automated motion detection (people, vehicles, animals, etc.) at the railway entrance in the port, where only the train set is allowed to pass through (Figure 40, Figure 41, Figure 42).
- Traffic analysis at the truck entrance gate area performing automated vehicle classification and counting, calculating speed, etc (Figure 43).
- Real-time video surveillance using aerial drones and body-worn cameras carried by security personnel, in order to support port operational activities and to provide additional personnel security.
- Security personnel/team status monitoring with positioning and triage operations support.

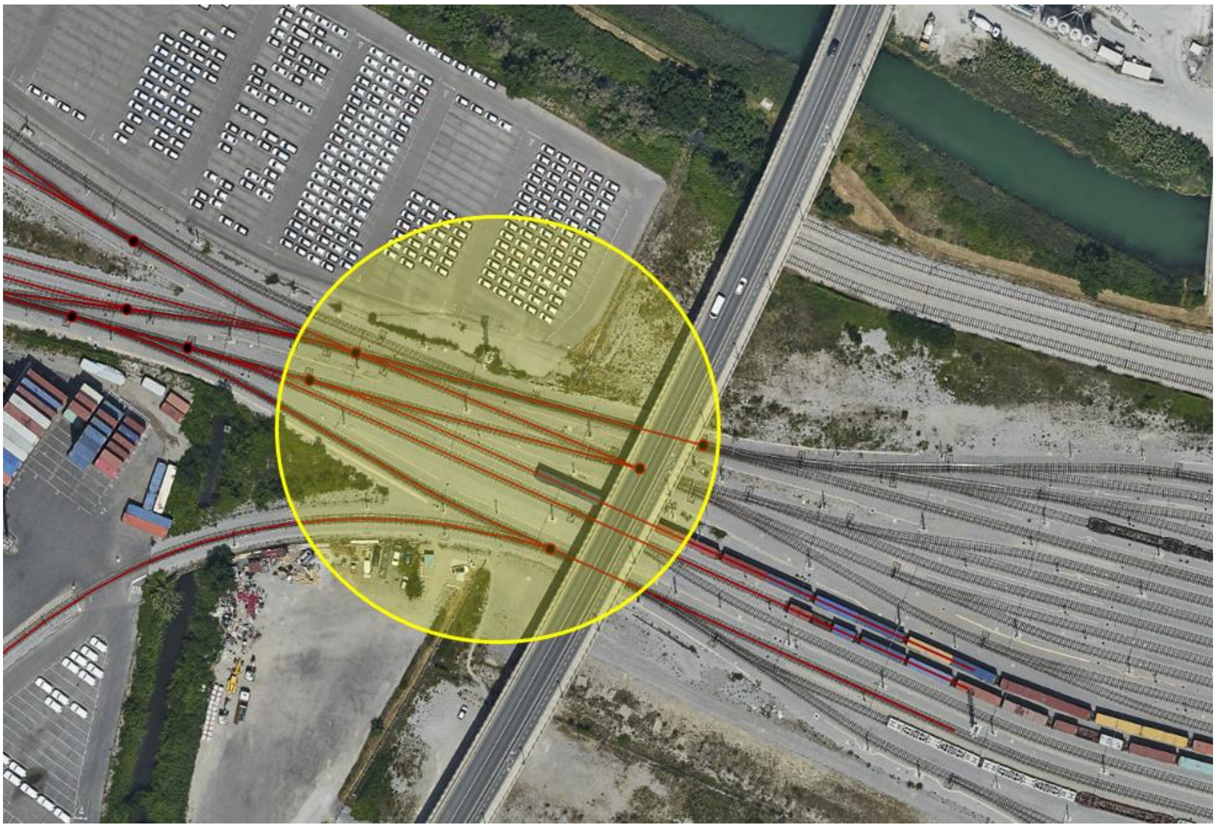


Figure 40. UC6 (Koper) - Railway entrance to port area (aerial view)

Figure 41. UC6 (Koper) - Railway entrance to port area (ground view)

Figure 42. UC6 (Koper) - Railway entrance to port area (flyover view)

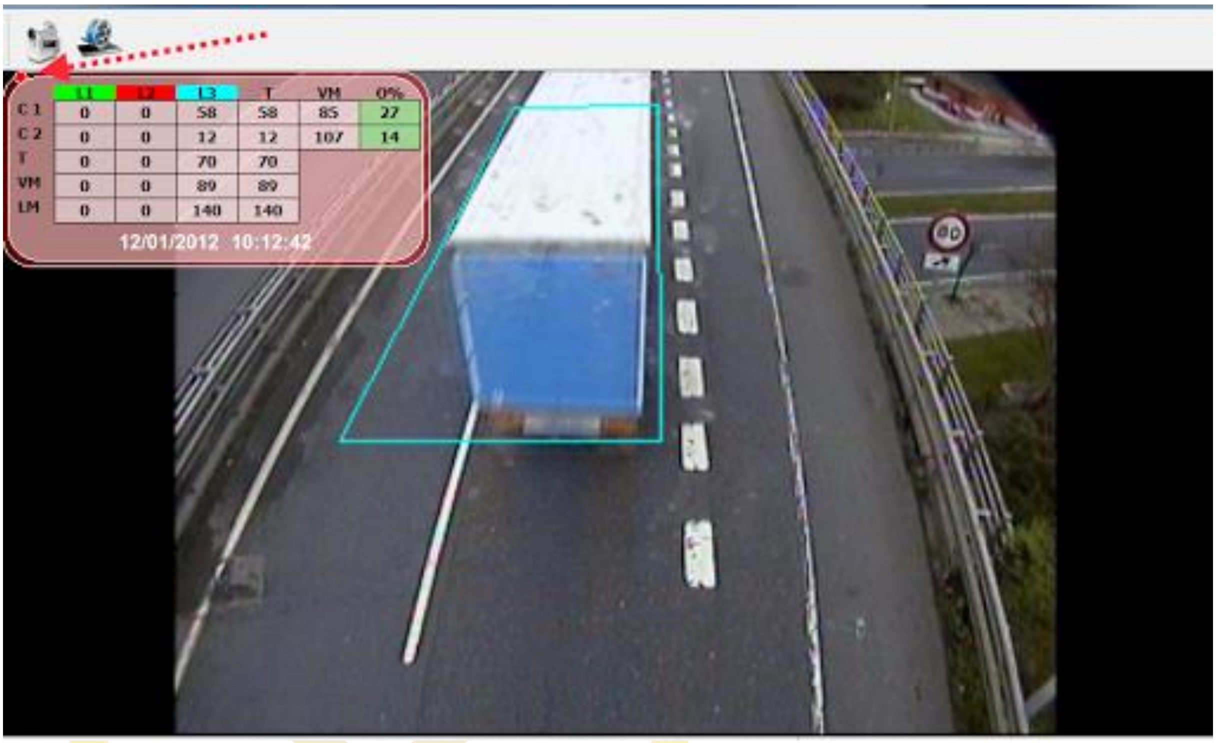


Figure 43. UC6 (Koper) - Monitoring traffic entering and leaving port area

Deployment and operation of the use case will be performed in several stages following an iterative approach. First installation and integration of several types and form-factors of the video sources (e.g. wearable cameras, portable cameras, drone-based cameras) will be introduced and connected to available 5G capabilities in the LL Koper. Based on the targeted use case scenario, captured video streams from the deployed video sources will be transferred in real time over the deployed 5G system to be available or used by different security and operational support systems inside the port (Figure 44).

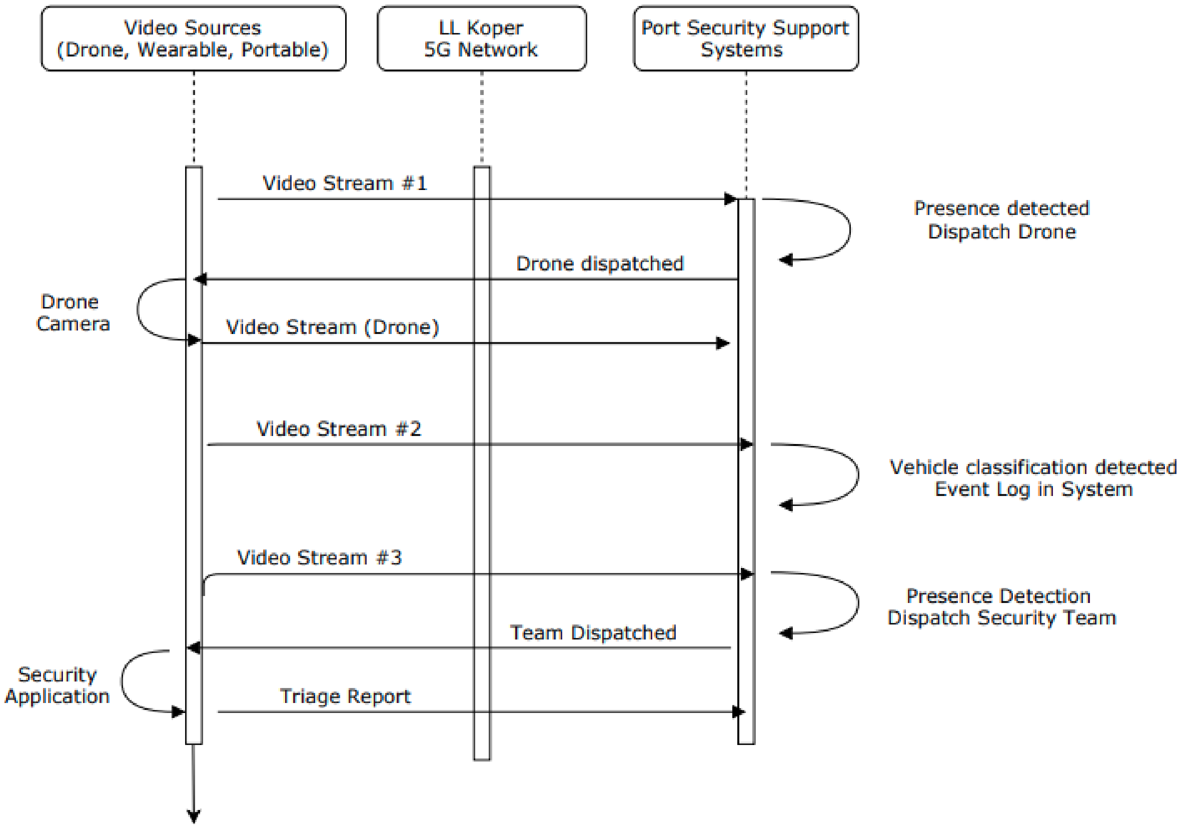


Figure 44. UC6 (Koper) - Operational Flow

In the case of the automated movement detection and vehicle classification scenario, video streams will be additionally analysed by the video analytics platform, where streaming management module will identify and prepare video streams to be processed by the presence detection and vehicle counting and classification modules (Figure 45). Presence detection module will perform two basic tasks: movement and object detection. In addition, object detector will classify among several categories of elements, differentiating train sets from other kind of movements at the controlled area. In case of security event, security control centre will be notified. In the case of triggered security alert, security control centre will have sufficient information to take action (e.g. personnel dispatched to the monitored area - Figure 46). For the road traffic monitoring purposes at the truck entrance gate, a vehicle counting and classification module will perform classification and counting among several kinds of vehicles and their speed. Results of the video analytics platform process will be stored in database (e.g. Kafka) and will be available to be used by other port operating support systems in the LL Koper.

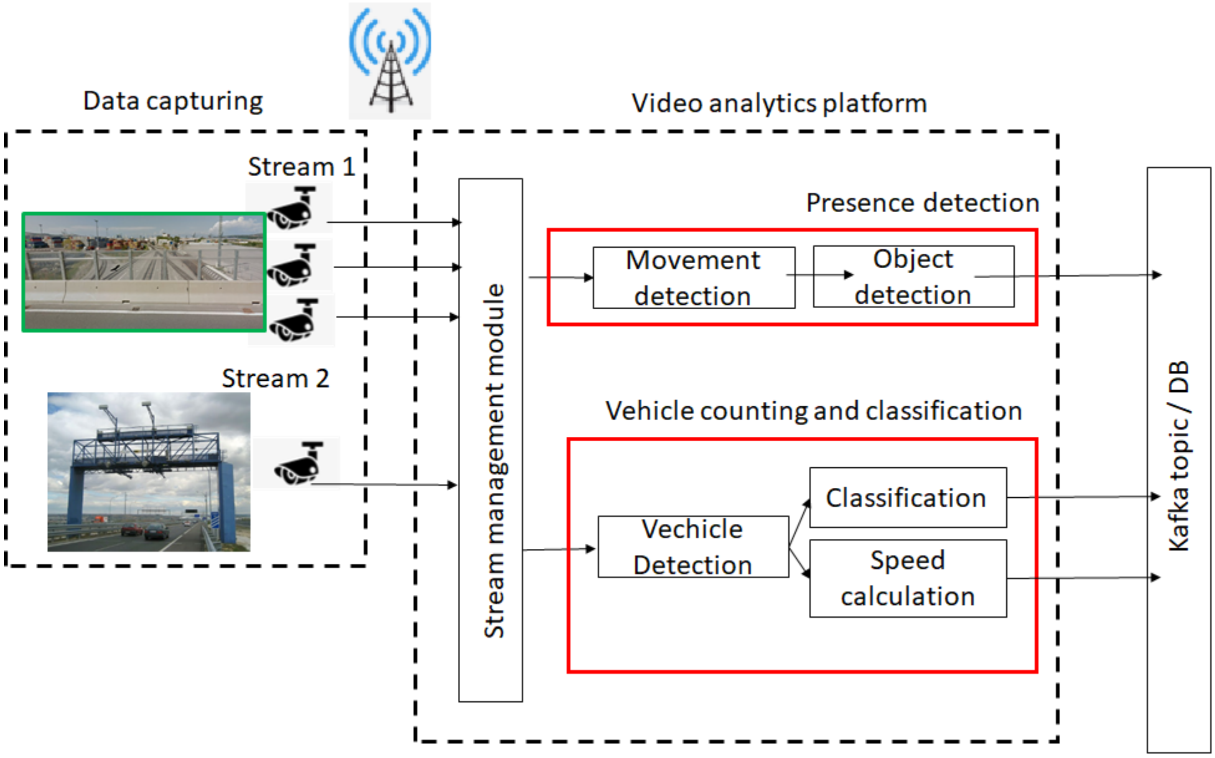


Figure 45. UC6 (Koper) - Block Diagram

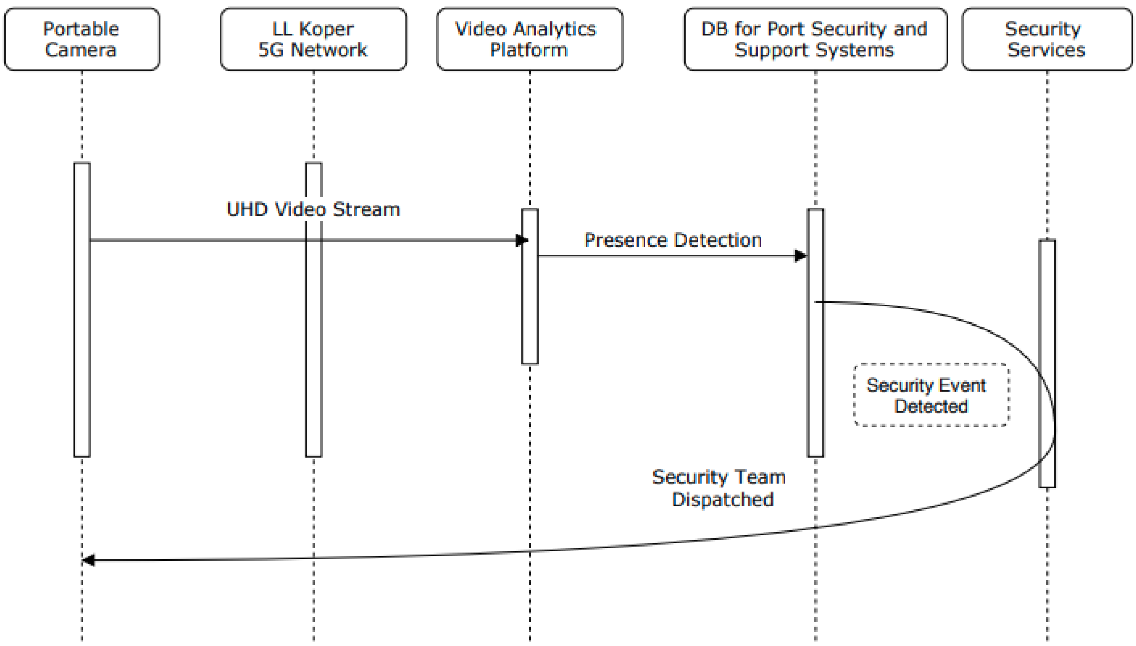


Figure 46. UC6 (Koper) - Operational Flow (automated movement detection)

In addition, and to complement network operational aspects, reliability and resilience of the multi-faceted real-time video surveillance will be targeted for mission-critical needs using commercial and private 5G network services.

4 LIVING LAB EXTENSIONS

The above-described use cases will be extended through the integration of innovative solutions brought by the winners of an Open Call dedicated to start-ups and SMEs. Following chapters provide an overview of Open Call boundaries and requirements, which represent the foundation for the related activities in WP4.

4.1 Open Call Overview

5G-LOGINNOV will organise an Open Call for the selection of five innovative start-ups and SMEs aiming to develop 5G-based solutions in the framework of activities carried out at the three Living Labs; the selected applicants will be incorporated in project consortium through a subcontracting granting a lump sum of € 50.000 each.

The Open Call is reserved to start-ups and SMEs complying with conditions described in chapter 4.1.2. The scope of such Open Call is intentionally left as general as possible, given that all candidate solutions shall apply to the physical context and infrastructure of (one of) the three Living Labs; however, chapter 4.2 provides some specific areas of interest that have been individuated by the Living Labs during the scoping phase.

The Open Call will be launched through the publication of a Manifesto indicating all the terms of submission, evaluation and granting of the applications. The launch will be publicized through a pervasive advertising campaign on partners' business networks and through a targeted communication action on local start-ups ecosystems possibly related to the three Living Labs.

4.1.1 Timing and Overall Management

The 5G-LOGINNOV Open Call will be entirely managed within Work Package 4, more specifically in task T4.2 - Emergence of new actors. The following table illustrates the timing of T4.2 activities.

Activity	Timing
Preparation of Open Call Manifesto. Definition of evaluation criteria.	Jan 2021-Feb 2021
Advertising campaign	Jan 2021-Feb 2021
Setup of support environment	Feb 2021
Launch of the Open Call (submission of applications opened)	01-Mar-2021
Closure of the Open Call	30-Apr-2021
Evaluation of received applications	May 2021-Jun 2021
Publication of final ranking	01-Jul-2021
Engagement of selected applications (subcontracting)	Jul 2021
Preparation of start-ups integration report (Deliverable D4.2)	Jul 2021-Aug 2021

Table 27. Open Call Timing (preliminary)

The Open Call Manifesto will be published on the project website and will indicate all the terms of submission, evaluation and granting of the applications, as well as the detailed technical infrastructure of the three Living Labs hosting selected applications.

The applicants will submit their applications by compiling an Application Form (also available on the project website) and by sending it to a functional (i.e. not personal) mailbox during the opening time frame (indicatively March-April 2021). Applicants shall also indicate which is the reference Living Lab where the developed solution will be deployed, validated and showcased. All applications received outside the time frame or through a different channel will be automatically discarded. During the opening time frame a helpdesk service will be active via a dedicated functional mailbox.

The applications will be evaluated against the criteria and according to the principles described in the Manifesto. All applications will be sorted according to their overall score. The 5 applications with the highest score will be considered as main candidates for the integration in the project. All other applications (above a minimum threshold to be defined within evaluation criteria) will be considered in a reserve list and will be recalled (starting with the one with the highest score) in case one or more main candidates withdraw from the process.

4.1.2 Beneficiaries

The accepted applicants for 5G-LOGINNOV Open Call are start-ups in the form of SMEs or group of individuals (that is, a start-up may be legally incorporated or not):

- Incorporated SME, according to the European Commission Recommendation 2003/361/EC [5] and the SME user guide [6]. As a summary, the criteria which define a SME are:
  - Headcount in Annual Work Unit (AWU) less than 250.
  - Annual turnover less or equal to €50 million *or* annual balance sheet total, less or equal to €43 million.
- Group of individuals: when there is not a constituted SME, the applicants could be a group between 2 to 4 individuals with a written commitment to have set up a legally registered SME if selected for granting.

4.1.3 Funding

All selected applications will be granted with a fixed subcontracting of € 50.000 each, regardless the efforts they will put into the development of the application (no cost/effort reporting needed). The payment of the grant is subjected to the achievement of objectives declared in the application, to be assessed through the deployment and validation on the reference Living Lab indicated in the Application Form.

4.2 Specific Areas of Interest

The following chapters describe a set of gaps and/or additional features that have been individuated within the analysis of Living Labs scope, which will be annexed to the Open Call Manifesto in order to provide focused suggestions to the applicants. Such suggestions are merely indicative and do not set any binding constraint to the scope of proposed applications, nor do they imply any preference criteria in the evaluation.

4.2.1 Living Lab 1 - Athens

Augmented Reality (AR) Platforms-as-a-Service can fully exploit their potential by using a fully developed 5G infrastructure. AR is placed on the real-world but offers a more comprehensive experience and perception of it by overlaying additional data. These services introduce new ways for content creation, consumption, and in how such data is communicated, that will undoubtedly help a wide variety of industries, in particular ports and their operations, to increase productivity levels, change the way they do business and view/plan/shape the evolution of their operations.

Through 5G-LOGINNOV, at Piraeus Container Terminal, applicants are invited to develop their platform solutions targeting innovative AR applications, including (but not limited to) the generic scope of the following use cases:

1. *AR-assisted guidance to speed up repairs in port assets (e.g. trucks, lifts, cranes, etc.)*. Production/operation lines are becoming increasingly complicated, hence, (unplanned) asset downtime is a potential (serious) revenue loss for port operators, and thus, cutting downtime for repairs is of paramount importance.
2. *Increase quality in manual production tasks and lower the chance of errors in warehouse operations*. AR-guided cargo load/unload operations (e.g. in open or closed space storehouses) can significantly speed up day-to-day port functions which are potentially part of other service chains in port operations, and thus, significantly improve the overall operational efficiency.
3. *Reduce training time at port operations and related assets, with on-the-job real-time tuition*. Training new personnel in highly complex port operations and relevant assets (e.g. quay cranes) can pose significant challenges for port operators. AR-guided tuition can speed up the training process, minimize the possibility of errors, and contribute to optimal human resource allocation.

Additional areas of interest include use cases that involve distracted driver & drowsiness detection. Distracted driving comprises any activity that takes away the (truck) driver's attention from the road. Drowsy driving signs, according to the American Academy of Sleep Medicine, are frequent yawning, difficulty keeping your eyes open, "nodding off", and having trouble keeping your head up. Technical 5G-enabled solutions, based on e.g. advanced computer vision and artificial intelligence, capable of recognizing -in video streams- indicators for both distracting and drowsy driving in real-time, are of paramount importance for within (and outside) port operations, to increase road (and asset) safety.

4.2.2 Living Lab 2 - Hamburg

From the overall design of the Hamburg LL, the 5G infrastructure enables the collection of extended Floating Car Data and expands this data to Floating Truck and Emission Data (FTED). A typical example is the detected fuel consumption available via CAN-Bus and FMS, which is transferred to the MEC and used for further calculations and evaluations, as e.g. to be compared with the calculated data of the LCMM App or for efficiency analysis by Entruck. By this way, the derived CO_2 emissions can be quantified much more reliable than the emissions derived from the WLTP reference cycle, measured in [%].

There are numerous other examples of available data from CAN-Bus and other sensor data which can be transferred from the vehicle to the MEC. This leads to the following possible topic of interest:

1. *Applications can make use of the given 5G-LOGINNOV infrastructure (e.g. MEC, Telematics Device, etc.)* and based on this:
   a. Design innovative value-added services for sustainable traffic management beyond the use cases described in 5G-LOGINNOV.
   b. Extend the 5G-LOGINNOV services beyond traffic management, making use of available data sets from the truck.
   c. Enrich 5G-LOGINNOV FTED by additional data from other sources inside the vehicle and the environment (e.g. additional in-vehicle sensors, weather data, environmental sensors).

GLOSA will be used first time for Automated Truck Platooning (ATP) and sustainable traffic management measures in a 5G environment. The platoon(s) will be operated manually during the demonstration; the technical transfer from this demonstration scenario to in-vehicle components (which will trigger fully automated operation) is not part of the Living Lab. This leads to the following possible topic:

2. *Contributions can elaborate an uptake of the described GLOSA-ATP for Hamburg LL to an OEM-centric integration vehicle data sources and their data fusion*. The objective is to use the Floating Truck Emission Data available in GLOSA-ATP as input for automated driving functions used directly for vehicle operation, e.g. gear shift.

The traffic management services proposed for implementation in 5G-LOGINNOV are based on the GLOSA principles. They do not consider other mobile services which will help to reduce emissions. Nevertheless, truck data is highly valid when used by modern navigation software, which leads to the following topic:

3. *How can navigation systems make use of FTED for "Green Navigation"*? Given the planned truck and emission data closely linked to Traffic Light Forecast, the calculation of routes can be expanded to emission reduction criteria, generating a strong environmental impact given the wide usage of mobile navigation.

Besides "Green Navigation", the truck and emission data can also be used for eco-drive training, nowadays very common by truck OEMs to promote their brands towards energy-efficiency. This leads to the following topic:

4. *How can 5G-LOGINNOV support Eco-Drive training out of the generated data and the data fusion out of 5G (MEC, etc.)*?

SMEs and start-ups who intend to apply for a demonstration in Hamburg LL may address all of these topics or make use of parts mentioned above.

4.2.3 Living Lab 3 - Koper

5G combined with the emerging technologies, such as UAVs (Unmanned Aerial Vehicles, e.g. drones) and AI-assisted video analytics deployed in cloud, presents immense potential for the development of innovative applications targeting services for the established vertical industries such as logistics, industry 4.0. and security.

As part of 5G-LOGINNOV Open Call, innovative SMEs are invited to develop beyond-state-of-the-art solutions and applications addressing security and environmental aspects of port operation, to be integrated, tested and showcased in live port theatre. Special attention should be given to the following supportive services and use cases:

1. *Providing autonomous operation of UAVs (e.g. drones without human pilots) in harsh industrial and port environment*, targeting technologies and applications for supporting automated charging of UAV, self-flying and self-piloting actions, scheduled and event triggered UAV take offs, mission control planning, head back to the landing/charging station and finally receiving mission data in real and non-real time as part of fully automated process.
2. *AI- and ML-based applications for cloud environments targeting support services for the port security operation*, based on the exploitation of real-time video streams from moving and stationary drones to recognize security-related events and to identify objects of interest in real time.
3. *AI- and ML-based applications for cloud environments targeting port safety and environment monitoring on the land and sea*, based on the exploitation of UHD video streams from moving and stationary drones and other supportive sensors to identify environmental, safety and other hazardous events that may present damage to the health of people and other organisms. These events can be oil and chemical spill and other maritime pollutants coming from the cargo ships and open cargo already stored in the port area.

Presented use-cases should not limit applicants to propose other novel beyond-state-of-the-art technologies and applications incorporating 5G and other supportive systems that are addressing security, safety and other environmental challenges of modern EU-based ports.

5 CONCLUSIONS

The present document is the main outcome of task T1.1 "Living Labs innovation specifications", and represents the foundation for parallel tasks in WP1 (namely T1.2 "5G architecture requirements", T1.3 "Living Labs infrastructure requirements", T1.4 "Evaluation methodology and requirements" and T1.5 "Data handling and cyber-security requirements"), which all together will produce the overall requirements of the three Living Labs (Athens, Hamburg and Koper) and related use cases, preparing their implementation and execution (which will follow in WP2 and WP3).

Through the exhaustive analysis of processes currently in operation at the three Living Labs, all involved logistics operators (supported by technology providers and ICT infrastructure operators) contextualized the use cases that have been sketched in the proposal, identifying all major gaps that will be addressed and describing the technological infrastructure that will host developed solutions. During this phase, LL Leaders also carried out the engagement of external stakeholders that will participate to the Living Labs, illustrating their scope and objectives.

The document also provides an overview of 5G technology, including distinctive features/services and vertical applications that are particularly relevant for the logistics domain. The process/gap analysis showed a wide coverage of such features/services, demonstrating how 5G is a key factor for the implementation of planned use cases.

Proposed use cases cover a broad range of applications and services supporting logistics operations in ports and hinterland, both at operational level (e.g. increase of the overall efficiency, reduction of handling/transit times, preservation of assets, reduction of costs, etc.) and socio-environmental level (e.g. reduction of emissions, safety of operating personnel, etc.).

Athens Living Lab is focused on the optimisation of port operations through the optimal assignment of container jobs to yard trucks, the automated detection of container seals (without intervention from human personnel) and the predictive maintenance of yard equipment; the LL will also cater for the improvement of personnel safety through analytics of 4K video streams. These objectives will be pursued through the deployment of a 5G network in the port area, the installation of 5G access points on yard trucks (connected to in-vehicle network and sensors), the deployment of 5G-IoT devices and Ultra-HD cameras on port machinery and the deployment of 4K surveillance cameras on the quay side and the rail terminal.

Hamburg Living Lab is focused on the exploitation of 5G for the enhancement of traffic management applications, with special attention to freight road traffic in port hinterland area. The LL will develop an innovative methodology to capture the effect of the traffic infrastructure on pollutant emissions, and will be part of a wider agenda for the development of Intelligent Transportation Systems (ITS) in the area of the Hamburg City (ITS Policy Strategy 2030), also featuring advanced cooperative services (C-ITS) like GLOSA (Green Light Optimisation Speed Advice) and ATP (Advanced Truck Platooning).

Koper Living Lab is focused on the development of a MANO architecture (MAnagement and Network Orchestration) and its cloud extensions, which will support the automated deployment and life cycle management of Industrial IoT applications related to port control, remote automation and security. Such applications include advanced video analytics for identification of container markers and detection of structural damage, port equipment monitoring and remote telemetry of operating machines (e.g. terminal tractors) and mission critical communications (namely real-time video surveillance using body-worn cameras, video surveillance cameras with night vision capabilities for security monitoring, automated drone-based surveillance and automated detection of objects, vehicles and personnel movement in a specific port area.

Task 1.1 worked in close cooperation with task T4.2 "Emergence of new actors", which will support the involvement of new actors in LL activities (namely innovative start-ups and SMEs); more specifically, T4.2 will launch and manage an Open Call for the selection of five start-ups that will be funded by the project to develop their ideas based on the application of 5G technologies tested in the Living Labs, thus reducing the existing gaps between the current and future scenarios. The cooperation between T1.1 and T4.2 identified a set of candidate features per Living Lab (also part of this document) that will be annexed to the Open Call Manifesto in order to provide focused suggestions to the applicants.

Activities in task T1.1 showed a very high degree of cooperation and integration between involved partners, both at Living Lab level and at global (project) level, contributing to reach a common understanding of the project goals and the ways to pursue them, which is the key for the successful prosecution of activities in following work packages.

6 REFERENCES

[1] Grant Agreement number: 957400 - 5G-LOGINNOV, 2020

[2] ISO/DIS 23795-1: Intelligent transport systems - Extracting trip data via nomadic device for estimating CO_2 emissions - Part 1: Fuel consumption determination for fleet management, https://www.iso.org/standard/76971.html

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[4] Nocera, Willenbrock, Reducing fuel consumption and carbon emissions through eco-drive training, Transportation Research Part F 46 (2017) 96-110

[5] European Commission Recommendation 2003/361/EC, 2020

[6] The new SME definition, 2020