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# 5G - LOGistics value chain INNOVation

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## Introduction

This paper describes the Living Labs and the corresponding Use Cases that will be demonstrated in the context of 5G-LOGINNOV, a European Union project funded under the H2020 framework that has started in September 2020 and will last three years. After a brief introduction to the 5G-LOGINNOV, the paper describes the three Living Labs, the innovations that will be introduced by the project and how the project will contribute to the future European Commission policy in the transport and logistics domain. Finally, some preliminary conclusions are reported.

## The 5G-LOGINNOV project

5G-LOGINNOV aims to bring technological innovations to the logistics value chain. More specifically, thanks to the integration and validation of Connected Automated Mobility (CAM) and 5G technologies, new services will be created to handle the increase of traffic, the need for larger port capacity and more efficiency. The introduction of 5G technology will allow to deploy new types of Internet of Things (IoT) devices and Artificial Intelligence (AI) with Machine Learning (ML) analytics, traffic management services can be implemented to optimize port operations and reduce the impact on the environment in the city and the disturbance to the local population. Finally, 5G-LOGINNOV will open SMEs' and Start-Ups' door to these new markets using its three Living Labs as facilitators and ambassadors for innovation on ports. 5G-LOGINNOV promising innovations are key for the major deep-sea European ports in view of the mega-vessel era (Hamburg, Athens), and are also relevant for medium sized ports with limited investment funds (Koper) for 5G.

## Living Labs

The 5G-LOGINNOV project consists of two main groups of Living Labs. Figure 1 shows that whereas Hamburg focuses on hinterland use cases, Athens and Koper will pilot their use cases inside the operational area and under the responsibility of the local Port Authority.

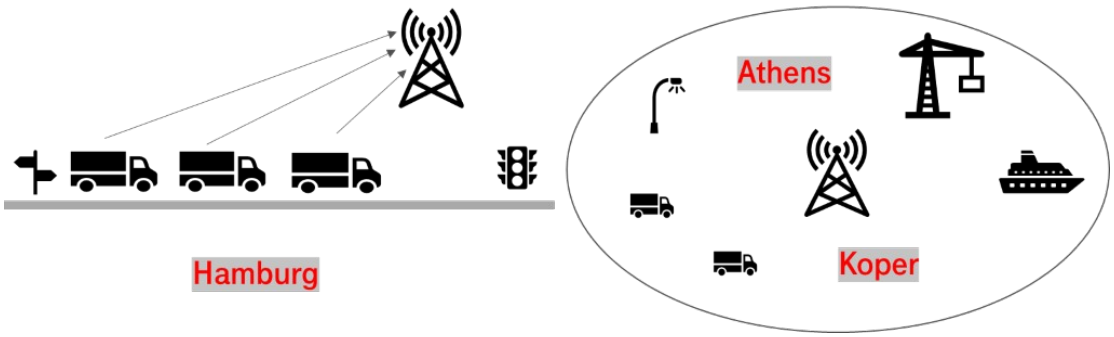


Figure 1. 5G-LOGINNOV port and hinterland use cases and cities to pilot them

The following sections provide an overview of the three LLs and the related use cases that will be demonstrated in the context of 5G-LOGINNOV.

### Hamburg Living Lab

The Port of Hamburg is ranked third in Europe, with 9,3 million TEU in 2019. The port is located on the Elbe river that gives accessibility to the North Sea by navigating 70 miles. In the port, there is an excellent rail network that connects the terminals to the hinterland, thus allowing for inter- and multimodal transport and logistics.

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 e.g. transfer of containers from depot to terminal, to customs inspections, etc. Repositioning of containers by a typical Logistics Service Provider (LSP) requires up to 100 truck rides per day inside the port and along public roads. Furthermore, it implies that trucks have to wait at terminals due to traffic, they have to book (limited) available time slots at terminals and there should be an alignment between the intermodal operator and the various terminals. Repositioning shows the sensitivity of connecting the inner-port area with the out-of-port area, especially when public roads have to manage passenger vehicles, vulnerable pedestrians and heavy-duty trucks for just-in-time delivery to the vessel waiting for the container. For any city port such as Hamburg, the deployment of C-ITS and automated driving are ideal innovation strategies to increase the capacity of the limited road network.

The Hamburg LL will demonstrate the Floating Truck & Emission Data (FTED) which will make available emissions data in the cloud for monitoring purposes, where emissions are calculated based on vehicles/trucks data (LCMM methodology[1]). Furthermore, the Hamburg Living Lab will integrate the EnTruck[2] data and will provide 5G communication, which will automate the analysis and quantification of micro-scale dynamics according to the context (vehicle, load, driver, infrastructure, TMS situation, etc.). 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 and go of the truck platoon.

Moreover, the Green Light Optimal Speed Advisory (GLOSA) will help 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 (ATP) based on 5G technology. Vehicles/trucks will be provided with information on current and predicted traffic lights signal to allow optimizing route planning of automated vehicle manoeuvring across intersections, thus saving energy and emissions. More specifically, it will be possible to determine the optimal speed towards the next intersection, thus avoiding unnecessary energy consuming manoeuvres and reducing pollutants to a considerable degree. Currently, a total number of 26 traffic lights equipped with ITS G5 for traffic management is currently available for test runs. The test field is located in the city centre close to the ferry boat terminals.

Finally, the Dynamic Control Loop for Environment Sensitive Traffic Management Actions (DCET) will provide traffic management strategies based on information available in the previous use cases (i.e. emissions data, traffic lights information, etc.) to control traffic by, for instance, changing traffic light framework programs, set speed limits advice or provide instructions or giving directives to vehicles. For the latter use case, data from vehicles and traffic light status/predictions are based on real data linkage, while traffic management measures are demonstrated as a concept.

## Athens Living Lab

The port of Piraeus is ranked fourth European port with 5.7M TEUs in terms of container throughput as of 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. The port is managed by Piraeus Container Terminal (PCT S.A.), wholly owned by COSCO Shipping Ports Limited. Quay side length is already fully utilized making the addition of quay cranes practically impossible. Moreover, more than 170 yard trucks are operational at the port premises, in addition to external (incoming) trucks, imposing significant revenue opportunities, but also challenging several port operations that affect various work chains in Piraeus.

Several key aspects in day-to-day port operations will be addressed through the developed 5G-LOGINNOV use cases in Athens Living Lab, mainly focusing on port automation and logistics, environmental impact, as well as human safety, realized through 5G technology. Particularly, at PCT terminal, 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

1 The LCMM (Low Carbon Mobility Management) methodology was developed and piloted in the last decade by T-Systems, together with several LSPs in Europe and China.

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

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. Real-time traffic 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 to expedite and optimize the workflow of yard truck daily operations.

Additionally, a key concern at Piraeus port 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 tool (based on insights from the COREALIS[3] 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.

Finally, novel 5G-IoT devices will be designed tailored to the LL requirements, enabling far-edge computing services at the port premises targeting applications in port control, logistics and remote automation as well as personnel safety at high risk areas. Particularly following the NFV-MANO (Network Functions Virtualization - MAnagement and Network Orchestration) paradigm, pioneering computer vision techniques will be developed as virtual network functions (VNFs) for the detecion of container seals and human presence in specified areas. Several 4K surveillance cameras will be deployed at selected areas of interest (addressing direct port needs) that will be utilized as data capture devices for the developed computer vision techniques hosted at the 5G-IoT devices, as well as for providing a real-time video stream to the central operations monitoring platform of PCT, utilizing the eMBB services and low latency transmissions of 5G technology.

## Luka Koper Living Lab

The Port of Koper is located in the Northern part of the Adriatic Sea. In 2018, the container throughput was 988.499 TEUs[4]. With the extension of Pier I the Port's annual capacity will rise to 1.3M TEUs. The core business of the port comprises the transshipment and warehousing of a variety of goods and a range of complementary services, providing customers with comprehensive logistics support. Transshipment 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. The Koper Living Lab is directly linked to the Port of Koper and its logistic and security services, which is operated by Luka Koper Company.

The main applications that will be supported in the 5G-LOGINNOV are based on Industry 4.0 scenarios and include use cases (UC) related to port control, logistics and remote automation. The Koper Living Lab (LL) 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 the needs of port environment. 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 and low-latency requirements, commercial Mobile Network Operator (MNO) infrastructure will be extended with Multi-access Edge Computing (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, 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 mobile network in Koper LL.

Furthermore, to automate container logistic services operating port machinery (STS crane) will be equipped with industrial cameras for capturing and transfer of Ultra-High Definition (UHD) streams over the 5G network to the cloud-based video analytics system for identification of container markers and detection of structural damage of containers using advanced AI/ML based video processing techniques. Each targeted STC crane will have up to 5 cameras installed, so 5 different

3 COREALIS is a H2020 project that proposes a strategic, innovative framework, supported by disruptive technologies, including IoT, data analytics, next generation traffic management and 5G,for modern ports to handle future capacity, traffic, efficiency and environmental challenges.

4 https://ec.europa.eu/inea/sites/inea/files/cefpub/12_-_panel_2-5_richter.pdf

angled images from each container will be received and analysed in real-time. In addition, the transfer of remotely collected information will be enabled and made available to other port operations systems.
Secondly, telemetry data will be remotely collected from the port vehicles (e.g. terminal tractors). This information will be assured from the vehicle CAN-Bus, using the 5G-enabled IoT Device, and transmitted via the 5G network, to the port operation support system. Typical data to be collected include vehicle position, battery level, fuel level and consumption, oil level and tire pressure and will assure optimization of the terminal vehicle usage inside the port.
Finally, a real-time video surveillance will be implemented using 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 will be used to monitor specific port area (e.g. railway entrance) for the specific security services, and automated and coordinated drone-based surveillance will be implemented for extended ad-hoc video surveillance support. 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.

## 5G-LOGINNOV contribution to the European Commission policy

In a fragmented and collaborative ecosystem like logistics, data is a key element that can be used to increase efficiency in the shipping process.
Digitalisation and data is at the heart of this transformation, notably thanks to the mobile & IoT &5G revolutions that enable to connect people and things with business. EU business and SMEs are using or sharing data to develop new services or applications to maintain their leadership and competitiveness. The high fragmentation of the supply chain and the fact that a wide range of SMEs participate in it, turn the lack of interoperability into a main barrier that makes the connection of companies and their services difficult, resulting in the lock-in effect and the increasing the cost for enterprises.
5G-LOGINNOV project considers that Digital Transformation is a key business driver aims to contribute also to a common understanding and common solutions for data sharing in supply and logistics that are a basis for innovation and cost reduction, and contribute to societal challenges like safety, security, and sustainability.DTLF[5] expert group of the European Commission establishes the objetive of using data sharing as a commodity, based on the following principles: Plug and Play, Technology independent infrastructure services and Trusted, safe and secure solutions. 5GLOGINNOV Living Labs will implement these principles and further will contribute to the European Digital Transformation process.

## Conclusion

The three Living Labs of the 5G-LOGINNOV project aims to demonstrate a set of use cases that are implemented thanks to the introduction of novel 5G systems and supportive technologies. Most importantly, the 5G will enable a set of real time services such as the optimal allocation of vehicles to container jobs or the management of vehicles and driving behaviour outside the port that require precise positioning of the vehicles, the exchange of UHD video for image recognition of people in dangerous areas of the port, the implementation of industrial IoT services and of truck platoons. All these innovations are expected to bring several advantages to the ports such as reduction of pollutant emissions, optimization of port operations, costs reduction. There are considerable differences among the 5G-LOGINNOV Living Labs in terms of dimension and areas where the demonstrations will be executed. The Port of Hamburg and of Piraeus are two large transshipment ports, while the port of Koper is medium sized located on the Adriatic Sea and connects the markets of Central and South of Europe. And finally, difference from the operational perspective relies on the fact that use case deployment and demonstrations in Piraeus and Koper deal with the inner port services, while in Hamburg the main focus is the area connecting the city to the port.

5 Digital Transport and Logistics Forum (DTLF): A group of experts in transport and logistics. DTLF was established by DG MOVE and supports the EU strategy for an internal market for transport (www.dtlf.eu).