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The role of 5G and companion technologies in the domain of port logistics: the 5G-LOGINNOV project

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"A mia madre,
le cui notti insonni,
i pianti,
le ansie,
le angosce,
le apprensioni,
hanno reso possibile questo viaggio.
Grazie."

"E a mio padre,
ca senò ci lu sente.
Grazie."

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
5G	5th Generation (of broadband cellular networks)
5G-LOGINNOV	5G creating opportunities for LOGistics supply chain INNOVation
5G-NR	5G New Radio
5G-PPP	5G Infrastructure Public Private Partnership
ACC	Automatic Cruise Control
ADAS	Advanced Driver Assistence System
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
ATP	Automated Truck Platooning
CAD	Connected and Automated Driving
CAM	Connected and Automated Mobility
CCAM	Cooperative and Connected Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
COREALIS	Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era
DCET	Dynamic Control Loop for Environment Sensitive Traffic Management Actions
DTLF	Digital Transport Logistic Forum
eMBB	Enhanced Mobile Broadband
ERTICO	European Road Transport Telematics Implementation Co-ordination Organisation
ETP	*European Technology Platform*
FCD	Floating Car Data
FMEA	Failure Mode And Effect Analysis
FTED	Floating Truck & Emission Data
GLOSA	Green Light Optimized Speed Advisory Systems
IoT	Internet Of Things
KPI	Key Performance Indicator
LCMM	Low Carbon Mobility Management
LL	Living Labs
LK	Luka Koper, Port and Logistic System D.D.
MANO	Management and Network Orchestration
MEC	Multi-access Edge Computing
mMTC	Massive Machine Type Communication
MNO	Mobile Network Operator
NFV	Network Functions Virtualization
SCADA	Supervisory Control And Data Acquisition
SME	Small Medium Enterprise
TEN-T	Trans-European Transport Network
uRLLC	Ultra-Teliable Low Latency Communication
WP	Work Package

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Overview

The importance of Short Sea Shipping (SSS), also in connection to River Sea Shipping (RSS), will increase in the next years. One significant aspect in this context is the decrease of terrestrial transport services (road and rail) in contrast to increasing services in the maritime transport sector, especially considering the relief off the road and railway infrastructure. Looking at the present situation, SSS and RSS are already used in many different transport fields all around the world. However, there exists still a great potential which currently is not used or not sufficiently exploited for many different reasons. The focus on the positive effects of maritime transport has to be considered not only economically but also ecologically; the implementation of such projects implies the creation of an appropriate legal framework and a necessary transport infrastructure which enables a definition of cross-border corridors. This is the fundamental basis for the development of network structures which will be built of different transport means including logistic facilities.

The 5G-LOGINNOV vision is to path the way towards efficient freight and traffic operations at ports and logistics hubs; these objectives will be achieved by using new innovative concepts, applications and devices supported by the disruptive 5G technologies (Internet of Things, data analytics, next generation traffic management, CCAM 5G logistics corridor).
The project contributes to the emergence of global standards and globally harmonized frequency bands for 5G in the context of related developments at the level of global bodies like 3GPP, ITU and 5G standards (Rel. 16/17). It has a strong interest in the emergence of new market players, such as SMEs and start-ups, taking advantage of the growing adoption of distributed cloud computing technologies in 5G networks and making possible open innovation at service level in the logistics and Industry 4.0 sectors.
5G-LOGINNOV will use 5G technologies to expedite and optimize the Pan-European transport and logistics federative network by establishing the premier European logistics digital nodes as part of the future Physical Internet serving the European logistics community of shippers, logistics service providers, mobility infrastructure providers, cities, and authorities.

5G-LOGINNOV's first aim is to build a first-class European industrial supply side for 5G core technologies and new IoT-5G devices (e.g. slicing, eMBB, uRLLC, mMTC, MEC, 5G-NR) with global market footprints: use cases will be deployed in three Living Labs (Athens, Luka Koper, Hamburg) and will test and evaluate 5G-enabled services during the project, resulting in a strong impact in the logistics industry; the technological significance, as well as the business impact and market penetration of the 5G-LOGINNOV results and developed solutions, will be guaranteed by the participation of port operator (PCT, Hamburg, Luka Koper), major telecom industry stakeholders (MNOs, vendors, technology integrators) and the 5G-LOGINNOV consortium.

5G-LOGINNOV will be able to ensure Supply Chain tractability and anticipatory advancements in the Physical Internet roadmap Towards Zero Emissions Logistics 2050, including Supply Chain synchronization and 5G "intelligent" approaches to the management, routing and optimization in ports area.
The project will also utilize a secure information sharing infrastructure from previous projects and will reuse existing components and libraries to ensure the best use of existing 5G infrastructural options in order to minimize development, integration and training costs for the future 5G-LOGINNOV users.
The project will involve the active participation of different local 5G stakeholders, aiming to achieve[1]:

- 10% higher load factors with best modes combination routed via CO2 reducing transportation (potential >15% reduction) measured through the increased use of more efficient means of transport (10% improved reliability on synchro-modality linked to Service Level Agreements (SLAs));
- Commitment to reducing CO2 emissions, congestion and air pollution in order to improve the quality of life of European citizens and to reach the goals set by the Paris Agreement and the European Green Deal (December 2019).

Background

The 5G Action Plan for Europe (5GAP), adopted by the European Commission in September 2016, calls for actions to achieve uninterrupted 5G coverage in all urban areas and along all main transport paths across Europe by 2025. It is expected that the 5G infrastructure will be a key enabler for the development of connected and automated mobility (CAM), providing a broad range of digital services to the vehicle and paving the way to fully autonomous driving by the end of the decade on specific sections of roads equipped with 5G. It is also expected that 5G infrastructure will provide Gigabit connectivity to trains and support the digitalization of rail operations and inland waterways.

The Commission has underlined in its strategy on the mobility of the future the specific contribution of 5G-enabled CAM in:

- enhancing road safety,
- optimizing road traffic and
- reducing CO2 emissions and traffic congestion,

and thereby to a more sustainable infrastructure and climate action in Europe, in line with the Green Deal of December 2019. In its Communication of February 2020 on "Shaping

[1] Source: 20201014_5G-LOGINNOV_Project

Europe's Digital Future", the Commission underlines this objective for the deployment of 5G highway corridors and 5G rail corridors during the period 2021-2027.

To date, a total of 12 5G cross-border corridors (TEN-T corridors) have been agreed among neighboring states and regions across Europe in view of hosting projects funded with the support of European and national funding resources in the fields of R&I (Horizon 2020) and deployment (Connecting Europe Facility).

In order to briefly present some of the main objectives of the 5G-LOGINNOV project, reference can be made to Table1, which in particular refers to the objectives relating to the port of Athens[2].

Objective	Measurable Objectives & indicators	Validation/Measurable outcomes
#O1	**Minimize percentage of yard equipment asset idling for more than one shift**	**Development and deployment of optimal yard truck selection service (UC3)**, predictive maintenance service (UC7, 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 utilization of the port warehouse and storage spaces by at least 15%	Development and deployment of predictive maintenance service of UC7
#O1	**Optimize 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.
#O4	**Extrapolation of the potential CO2/Nox 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 yard trucks services of UC3** and device management platform ecosystem service of UC2 at Athes LL

[2] This image comes from a table on the site "https://cordis.europa.eu/project/id/957400/results", document "5G-enabled logistics use cases". It should be noted that these statements have been transcribed from the table and those closest to the following discussion have been highlighted in bold. This summary table has been placed here only as an example; for the corresponding images relating to the ports of Hamburg and Luka Koper, we can directly refer to pages 35 and 38

#O5	**Attract at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in %G, 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 a TRL 2-3 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** The target value of (at least) 10 applicants is set at project level; there is no predefined scheme for the deployment of selected (5) applicants 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**	**Development and deployment of 5G connected** **trucks and services (as mobile 5G-IoT devices)**
#O7	Novel surveillance technologies and mechanism (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 Conferences, 5G, IoT conferences and international events**	**Project presentation (international, conferences). Supported by all use cases**

Table 1: Objectives of Athens Living Lab

1. Environment-Oriented Traffic Management[3]

Business Model Canvas

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relationships</th><th>Customer Segment</th></tr>
<tr>
<td>• European Commission CCAM
• 5G-LOGINNOV Consortium and Open Call winners
• Public authorities
• Network and telco operators
• Transport operators
• ALICE
• Complementary research projects</td>
<td>• Implementation of Smart Port solutions:
- Automated truck platooning and dyamic control loop
- Floating truck and emissions data (FTED)
• Real-time analysis of maneuvers
• Increase of precision for the parameters of the applied energy equation used by LCMM and Entruck
• Measurement of KPI's of environment-sensitive traffic management actions
• Development of a modular solution (i.e. adaptation to each port needs)

Key resources
• Infrastructures and technologies hardware and software (e.g. telematics and telemetry sets, Entruck on boards unit, eMBB, mMTC and uRLLC capabilities with 5G network slicing support; LCMM, D-GPS and MEC)
• Financial Resources
• Data (Traffic Monitoring Data and FTED collected By LCMM)
• Traffic management algorithms
• Intellectual resources</td>
<td>• Port gates and surrounding areas congestion reduction
• Pan European transport and logistic network optimization
• Port total environmental footprint reduction
• Low Carbon Mobility Monitoring
• GLOSA</td>
<td>• Stakeholder driven approach
• Open call
• Exploitation and Dissemination
• Collaborative Innovation Days

Channels
• Living Labs testbeds and use cases
• Exploitation and Disssemination (e.g. conferences, workshops, collaborative innovation days, hackathons)</td>
<td>• Port Authority
• Terminal Operators
• Transport Operators
• Public Authority (regional authority)
• Local industries and associations
• Traffic management authorities</td>
</tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
<tr><td colspan="3">• Development costs (e.g. hardware and software costs)
• Maintenance costs</td><td colspan="2">• Usage and Licensing fees
• Reduction of social costs</td></tr>
</table>

Table 2: BMC - Environment-Oriented Traffic Management

[3] Since the two topics are basically two sides of the same coin, some of the 9 sections ("Customer Relationship" "Channels", "Customer Segment", "Key Partners", "Cost Structure" "and "Revenue Streams") into which the scheme used for the analysis (Business Model Canvas) is divided will be effectively shared; therefore, having already been presented during the exhibition of the first BMC, they will not be repeated

1.1. Value Proposition

While respecting circular economy principles, being of service to the urban environment and financially viable, 5G-LOGINNOV develops and validates solutions that will increase efficiency and optimize land-use. Through this project, the ports will make a huge attempt to minimize their environmental footprint for the city while attempting to reduce the disturbance to the local population by significantly reducing congestion around the port.

The project foresees the birth of different solutions, which, first discussed on paper, will later be implemented and validated in three Living Labs, in the ports or in the neighboring urban areas of Athens (Greece), Hamburg (Germany) and Koper (Slovenia); the main challenges to be faced will be:

- first of all to understand how much and how such solutions can be integrated in the so-called era of mega ships;
- solving the most pressing problems for medium-sized ports with limited investment funds for 5G infrastructure and automation.

The Hamburg Living Lab operates in the hinterland area, while the activities of the Living Labs in Athens and Koper focus on the current port areas.

A port area must also invest in technological and social innovations, new business models, changes to mentality, reflecting the high goals of 5G-LOGINNOV; these changes are necessary in order to achieve capacity and efficiency objectives, reduce its environmental impact and establish a truly integral and bidirectional relationship with the urban space that surrounds it.

The value proposition of 5G-LOGINNOV project related to “Environment-Oriented Traffic Management” is structured as follows:

- Port gates and surrounding areas congestion reduction
- Pan-European transport and logistic network optimization
- Port total environment footprint reduction
- Low Carbon Mobility Monitoring
- GLOSA

Congestion Reduction

To date, there are only a few examples of use cases: in fact, 5G is not so widespread today as to allow its global use. However, it should be emphasized that 5G is not one of the alternatives that can be used to make the most of the innovations brought by the project: although today, in some tests, there are some use cases, 5G is essential to go beyond these cases of use, allowing a certain scalability of the project, and therefore to extend the same in an entire

country or region; furthermore, this is critical for widespread adoption as logistics companies don't want solutions to fail when their vehicles are in congested areas.
Real-time routing and optimization will increase the productivity of road freight in two ways:

1. Decrease in distance traveled: by constantly updating the route and schedule in real time to ensure is the most efficient, the total distance traveled by each vehicle would decrease by an estimate 5% on average.
2. Reduced waiting times: by improving the visibility of the supply chain, travel and arrival times can be better planned to ensure that goods are moved just when they are needed, reducing waiting times (for example, if the arrival time of a truck in a warehouse is known precisely, the necessary Stocks can be prepared in advance so they can be loaded immediately once the truck arrives, most importantly important for chilled broth that can't be left around).

Pan-European logistic optimization

The 5G Infrastructure Public Private Partnership (5G PPP) is a joint initiative between the European Commission and European ICT industry (ICT manufacturers, telecommunications operators, service providers, SMEs and researcher Institutions). The challenge for the 5G Public Private Partnership (5G PPP) is to secure Europe's leadership in the particular areas where Europe is strong or where there is potential for creating new markets such as smart cities, e-health, intelligent transport, education or entertainment & media. The 5G PPP initiative will reinforce the European industry to successfully compete on global markets and open new innovation opportunities.

The 5G-LOGINNOV project will be part of the third phase of the 5G-ppp, which implies supporting the development of a "core" market involving cooperation models with key vertical sectors contributing to the broader policy objectives of the digitalization of industry in the digital single market.
Through the main innovations of the key 5G-LOGINNOV technologies present within the three Living Labs, the first significant time savings and cost reductions, greater and faster acquisition of knowledge, full exploitation of the available network capacity will begin to be noticed. Consolidated operations will result in fewer freight trips and fewer vehicle kilometers.
Furthermore, the improved efficiency of operations that 5G-LOGINNOV will allow will result in a net increase in the quality of the delivery service, as well as safer working conditions for staff and greater safety for transport.

Port total environment footprint reduction

The European Union has adopted a highly ambitious plan for decarbonizing the entire EU block by 2050 (Green Deal).

A significant part of this work will address emissions of greenhouse gases from transport needing to be reduced by 90% by 2050. The main related measures for freight transport consists of giving multimodal transport a strong boost by shifting substantial part of the 75% of freight movements carried by road today to railways and inland waterways.

The 5G-LOGINNOV project fits strongly in favor of the European Green Deal, thanks to some of its main objectives: aiming at greater efficiency of port operations in the ports of Athens (Piraeus), Hamburg and Koper (of which only a brief mention, being the subject of a further thesis mainly focused on "Operational Efficiency" and "Maintenance") and their links with road transport, supporting the multimodal transition from road to inland and maritime waterways.
Each of these ports is also a multimodal hub, thus also improving links with rail transport. In addition, the project supports other Green Deal transport decarbonization measures, such as the implementation of automated and connected multimodal mobility through intelligent traffic management.
5G-LOGINNOV Living Labs are targeting significant cost savings and environmental alleviation to be achieved in terms of CO2 and NOx mitigation. Besides, fewer freight trips imply less energy needs and reduced total fuel consumption.
Let's take for a moment an example given to us by the port of Hamburg, trying to understand the benefits that could be brought by in: given an average number of 8000 trucks driving 40,000 times within the inner circle of the Hamburg port area per day with an estimated fuel consumption of 20 liters per 100 km and a 30% saving by implementing 5G-LOGINNOV, a CO2 reduction of approximately 23 Mega-Ton of CO2 in the 10 km road network alone is considered realistic and measurable according to the recent ISO ISO IS23795-1 Ed.1 standard. By expanding the test field to 5 logistics corridors and to the 10 biggest sea ports[4], potential savings of 1 Giga-Ton CO2 in the port sector alone are possible. Additionally, there is a measurable impact by 5G truck platoons for NOx savings, already proven by connected and automated truck platoons using 3G/4G. These measurable savings can be projected to environment-oriented traffic
management strategies to comply with the Clean Air Policy of the EU and the challenges of European cities addressed by the European Court.

Low Carbon Mobility Management

For the calculation of emissions, the Living Labs (initially Hamburg) will adopt a methodology called LCMM (Low Carbon Mobility Management), which was developed and piloted in the

[4] Note that the discussion here and in the following is kept on the topic "Environment-Oriented Traffic Management", while only at a later time we will talk specifically about “5G logistic corridors”

last decade by T-Systems, together with several Logistics Service Providers (LSPs) in Europe and China.
The basic idea behind LCMM consists of reducing the large set of parameters used nowadays 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.

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[5] and analyze 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.

Green Light Optimal Speed Advisory

Green Light Optimized Speed Advisory (GLOSA) is an application where vehicles and traffic infrastructure communicate with each other in order to minimize capacity shortage across complex urban road networks.
In addition to needing a safe and targeted communication environment and strategy, GLOSA, in its interaction with ATP, must be accompanied by the automatic recognition and assessment of the impact on emissions of driving maneuvers and the relative influence of the infrastructure, as well as from TMS systems and TMS GLISA measurements. To date, in fact, driving maneuvers are classified into characteristic cases (braking, acceleration, constant speed) and linked to the characteristics of the static infrastructure (cornering, climbing,

[5] Floating car data (FCD) in traffic engineering and management is typically timestamped geo-localization and speed data directly collected by moving vehicles, in contrast to traditional traffic data collected at a fixed location by a stationary device or observer.

descending); at the same time, the dynamic traffic control systems (traffic lights, lane and speed indicators) are recorded / localized (and localized as specific GLOSA POIs) and the specific information / content needs available are interrogated and structured.
The variations in the behavior of the emissions are then determined, assigned and evaluated, on the basis of the variations in driving maneuvers (when the TMS / GLOSA measures, the state of the traffic situation and the knowledge of other surrounding conditions are known); all this is also evaluated on the basis of the variation of the driving profile.
Using Entruck data to calibrate the LCMM methodology, the emission trend is then determined, using real driving and consumption profiles; Thanks to this approach, the effect can be recorded for individual vehicles, using the different driving situations (phase from green light, phase from green wave to red light), and evaluated using a routine adapted from UC8 / 9.
This necessarily leads to an "extreme" consideration within the fundamental diagram: the acceleration and deceleration maneuver components are in fact close to zero in the ideal case, in favor of the constant driving component. The reflection on the real traffic conditions will be evaluated on the basis of the field data and in a specific GLOSA simulation for the development of control strategies, applied to the potential estimation and planning of possible logistic corridors.

In any case, it must be borne in mind that in this approach there are some fundamental elements for success:

- the exact positioning (at lane level) of vehicles and TMS systems,
- the exact mapping of the static conditions of the infrastructure (3D profile, curve radii of the gradient, slope)

It is in fact necessary to predict the driving resistances, traffic situation and arrival times of the platoon to the traffic control system (influencing the weather control).
Furthermore, the results and control strategies will be integrated into UC11, where these results, based on the knowledge gained from UC8 / 9, will be translated into promising approaches for dynamic traffic management to meet / optimize higher level emissions and requirements. extension of participants from the port and logistics sector, as well as with environmental and traffic management authorities in the test area.

1.2. Customers & Stakeholders

Different types of stakeholders and eventually conflicting interests may come together due to the ecosystem of a digitalized port, which is a multi-stakeholder environment.
There are two main activities related to the port:

- A physical one, stevedoring, that take place in the port area;
- An organizational one: logistics, to deliver goods.

Keeping in mind these aspects, there are a lot of customer/stakeholders that could be reached with the project, which therefore should be considered in the analysis of such BMCs.

• Local governments: ensure that the activities are carried out according to local rules, they have an interest in ensuring order and legality. For local government of the city-port is useful establish a rapport whit the port itself to improve infrastructures, data sharing and create a smart city.

• Regulators: they are institutions universally recognized that supervise and eventually sanction business activities or industries. Regulators are important but they only have the powers specified to them by government authorities; in this project is considered the International Telecommunication Union whose goal is to coordinate telecommunication operations and services throughout the world, but also the ECC (Electronic Communications Committee) and the CEPT (European Conference of Postal and Telecommunications Administrations).

• Policy makers: responsible for making new rules or laws. Policy makers provide the highest authority and must regulate relationships between all the stakeholders of the ecosystem considered. They could be national, international or European government authorities that set the limits of policies and legal aspects. Often is difficult establish right policies not knowing the new technology and its possible effects or unclear scope of application.

• Logistics/Transport companies: they have direct relationship to the port and represents trucks owner, they have the goal of transporting cargo to or from the port but also loading and unloading. They usually hire truck drivers to handle goods, but it is also possible considering railway companies.
To achieve cost and transport efficiency they need data and information from the port but also from the road infrastructure to constantly update the delivery roadmap.

• Physical port infrastructure made up of terminals, sea fairway signs and warehouse, it is the base for every port operation to serve ships, cargo or vessels and should anticipate the needs of logistics and transport sector. One of the main problems in a port is the traffic jam and quay side queues within the container terminal, which reflect also in a high risk of serious bodily injuries, especially for those who work at the quay side. The aim is owning automated handling equipment and more flexible infrastructures providing connectivity and integration of the

system and data (IoT). The port would like to reduce operational costs and optimize not only operation but also maintenance, always ensuring safety.

• Port-city residents: they represent all the people who live near a port. In everyday life people carry out various activities; they move to one part of the city to another for work or to go to school by car or public transport. Even if there is a port, residents do not want truck-congested roads or traffic jam but adequate road infrastructures that allow cars and trucks to coexist. The port should reduce noise pollution and better organize trucks movements knowing that it has a strong impact on the city and its residents.

• Road infrastructure operators: they had to ensure safe and reliable road infrastructure for travelling and transporting goods. They are national or regional entities in charge of maintenance and deployment of physical road and every country has his rules. Road infrastructure operators need to manage and operate road infrastructure to increase value for public transportations, drivers and logistic firms but also monitoring traffic pollutions and implementing performance measures.

All three Living Labs will organize at least one local stakeholder workshop and demo each to engage local and national stakeholders and present them with the operation and status of the developed systems, collecting their feedback and securing possible future cooperation and business.

1.3. Customer Relationship

Stakeholder Driven Approach

The 5G-LOGINNOV project has among its main objectives the creation of a strategic impact that supports the emergence of new markets, with new and existing players, aiming at improving the efficiency of port operations and maintenance activities of port hubs and logistics activities in logistics hubs.

The project will increase the competitiveness of the players (including SMEs and start-ups), giving the possibility to exploit new market opportunities through 5G Core Technologies applied to the operations of logistics hubs. The entry of new players is therefore one of the main channels to maximize the impact of the project.

The attempt to attract new players (addressed in WP4) is tailored to try to increase business opportunities: using the innovative start-up model, resulting therefore from the Open Call for start-ups, from their inclusion to interior of the Living Labs and subsequent development / distribution, etc., will therefore try to create new markets. The use cases are selected by logistics hubs and port operations professionals and aim to be in close contact with real needs, keeping an eye on future roadmaps for freight traffic management. Telecom professionals (T-Systems, Telecom Slovenia and Vodafone) will also ensure the suitability of integrating use cases into future 5G core networks.

5G-LOGINNOV will produce a comprehensive market analysis evaluating all market opportunities, including a correct definition of marketable products and services at TRL7 or above, with potential customers, volumes, prices, in relation to the demand side.

As we can see in the "Grant Agreement", one of the main objectives of the project [Objective5 (O5)] is "Enhancing innovation in the management and maintenance of ports and logistics hubs with the involvement of new market players including SMEs and Start-ups ".

To achieve this, the project will seek to include at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in 5G, IoT, renewable energy and circular economy to improve the port environmental footprint for pilot project, provide a startup innovation financing scheme for 5 SMEs selected in the respective city in order to design and implement at TRL2-3 level the proposed technologies.

We will see below in more detail the methods and techniques of involvement that the project will try to exploit to broaden the market horizon.

Open Call

SMEs and start-ups will participate in 5G-LOGINNOV activities and events, especially SMEs and spin-offs of research institutes, who are willing to contribute to the project's experiments with innovative ideas.

The project will create and chair a network of start-ups to be supported for addressing the development of economic opportunities of 5G-enabled next generation logistics hubs and

port operation. Furthermore, five selected start-ups[6] resulting from the Open Call will be integrated in the project for developing and deploying innovative applications, using 5G augmented capabilities and integrated in the 5G network architectures at three EU Living Labs (Athens, Koper, Hamburg).
This 5G-LOGINNOV start-ups activity will benefit the logistics community as well as the network of start-ups to assess and address the opportunities in deploying the next generation logistics operations. Last but not least the existing strong relationships between the 5G-LOGINNOV beneficiaries and 5G-PPP will rapidly bridge the potential gap of Start-Ups relating to 5G knowledge.

5G-LOGINNOV addresses the "ICT-42-2020: 5G PPP – 5G core technologies innovation" call as described as follows:

- 5G offers prospects for a range of new technologies and hardware devices to enter the market and to create economic opportunities for new and innovative market actors
- Reap the fruits of earlier R&D investments in these enabling technologies to support the emergence of new markets and new market actors in Europe.
- Decrease emissions through the green truck initiative truck platoon; an emissions database is included; circular economy is promoted, i.e. by a cost-benefit analysis for adopting renewable energy sources and implementing a micro-grid; port-city interface is enhanced by decreasing disturbance to the city, promoting innovative industries and engaging city stakeholders.
- Primarily hardware-based (e.g. phase array antenna, array processors, millimeter wave devices and subsystems, photonics based devices, baseband processor platforms, low-cost access points, new generation of 5G terminals notably for future Connected and Automated Mobility)
- Provide opportunities for innovative high-tech SMEs access to new markets through pilot validation of promising solutions
- Address integration and validation of technologies as part of an overall architecture representing a subset of 5G network functions

These operations are expected to offer opportunities for reducing costs and for positive impacts on the ecosystem.
The project will contribute to build a first-class European industrial supply side for 5G core technologies with global market footprints in the logistics sector, creating and chairing a network of start-ups to be supported for addressing the development of economic opportunities of 5G-enabled next generation logistics hubs and port operation.

Exploitation And Dissemination

[6] Unfortunately, the Open Call winners were made known with timelines that did not reconcile with the time constraints required by the delivery of this thesis.

Regarding the dissemination of results, it can be said that the dissemination strategy will be aligned with the global communication strategy.
the 5G-LOGINNOV project, aware of its potential, will implement tailor-made plans for the exploitation and dissemination of results (PEDR) to increase awareness among the scientific and research communities and to encourage the adoption by commercial enterprises of the results of the project.
Regarding the dissemination of the project, the focus will be on raising awareness of the project, ensuring the availability of exploitable results at the European level at first and later globally, establishing links with the sector actors and the relevant standardization bodies, ensuring a good scientific reputation for the project.
In order to be able to disseminate as widely and quickly as possible, innovative communication channels, networks and clustering activities will therefore be used.
A dissemination plan has also been provided (D5.2), which, initially delivered in May, has then been regularly updated during 2021 and until today; however, the delivery of this report is also foreseen ("The final dissemination report", (D5.3)), which will be presented at the end of the project.
The dissemination channels will be developed with the regular contribution of the consortium members and ensuring consistency with the specific strategies of communication, exploitation, standardization and spectrum and clustering and networking.
The project will publish scientific and technical articles in peer-reviewed logistics journals and conference proceedings that will present the project's research and results. It will therefore be possible to obtain feedback from the scientific and technical community, through presentations and scientific papers.
In full support of the green model, scientific publications will be available in open access mode: therefore the peer reviewed scientific articles resulting from the project will be shared in the "Library" section of the project website in open access mode.
Project beneficiaries will aim to ensure open green access (in some cases even "gold"), whenever possible and not limited by external rules, to all peer-reviewed publications related to project results. The author's copyright agreements will determine whether the scientific publications resulting from the project will adopt the gold or green model[7].

Demonstration events, press conferences and project events are planned throughout the duration of the project, in order to convey the results mainly to policy makers (at local, national and European level) and industry stakeholders. The three Living Labs (Athens, Hamburg, Koper) will organize at least one workshop and one demo, each to involve local and national stakeholders and introduce them to the functioning and status of the developed systems, to collect their feedback and ensure possible future cooperation. and business. The logistics of the workshops will be organized at the Living Lab level (with the support of the

[7] Scientific and technical publications will comply with the procedures governed by Article 29.1 (Obligation to disseminate results), 29.2 (Free access to scientific publications) and Article 29.3 (Free access to research data) of the grant agreement and by paragraph 8.4.2 (Dissemination of own Results) of the Consortium Agreement.

partners responsible for Communication (ERTICO) and Dissemination (CIRCLE)).
The contents of the workshops and their presentation will be curated and managed by the Living Labs; the sending of invitations will be borne by all partners (mainly focused at the Living Lab level). The partners involved will be in charge of producing useful information for reporting, according to their specific role.
The project will organize a workshop within T5.2 in conjunction with a major ITS event (eg ITS World Congress - 11-15 October 2021) to engage a wider audience and ensure greater visibility.

The coordination will be borne by CIRCLE, the logistics of the event will be designed by CIRCLE and ERTICO and managed by ERTICO, the contents will be designed by the technical managers of the project. The sending of the invitations will involve the whole project consortium.
Towards the end of the project (in the period from March 2023 to June 2023) one of the three Living Labs will host a final event to present the results of the project through live demonstrations, presentations and panels. The final event will focus on the impact and the way forward for the exploitation and sustainability of the project work.

The project's dissemination will target those for whom the project results have potential implications and benefits, including but not limited to:

1. Port operators;
2. Authorities (port authorities, city authorities, customs, coastal management organizations, etc.);
3. Industry (shippers, logistics companies, IT solution, service providers);
4. Freight forwarders;
5. Policymakers (EU R&D personnel);
6. Standardization fora (ETSI EMTEL, CENELEC, etc.);
7. Organizations, associations, technical communities and fora (European Technology Platform ALICE, Digital Transport and Logistics Forum, Council of Supply Chain Management Professionals etc.);
8. Scientific and research community.

Digital Transport & Logistic Forum
Not to be forgotten is certainly the presence of the DTLF.
The Digital Transport and Logistics Forum (DTLF) is "a group of experts that brings together stakeholders from different transport and logistics communities, from both the private and the public sector, with a view to build a common vision and road map for digital transport and logistics.."[8]; it aims to build a common vision and road map towards a federative platform in Europe, where existing data markets and platforms are interoperable and operate as one

[8] https://www.dtlf.eu/

towards enterprises and authorities. For ALICE, this is the digital backbone of the Physical Internet.
With the emergence of new business models and services, companies begin to interact in a different way, based on the principles of collaboration and sharing economy and enabled by advanced data and digital technologies.
Only through this vision can we expect to finally have the vision of a European transport system that stands as a solution of continuity. Thanks to digitalization, today there is easier cooperation between the various actors in the supply chain, better visibility and real-time management of goods flows; this leads to the reduction of administrative burdens and allows a better use of infrastructures and resources. All this in turn makes transport and logistics operations more efficient, also allowing for easier integration of the different modes of transport.
Precisely in order to support this process, the Commission has set up the Digital Transport and Logistics Forum (DTLF), whose overall objective is therefore large-scale digital interoperability and data exchange in a transport and logistics data space. shared, safe and reliable. To date it is divided into two subgroups, which constitute as many work sections:

- Subgroup1: preparation of the EU regulation proposal on electronic freight information (eFTI); it also continues to have an essential contribution to its implementation work;

- Subgroup2: building a common framework for data exchange that connects existing transport and logistics data sources and platforms easily and in a collaborative and reliable environment.

Collaborative Innovation Days
The European Research and Innovation Days is the European Commission's annual flagship event for research and innovation, as it brings together entrepreneurs, policymakers, researchers and the public to discuss and shape the future of research and innovation. innovation in Europe and beyond.

2019 marked the start of Horizon Europe, the most ambitious EU research and innovation program ever, not only for the amount of funds linked to it, but also for the number of partners involved; this start was nothing more than an opportunity to strengthen our European Research Area.
Especially since we are in a delicate and unusual situation constituted by the current COVID-19 pandemic, cooperation in research and innovation will certainly be essential to pave the way for a greener and more digital future.
The European Days of Research and Innovation represented a unique opportunity to "add

your voice to the conversation", making the population feel involved on several levels: a way to try to get to the most disparate ideas by comparing as many as possible. people as possible, the most heterogeneous from each other but all united by a certain interest in matter.

ALICE together with ERTICO organized this one-day Collaborative Innovation Day in 2019.
In order to optimize processes and synchronize them, companies and authorities operated within complex global supply and logistics networks that increasingly rely on data exchange. Data management has been a key research topic for more than a decade: is in fact a significant success factor for logistics companies today. Data platforms are important enablers to achieve continuous information sharing to build efficient end-to-end logistics operations, as well as the creation of data markets. Through data analysis, companies can optimize their supply chain and that of their customers to build interconnected logistics networks (e.g. physical Internet).

Through the Collaborative Innovation Days, experiences and knowledge on industrial and public initiatives, research and innovation projects in the field will be shared, as well as revisiting the priorities included in the ALICE roadmap on information systems for interconnected logistics and the conclusions of the Digitalization Collaborative Innovation Day in the 2017.

This topic requires collaborative innovation so that it can be addressed by users, authorities, transport and technological development perspectives to accelerate the exploitation of opportunities. After the success and results of the previous editions, the objectives of this Collaborative Innovation Day (CID) are:

- Present a review of what has been achieved by the data market and platform providers and present their future visions and plans.
- Present the business perspective by introducing the various challenges for supply and logistics companies.
- Share and discuss the results, challenges and opportunities for the industry in the short and medium term.
- Introduces the political perspective at both EU and national level of the Member States. Specifically, get an overview of the results of the DTLF and future plans.
- Provide an overview of projects and initiatives (publicly funded).
- Discuss and agree on next steps and further research and innovation needs, as well as topics already sufficiently addressed.

Research and Innovation Days 2021

Through the event lasting just two days, it became clear that there is a large and multilevel potential, which could make the EU the world leader in innovation.

This year's edition of the main flagship event could be considered a sure success having attracted more than 21,000 registered attendees from 105 countries.

The two-day event consisted of 70 sessions and workshops, which resulted in 230 appointments with project managers for consultations.

Since research and innovation embrace and connect many distant fields of human life, the implications of this event, also given the numbers achieved, can only be numerous.

1.4. Channels & Exploitation

As also described within the Dissemination Plan (D5.2), the project will leverage a variety of channels / activities to inform and engage with target dissemination groups; among these, will be included:

- **Conferences and external events:** the project will be presented by means of technical papers and presentations at relevant conferences, events and meetings on ICT, ITS, policy and transport and logistics for the duration of the project (including TOC Europe, fair Transport & Logistics, SITL Europe, ITS World and European Congresses, TRB annual meeting, related IEEE events, CSCMP's Annual Global Conference, EMEA Supply Chain & Logistics Summit & Expo, Transport Research Arena, ETP-ALICE and European Freight and Logistics Leaders events Forum). Participation in other targeted events on topics related to 5G and next generation communication technologies, such as EuCNC, will be coordinated with 5G-PPP. In addition, special interest sessions and demonstrations will be organized during these conferences in order not only to present the progress the project is facing, but also to gather important feedback from the public;
- **Workshops & Hackathons**;
- **5G-LOGINNOV events:** all three Living Labs will organize at least one workshop and one demo, in order to involve local and national stakeholders and present them with the functioning and status of the systems developed, collect their feedback and ensure a possible future cooperation and business activity. Towards the end of the project, one of the three Living Labs will host a final event to present the results of the project through live demonstrations, presentations and panels. The final event will focus on the impact and the way forward for the exploitation and sustainability of the project work;
- **Collaborative Innovation Days** (see above);
- **DTLF** (see above);
- **Networking and clustering events**: The project will look at organizing an event with the ALICE platform (in the framework of the Collaborative Information Days) focused on 5G-based innovative services in logistics (specifically dedicated to SMEs and Start-ups). 5G-LOGINNOV will collaborate with sister projects in organizing and participating in joint webinars and workshops;
- **Online presence, Website, Social media**
- **Featured articles, External media**

AUDIENCE	GENERAL MESSAGE
Port Operators	The project will improve the performance of the port operations
Port Authorities	It will make ports a central hub for state-of-the-art logistics management while creating new business opportunities for all
Other Authorities	The projects will have environmental and technological benefits which will impact ports and cities positively
Industry [9]	The project will optimise freight and traffic operations at ports and logistics hubs by using new innovative concepts, applications and devices supported by 5G technologies, IoT, data analytics, next generation traffic management, CCAM and the 5G logistics corridor. These operations will ensure port areas and city-ports can handle upcoming and future capacity, cope with traffic congestion, environmental challenges while developing economic and innovative business opportunities for the region
Policy Makers	The project will produce recommendations to drive effective implementation of new innovative concepts, applications and devices supported by 5G technologies, IoT, data analytics, next generation traffic management, CCAM and the 5G logistics corridor which will optimise freight and traffic operations at ports and logistics hubs
Standard setting bodies	The innovations and technologies produced by this project will contribute to the development of new 5G standards
Scientific and Research Community	The project will work to advance Artificial Intelligence, IoT, data analytics and 5G technologies
Networking Bodies	The project will produce recommendations to drive effective implementation of new innovative concepts, applications and devices supported by 5G technologies, IoT, data analytics, next generation traffic management, CCAM and the 5G logistics corridor which will optimise freight and traffic operations at ports and logistics hubs
General Public	Generate business opportunities, define new business models and a 5G edge infrastructure whilst ensuring data privacy, security and ownership
Research, Development and Innovati	Synergies between projects will be highlighted and conveyed

Table 3: 5G-LOGINNOV General messages

	Project Website	Social media	Project Video	Non scientific articles	Newsletters	Project roll up poster	Project Factsheet	Project Brochure	Technical leaflets
Port Operators	x	x	x	x	x	x	x	x	x
Port Authorities	x	x	x	x	x	x	x	x	x
Other Authorities	x	x	x	x	x	x	x	x	x
Industry	x	x	x	x	x	x	x	x	x
Policy makers	x	x	x	x	x	x	x	x	x
Standard setting bodies	x		x		x		x	x	x
Scientific and research community	x				x		x	x	x
Networking bodies	x	x	x	x	x	x	x	x	x
General Public	x	x	x	x		x	x	x	x
Research, Development and Innovation projects	x	x	x	x	x	x	x	x	x

Table 4: Target groups and communication tools/channels

[9] Source: D5.1 – Communication Channels and Plan

1.4.1. Athens Living Lab

The Athens Living Lab at Piraeus Container Terminal (PCT) will develop a set of use cases and platforms that communicate over the deployed 5G network with different types of end devices.

It includes:

- Communication with external trucks around the port (UC2: Device Management Platform Ecosystem)
- Yard trucks dedicated to port operations (UC3: Optimal selection of yard trucks, UC7: Predictive Maintenance)
- Novel 5G-IoT devices (UC4: Optimal surveillance cameras and video analytics, UC5: Automation for ports: port control, logistics and remote automation).

Figure 6 depicts the relation between the Athens Living Lab use cases (and components) with the other tasks of the project.

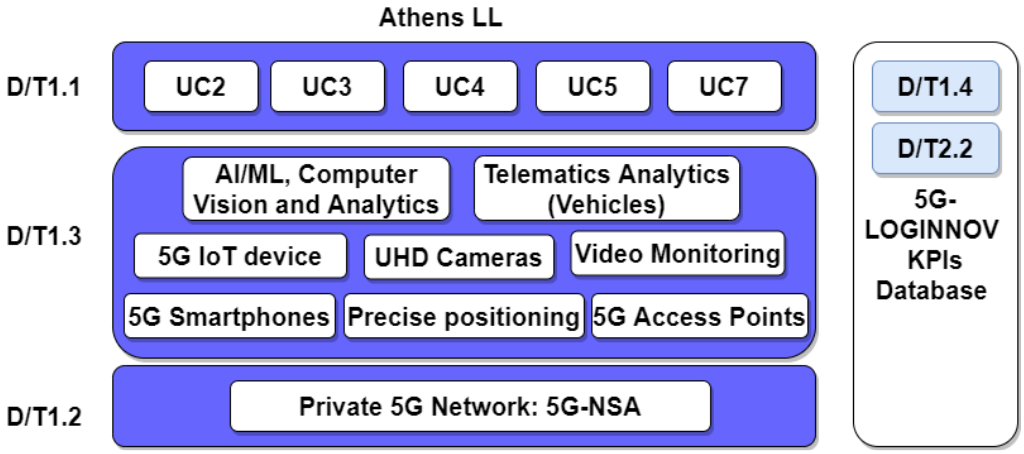

Figure 1: Hardware and Use Case Components for Athens Living Lab

Using 5G and more generally the logistics sector, the 5G-LOGINNOV project will address several key aspects of PCT's daily port operations. To date, the local fleet (approximately 170 trucks operating per day), in addition to incoming external trucks, imposes significant challenges in port operations which in turn affect various work chains in Piraeus. Efficiently managing and coordinating the movement of yard trucks within the port is vital, as most operations rely heavily on internal yard trucks to move containers horizontally between stacking areas and areas, loading / unloading systems for ships and railways.

Unfortunately, current network implementations and location services lack several key elements to optimally allocate container jobs to yard trucks (given the availability pool), where the trucks selected are often not the closest to the container. This suboptimal selection leads to longer (unnecessary) travel times for trucks, increased fuel consumption (and related CO2 and NOx emissions) and road accidents, which have a direct impact on productivity and

operating costs (for example in the life cycle of tires, costing more than 4 M€ in Piraeus, currently). Advanced location services and low-latency transmissions will be the key elements for the optimal allocation of container jobs to 5G-connected construction trucks, realized through the intended use cases that will be implemented through 5G-LOGINNOV.

Edge computing is a pioneering technology that enables the evolution towards 5G architectures and beyond, designed to bring applications and data closer to devices and their users (addressing different vertical markets), in order to overcome the inherent problems of the traditional cloud. such as high latency and lack of security. 5G-LOGINNOV in the Athens Living Lab will leverage far-edge computing to address two critical use cases:

- Use Case 4 (UC4) concerns the safety of employees and other personnel inside the PCT premises. Due to the frequent accidents involving collisions between booms, gantry or stacks, together with the presence of stowage personnel in the area, the risk of serious personal injury is far from negligible.
  A state-of-the-art (low latency) IT approach, integrated into a pioneering 5G-IoT device, will be adopted to discourage human presence in forbidden areas, based for example on innovative machine learning techniques. The realization of this use case will minimize the risk of serious personal injury by activating alerts to the responsible personnel and / or voluminous video streams (when necessary) from the 4K cameras associated with the MANO platform that will be developed in 5G-LOGINNOV.
- Use Case 5 (UC5) instead aims at the remote automation of port operations and logistic support, focusing on the detection of the presence / absence of container seals; to date this operation is carried out by an employee in charge, bringing with him safety problems, non-optimal use of human resources, equipment and port operations on site, as well as an increase in manual effort (e.g. manual updating of the database, etc.) . This use case involves using a similar state of the art (5G-IoT) processing device operating on port machinery (such as elevators, forklifts, terminal tractors, etc.), using a 4K video stream (and such e.g. computer vision techniques), to automate and manage end-to-end the life cycle of the container seal detection service. The 5G broadcasts will transmit the model inference to the MANO platform aimed at the logistics sector and Industry 4.0 scenarios.

To conclude, one of the main concerns of Athens LL is the storage and handling of bulky goods, such as spare parts / repairs. In fact, given the condition in which PCT operates (often close to the maximum annual capacity of the port itself), they occupy a significant area of the port. 5G-LOGINNOV will implement a predictive (algorithmic) maintenance tool (based on the insights of the COREALIS project) to analyze telemetry data (e.g. possible failures), in order to reduce downtime for repairs and optimize the stock of spare parts, increase the life of construction

vehicles and optimize operational efficiency through the minimization of breakdowns (as identified by the COREALIS project).[10]

Overall, 5G-LOGINNOV at Athens LL will optimize port operations through a diverse set of use cases, including the optimal assignment of container jobs based on localization (and other) data of internal trucks, predictive maintenance of yard equipment, improvement of personnel safety through analytics of 4K video streams 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.

One of the most important milestones brought by this project is that, thank to the modular solutions adopted, the results obtained can be replicated on any sea or land terminal, as well as container depots that base their business on heavy moving trucks and cranes.

Among the expected benefits for the port of Piraeus, we could see:

- Reduction of traffic congestion;
- 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.

[10] Note that these innovations (e.g., Predictive Maintenance) are only hinted at as they are not part of the two BMCs defined by this thesis

1.4.2. Hamburg Living Lab

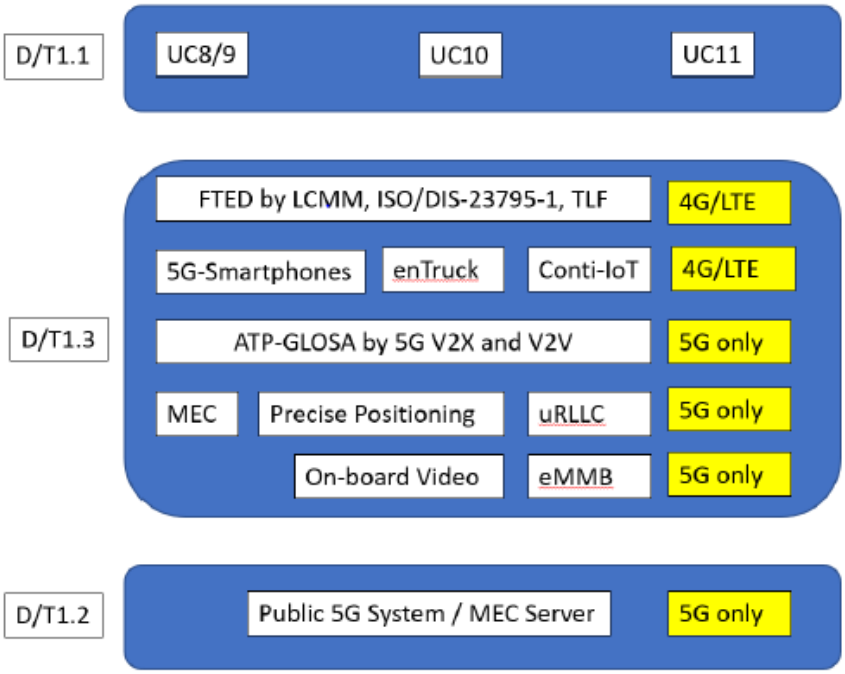

Figure 2: Hardware and Use Case Components for Hamburg Living Lab

Climate change poses enormous challenges for everyone, especially the transport sector, which is responsible for 20% of greenhouse gas emissions in Germany alone. Logistics could significantly impact the numbers related to these emissions, but tools are needed to monitor the carbon footprint at the corporate and travel level to reduce emissions at the operational level. To this end, the cause and effect of the carbon footprint occurring during a trip are very important and the reliability of measurement tools is a must for improving and reducing the carbon footprint.

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

	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 corridors avoiding stop e go incident of the truck platoon Facilitate the quantification of port decision impact for mid/long-term through Key Performance Indicators (KPIs): investments, stakeholder satisfaction, accessibility, modal split, CO2 emissions, air quality, green energy, market share, employment, ..	5G-LOGINNOV Floating Truck & Emission Data. Measured fuel savings of all participants off the truck platoon or trucks alone while driving with 5G GLOSA (LCMM/Entruck detect fuel proportional to CO2/Nox) Family of use cases: 8-9
#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 CO2/Nox savings based on the real traffic volume to the port terminals; Reduce emissions produced by trucks delivering/pickig 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 5: Objectives of The Hamburg Living Lab

1.4.3. Koper Living Lab

Koper Living Lab targets implementation of novel 5G technologies such as MANO-based services and network orchestration, Industrial IoT, AI/ML based video analytics, drone-based security monitoring and cutting-edge prototypes tailored to be operated in European port environments. Use cases (UC 1 - Management and Network Orchestration platform (MANO), UC 5 - Automation for Ports: Port Control, Logistics and Remote Automation and UC 6 - Mission Critical Communications in Ports) that will be supported are primarily targeting Industry 4.0 scenarios and include activities related to port control, logistics and remote automation. More specifically, the following 5G-enabled logistics support activities will be implemented and verified at the port area:

- Operating port STS (Ship to Shore) cranes will be equipped with industrial cameras connected to 5G network for capturing and transfer of UHD streams to cloud-based analytics for identification of container markers and detection of possible structural damage of containers using advanced video analytics based on AI/ML techniques.
- Port equipment monitoring and remote telemetry 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.
- Drone-based and portable night vision cameras connected to 5G network will be used to support real-time video surveillance and other security related port activities.
- Finally, a resilient 5G-based network scenarios over public and private 5G infrastructure will be implemented to provide alternative 5G-enabled network capabilities to the established operational WLAN network.

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 implementation of the 5G mobile network in the port of Koper will be based on the availability of commercial 5G products, in particular those related to the support of the eMBB and mMTC functionalities. The implementation plan already takes this into account and the use of products and components already commercially available or announced is envisaged. However, in the event of delays in the commercial rollout by 5G suppliers and consequent unavailability of some components / functions, these will be replaced with the most suitable prototypes and open source implementations already available in the 5G ecosystem.

The Port of Koper, despite being located in the territory of the Republic of Slovenia, has the status of an autonomous security zone, for which some specific safety and regulatory constraints apply. Partners involved in related activities and taking place in the Port of Koper will take these constraints into account and will work closely and under the guidance of the Port of Koper representatives to ensure compliance and execution of all formal procedures required in the context of the project timeline.
Regarding the use of drones and video cameras for streaming in seaports such as the port of Koper, the national legislation and regulations of the Republic of Slovenia will be considered, as well as the specific provisions for the port area to ensure that all requirements formal are satisfied. The Port of Koper will be in charge of investigating, planning and executing all necessary arrangements and will involve other LL partners, if necessary.

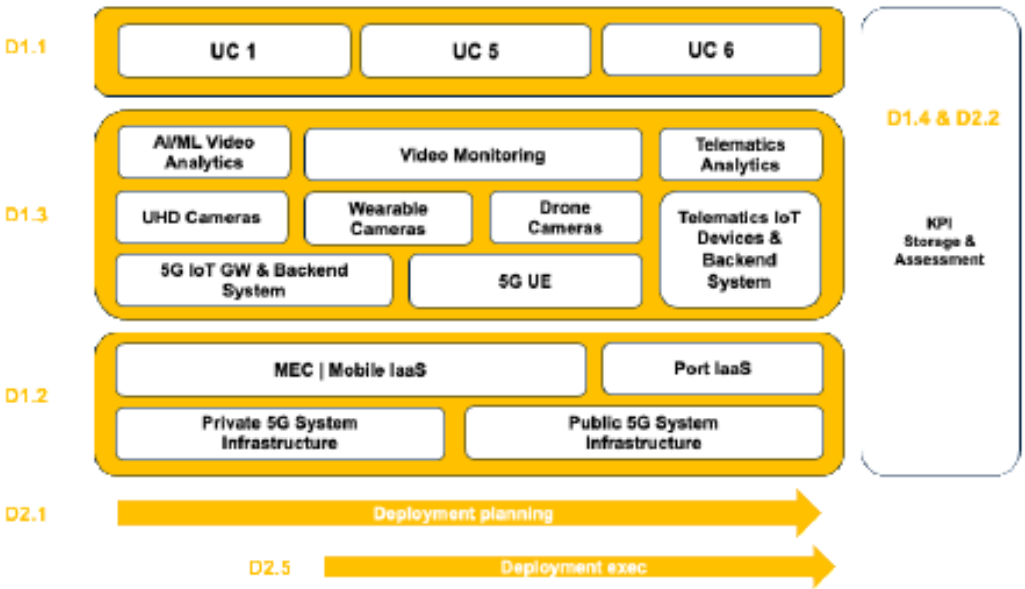

Figure 3: Hardware and Use Case Components for Koper Living Lab

In Figure 3 we can see relations between the Living Lab Koper use cases, 5G mobile network capabilities and other Living Lab infrastructure components with respect to the 5G-LOGINNOV deliverables (D1.1, D1.2, D1.3, D1.4., D2.1, D2.2 and D2.5) and other project tasks are presented. To assure needed infrastructure required to support targeted use cases deployment, testing and verification activities and to provide capabilities for the engagement of the innovative start-ups and SMEs, Living Lab Koper infrastructure will be composed of 5G mobile network services, mobile IaaS capabilities and additional services and applications components.

Based on the supported network, cloud, services and application capabilities all targeted use cases can be deployed, tested and verified. Living Lab Koper architecture is generic enough to host various other use cases targeting port operations, logistics and private security services which will be exploited and showcased as part of 5G-LOGINNOV open call.

	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.
#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 6: Objectives of The Luka Koper Living Lab

1.5. Key Activities & Resources

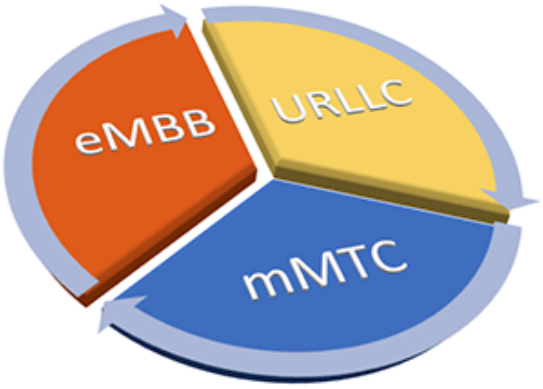

Figure 4: eMBB,URLLS,mMTC integration

One of the challenges of 5G is to validate its technological and business performance across all sets of heterogeneous requirements stemming from concurrent usage of network resources by different vertical domains. In this respect, relevant field trials will be conducted concurrently with multiple vertical use cases grouped over the three separate service classes of ITU requirements (eMBB, mMTC and URLLC). The purpose is to validate and capture evidence through the relevant performance KPIs to what extent slicing and virtualization are capable of successfully managing multi-domain resources, and how these capabilities are in line with such concurrent performance requirements and also, that there is no interference between vertical use cases in the presence of concurrent usage of resources (i.e. strict isolation is maintained). To support network slice management, dynamic service lifecycle automation and enable automatic real-time and concurrent orchestration across the 5G-EVE and 5G-VINNI facilities, the CDSO based on NOKIA's CBND will be leveraged, to bind all 5G-related services to be piloted and to control their flows.

Specifically, each of the service classes (eMBB, mMTC and URLLC) will incorporate the parallel execution of a number of use cases in each of the LLs. All classes of service will then run concurrently within each ICT-17 facility.

eMBB

The eMBB (enhanced mobile broadband) services provided in 5G networks support a large system capacity and an ever-increasing data rate for the end user. To meet this demand, the eMBB standard introduces two major technological improvements:

- *Shifting the spectrum of frequencies used towards the centimeter and millimeter wave range to achieve much larger bandwidth allocations;*
- *Advanced antenna arrays, including tens or even hundreds of two-way antenna elements to enable the use of highly parallel transceiver streams (massive MIMO) and directional irradiation with electronic beam control (beamforming).*

uRLLC

Ultra-Reliable, Low Latency Communications (URRLC) services define an entirely new family of use cases to enable ultra-reliable low-latency communications by supporting the most advanced requirements demanded by certain vertical application sectors, including autonomous driving for the automotive sector, remote surgery, robotics and cloud solutions for Industry 4.0. All applications require: Improved latency, Improved reliability, Greater availability, More security

mMTC

The massive Machine Type Communications (mMTC) communication service will make it possible to economically manage the robust connection of billions of devices without overloading the network.

Critical success factors include: Coverage, Affordability, Low energy consumption, Long-term availability.

1.5.1 Implementations of Smart Ports Solutions

1.5.1.1. UC8/9: 5G-LOGINNOV Floating Truck And Emission Data (FTED)

By now, for the management of traffic via device, it is usual to use a traffic management by a dynamic system. For this reason, it is essential to evaluate the cause and effect of specific maneuvers and the resulting emission profile. However, this evaluation is currently quite difficult (it should in fact be a reliable evaluation based on existing telemetry and telematics systems within a dynamic environment). The best possible results and answers to these problems can only be achieved by including the influence of the specific infrastructure (e.g. in consideration of the fact that even a static infrastructure, such as fixed signage and traffic routing) as a function of volume of traffic and disturbing variables always causes dynamic driving behavior as regards the execution and position of a maneuver. The overall emission reduction potential is mainly related to the vehicle type and configuration (bodywork, mass, powertrain, brakes, tires, etc.), current vehicle condition (e.g. maintenance level, load), vehicle characteristics route, TMS measurements (static and dynamic).), traffic flow, driver / driving profile (acceptance of TMS measures). To effectively synchronize TMS measurements and traffic it is necessary to analyze and describe driving maneuvers of commercial vehicles in such a way as to isolate the influence of route, infrastructure, vehicle, use case / weight and driver (interaction with the vehicle for perform a specific maneuver), assigning them individually to the emission profile of the cause.

The 5G-LOGINNOV project will achieve these results with the following methods:

- 5G real-time truck and emissions data (telematics and telemetry sets of vehicle-based sensors, including CAN-Bus data) collected by LCMM (Low Carbon Mobility Management) and Entruck;
- Increased accuracy for the parameters of the applied energy equation used by LCMM and Entruck (eg tire pressure, number of revolutions, efficiency and engine position);
- Real-time analysis of maneuvers and direct delivery of results in a specific format for use in other use cases or by third parties;
- Characterization of infrastructures with regard to wear and emissions based on real vehicle data and behavior, including continuous verification;
- Calibration of external services based on lower data resolution and speed profiles.

First step

Selection of an adequate fleet for the installation of on-board units foreseen for the collection of FTED data. Once the LCMM test data has been collected, the expansion to logistics service providers will proceed, with particular attention to the coverage of logistics corridors within the city of Hamburg. The fleet will be managed according to the principles of Floating Car Data and will analyze the road segment with regards to traffic quality, stop & go and standing start.

Therefore, 5 LCMM equipped vehicles will collect trip data for preliminary analysis.

Second step

Expansion of fleet LCMM equipment: will be installed the Entruck and Conti-IoT-Box on-board units.

Final step

Data collection will be done on three levels of data depth and collection method to illustrate the different media and hardware requirements. Equipped vehicles will carry out test drives along the self-driving test field in Hamburg to collect Floating Car Data (FCD) and deliver it to the MEC using a 5G network.
Additionally, a 5G-enabled MEC server infrastructure will be implemented to support SWARCO TMS decision support and the GLOSA ATP solution described in UC10 and UC11.

As we can see from the following figure, there are many expectations placed in the improvement of the quality of work by the FTED: it is expected that it will constitute a real "revolution".

UC goals	Floating Truck And Emission Data
Initial Conditions	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) condition (after 5G-LOGINNOV)	Dynamic traffic management can utilize real-time floating truck data: - Position/speed/arrival times known for traffic control - Pollutant e energy consumption known for environment 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 7: UC8/9 (Hamburg) - Gap Analysis

1.5.1.2. UC10: 5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)

As we said, the necessary tests for implementing automated platoons will directly be linked to Use Cases family:

- Using 5G GLOSA in the context of Automated Truck Platoons
- Test by implementing logistics platoons along the logistics corridor of Use Case 3
- Innovation by 5G linked to traffic control: precise positioning and D-GPS, MEC and eMBB

Therefore, to demonstrate the effectiveness of GLOSA in interacting with ATP, automatic recognition and assessment of the impact on emissions of driving maneuvers and the related influence of the infrastructure are required.

On the basis of changes in driving maneuvers (when the TMS / GLOSA measures, the state of the traffic situation and the knowledge of other surrounding conditions are known), changes in the behavior of emissions are determined, assigned and evaluated, based on the driving profile change. To determine emissions behavior, the LCMM methodology is calibrated using Entruck data, using real driving and consumption profiles: thus the effect can be recorded for individual vehicles, using different driving situations and evaluated using an adapted routine. from UC8 / 9.

In the fundamental diagram, this involves extreme consideration, as the acceleration and deceleration maneuvering components are close to zero in the ideal case, in favor of the constant driving component. The reflection on the real traffic conditions will be evaluated on the basis of field data and in a specific GLOSA simulation for the development of control strategies, applied to the potential estimation and planning of possible logistic corridors.

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
Measurements of these goals	Introducing data from the vehicle to TMS, GLOSA

Table 8: UC10 (Hamburg) - Gap Analysis

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

1.5.2. Real-Time Analysis: Tracking & Enhanced Visibility

Port operations can reap several benefits thanks to 5G-connected portable trackers that monitor in real time the position and condition of trucks / freight along the entire service chain, or along part of it. 5G-IoT mobile devices (i.e. 5G-connected trucks) could provide real-time, low-latency information to systems including geolocation, CAN-Bus data, custom on-board sensor data and other relevant, etc. Logistics companies and port operators, through this data, will be able to provide real-time updates on the status, understand where potential delays may occur, optimize truck / fleet routes and predict the exact moment in which the package or the vehicle will arrive at its destination. Throughout the course of the project, real-time monitoring and increased visibility inside the truck based on deployed on-board sensors will form the basis for the implementation of the different use cases.

1.5.3 Increase of precision for the parameters of the applied energy equation (LCMM, Entruck)

In particular, these functionalities will be developed and implemented in Hamburg, one of the three Living Labs foreseen by the project.

The ISO IS23795-1 Low Carbon Mobility Monitoring (LCMM) will be extended to environmentally oriented traffic management actions and quantification of effectiveness with regard to policy-driven clean air initiatives.

The eMBB and uRLLC capabilities will increase the options for connected sensors and distribution of results in real time. The LCMM app will be distributed on 5G smartphones: this decision will significantly improve the positioning accuracy (3GPPP) and therefore the accuracy of the ISO standard applied for the calculation of NOx / CO2 emissions.

Entruck is a vendor-independent telematics platform with advanced analytical capabilities that connects assets (e.g. vehicles, trailers, containers, machinery) with their asset management. It is used in logistics and research and development applications, among which:

- freight forwarders for planning and scheduling orders
- Approval associations for advanced tire / component testing
- Fleet operators for vehicle management, monitoring and maintenance
- OEM for R&D related tests and benchmarks

Within the Living Lab Hamburg, Entruck will be used to connect vehicles with the infrastructure and enable two-channel communication between vehicle and infrastructure via 5G. By enriching the data collected with data from third parties (think for example of infrastructures and meteorological information, analyzed at the maneuver level and returned to other interested parties such as LCMM and traffic management); among the different results, you can see:

- Segmentation of the route into maneuvers required by the infrastructure
- Segmentation of the route in maneuvers forced by traffic
- Influence of the infrastructure on consumption, emissions and wear
- Influence of traffic on consumption, emissions and wear
- Driver's influence on fuel consumption, emissions and wear
- Influence of the logistic operation (eg load, task, etc.) on consumption, emissions and wear
- Influence of the vehicle and the components used (eg HP, tires, powertrain) on fuel consumption, emissions and wear

These analyses and information will be converted to form information part of various indicators (e.g. active acceleration, active deceleration, constant driving, inertia, etc.).

1.5.4 Measurement of KPI's of environment-sensitive traffic management actions

Since the conception of the 5G-LOGINNOV project, we have proceeded with certain characteristics:

1. an approach guided by the interested parties was followed (mainly ports and annexed port cities), considering the great changes brought about by the transition to the logistic industry 4.0 based fundamentally on the functionalities and possibilities offered by 5G;
2. a preliminary set of 5 Personas has been identified (5G-LOGINNOV Personas);
3. in the first phase of the project (Living Lab Requirements & Specifications Phase), the 5G architecture requirements for the port / port city stakeholders will be produced through an iterative participatory method: all ports interested parties will be identified and classified, including the 5G key requirements and specifications to support the implementation of innovative advanced use cases;
4. The group of 5 people, after having produced a reclassified mapping of the requirements / specifications, will be extended to a larger, but manageable set of people, around which the scenarios describing the requirements and specifications of the Living infrastructure will be developed Labs in the 3 LL. created.

The approach is iterative also due to the methodology and evaluation requirements.

The assignment will carry out the following main activities:

- Define KPIs to measure the impact and increased efficiency of port operations resulting from Living Labs 5G enabled use cases and updated Living Labs architecture, including 5G technology integration;
- Define protocols for critical success factor (CSF) assessment to ensure port optimization goals;
- Define evaluation criteria to evaluate the advanced capabilities of Living Labs architecture with 5G technologies to create promising new opportunities for new market players;
- Develop 5G-LOGINNOV requirements and specifications (technical, operational, social, environmental, legal, security and other relevant).

The 5G-LOGINNOV requirements for data management and cybersecurity will identify and specify the requirement to efficiently manage the data shared with the different project participants, including data to manage use cases and data collected for the purpose of evaluation, in compliance with the GDPR and define the appropriate data policy. Requirements include the need to ensure the required level of cybersecurity and avoid any problems leading to a potential incident with port operations. This "pool" of scenarios will also be used as a channel for the dissemination / commitment of the initial project.

Obs: To allow the implementation of the system, the elements currently available will be divided and prepared as distributed and modular application components, so that they can be modified or fortunately adapted to the needs of each of the ports in which, in the future, they will be implemented.

1.6. Key Partners

A short list of the main partners taking part in the project will follow:

- **European Commission CCAM**: The CCAM Association is to promote and facilitate pre-competitive research on Connected, Cooperative and Automated Mobility (CCAM) within the European Research Area, by bringing together the different actors of the CCAM value chain.

  The role of the CCAM Association is to represent the innovation stakeholders in the Co-Programmed Partnership CCAM in the Horizon Europe program.

  Since it started, it already gathers more than 150 members: different industry sectors, research institutes and universities, associations and clusters, service providers, and national and local authorities.
- **5G-LOGINNOV consortium** is specifically built around the needs to create innovation in a multi sectorial eco-system with: Telecoms (5G), Transport (Logistics Operations, Trucks and 5G corridors), Ports (Logistics operations), SMEs and Start Ups (Innovation and application integration), Industry (targeting new opportunities in the Logistics, e.g. Continental or SWARCO).

  - **ERTICO**: ERTICO-ITS Europe is a public-private partnership of 120 companies and organizations representing service providers, suppliers, traffic and transport industry, research, public authorities, user organizations, mobile network operators, and vehicle manufacturers.

    ERTICO embodies thought leadership and fosters stakeholder engagement; Together with our Partners, we develop, promote and deploy Intelligent Transport Systems and Services (ITS) through a variety of activities including European co-funded projects, innovation platforms, international cooperation, advocacy and events. ERTICO is the organizer of the annual ITS regional and global Congress in Europe.
  - **AKKA**: As a global leader in engineering consulting and R&D services, AKKA supports the world's leading industry players in their digital transformation and throughout their entire product life cycle.
- **Open Call Winners:** Since September 17 is the date on which all those (startups) who have submitted an application will receive an answer, to date unfortunately the names of the 5 Startups that will be declared winners and who will therefore be able to enter directly into the programs of the 5G-LOGINNOV project, also thanks to their innovative initiative, they still don't know each other; we are now in the exact moment of evaluation of the applications presented.

- **Network/telecom operators**: companies that provide access to a wireless communication network or the Internet (MVNO, MNO). Network operators design, build and operate network services that are offered to service provider, orchestrating resources from virtualized infrastructure provider (VISP). In this project, they can supply network slicing, fulfilling different requirements, and a machine-to-machine communication (M2M) which is the direct communication between devices using wired and wireless channel. By doing so network and telecom operators search to make up the basis for having requirements for instant revenues.

  - **ICOOR** (Interuniversity Consortium for Optimization and Operation Research):
    ICOOR is an Interuniversity Consortium for **Optimization** and **Operations Research**.
    "Our aim is to carry out, promote and coordinate studies in the field of Operational Research. We trust in projects, in partnerships and in Open Source research.";
  - **CIRCLE**: Circle is then a credible partner for Italian and European companies that want to
    seize the challenge of innovation, internationalization, growth through a better organization and effective processes. Circle has a specific vertical expertise in ports, maritime and intermodal logistics that make it a distinctive and complete partner in this
    specific industry;
  - **ICSS**: The Institute of Communication and Computer Systems of the School of Electrical
    and Computer Engineering (ECE) of the National Technical University of Athens (NTUA);
  - **SWARCO**: The largest company in the SWARCO Group acts as a system integrator for traffic light systems and intersection controls, motorway and tunnel guidance systems,
    parking guidance systems and charging infrastructure for electric vehicles, including associated software development. A Germany-wide network of service technicians ensures that the traffic systems are ready for operation and well maintained around the
    clock;
  - **Internet Institute:** "A powerful and affordable solution to deliver the next generation of
    quality assurance in telco environments";
  - **Vodafone Innovus:** qualified partner with Smart IoT devices, global managed connectivity, secure IoT infrastructure, rich web & mobile UI and complete field & remote
    support services **;**
  - **Telekom Slovenije**
  - **tec4u**

- Vicomtech

- T-Systems

- **ALICE** (Alliance for Logistics Innovation through Coordination in Europe) European Technology Platform (ETP) with contribution to their **logistics roadmap** and co-organizing Collaborative Innovation Days
- **Luka Koper** (Port of Koper), **PCT** (Port of Piraeus), **Hamburg** (Port of Hamburg)
- **Complementary And Previous Research Projects**[11]

Initiative(call)	**Relevance to 5G-LOGINNOV**
AEOLIX, H2020 Transport, 16M€	Pan-European platform for interconnecting all logistics actors across TEN-T corridors; ERTICO is the coordinator; experience from the LLs conceptualisation of TEN-T will be brought to 5G-LOGINNOV, as well as transferability of solutions investigated to its LLs (***ERTICO**, TSYS)
CONCORDA CEF, 20M€	Integration of current and future connectivity solutions (ETSI ITS-G5, cellular based 3G/4G/LTE, pre5G LTE-V and MEC) with the ADAS domain. CONCORDA will be an architectural reference model and provide the initial set of key building blocks (***ERTICO**,ICCS, TSYS)
ICT4CART	Hybrid communication approach where all the major wireless technologies, i.e. cellular, ITS G5 and LTE-V, are integrated under a flexible "sliced" network architecture to enable the transition towards road transport automation. (***ICCS**, ERTICO)
ARCADE	Coordination Action for the innovation and deployment of Connected and Automated Road Transport in Europe. (***ERTICO**, ICCS)
FENIX CEF Obj.8 60,6M€	Preparation of the road infrastructure (both physical and digital) to facilitate the gradual insertion of automated vehicles in conventional traffic. (***ERTICO**, ICCS, T-SYS, PCT, SWARCO)
AUTOPILOTH 2020 ICT, total budget 25M€, 2017-19	IoT Large-Scale Pilots for the automated vehicle in a connected environment. IoT devices and cloud computing to progress automated driving. Integration of connected and automated vehicles into the Port Monitoring System. The experimental testbed used in AUTOPILOT (covering the ferry and cruise terminal) will be extended to include the CTs in 5G-LOGINNOV (***ERTICO**, AKKA, TSYS, VICOMTECH)
5G-MOBIX	Development of software for 5G-ready applications, as well as virtual and physical network functions and network services over sliced programmable infrastructure. (***ERTICO**, ICCS, AKKA, VICOMTECH)
COREALIS 5M€	Addresses traffic management efficiency at ports with IoT (***ICCS**, ERTICO, PCT)

[11] See the image for a summary diagram of the projects connected to the 5G-LOGINNOV project

Clusters2.0, H2020, 6M€, 2017-2020	Logistics clusters around major transport hubs, including ports; synchronisation and interconnection among different clusters; 5G-LOGINNOV will borrow concepts from the Proximity Terminal Network (***ICCS**, ERTICO)
CORE,FP7-SEC, 29 M€, 2014-2018	Considering historical vessel ETAs, maritime traffic and weather forecasts, an algorithm was executed to predict more accurate ETAs for specific containers. 5G-LOGINNOV, with a large dataset provided by the LLs railway and barge operators, will consider these developments to develop cargo flow optimiser. (***ERTICO**, ICCS)
NEMO,H2020-GV-2015, 7,8 M€, 2016-2019	The vision of NeMo is to create a Hyper-Network of new and existing tools, models and services which will provide seamless interoperability of electromobility services. ICCS was the coordinator. The predictive algorithms developed in NeMo will be considered in 5GLOGINNOV but in another context, those of load balancing for a micro-grid implementation. (***ERTICO**, ICCS)
iCargo – FP7 ICT, total budget 16.8M€, 2011-15	iCargo IP aimed at synchromodality, dynamic planning of services and resources. It delivered foundations for standardized information flow and process descriptions. IT infrastructure based on access Points was provided for seamless interconnection between SC partners. On the basis of these results 5G-LOGINNOV will easily interface partners for reliable information exchange, describe services in repository and plan them efficiently. (***ERTICO**, ICCS)

*Table 9: Overview of indicative 5G-LOGINNOV related projects (in bold with * the project Coordinator)*

1.7. Cost Structure & Revenue Streams

Please note that as of today the names of the Open Call winners are not yet known (due to timing reasons); therefore as regards costs and revenues, to date it is not possible to indicate them with a greater level of detail, except through assumptions: the "real" data will then be clear when the winners of the Open Call are decided, with their actual implemented solutions.

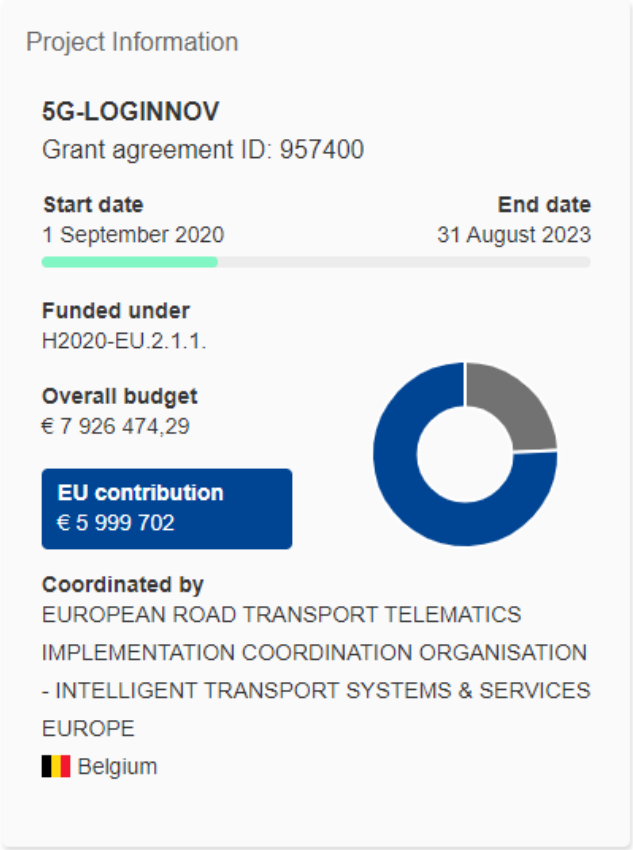

Figure 5: 5G-LOGINNOV information

As can be seen from Figure 14, the project was founded under the leadership of H2020 (Horizon 2020) and the EU and has a total budget of just over € 7.9 million, of which around € 6 million (actually a little less) was funded by the EU.

The costs that will have to be incurred are obviously related to:

- development of procedures, devices, initiatives (hardware and software)
- maintenance

More specifically, to achieve the 7 objectives stated in the Grant Agreement of the 5G-LOGINNOV project (see figure 17) it will be necessary (as again stated in the Grant Agreement)

to carry out a series of very innovative actions / implementations, which necessarily bring with them the related costs.

To date, it is reiterated, there is no prospect of these general costs, nor is the attempt to trace their extent among the objectives of this thesis; however, for the sake of simplicity, the main initiatives linked to the achievement of the 7 objectives mentioned above are reported in the following Table9[12].

#O1	1. Connecting in-vehicle 5G-IoT devices exchanging data with external RSU and traffic controllers enabling 5G Automated Truck Platooning 2. Minimise percentage of yard equipment assets idling for more than one shift 3. Optimise the use of human resources in yard equipment port operations
#O2	1. Deliver containers by automated truck platoons in the time frame of port's existing slot booking system 2. Optimise stacking height and stacking coordinates
#O3	1. Real-time emission data from truck sensors will be transferred to RSU and traffic controllers calculating the optimum speed for the automated truck platoon in the logistics corridor avoiding stop & go incident of the truck platoon 2. Facilitate the quantification of port decisions impact for mid-/long-term through Key Performance Indicators (KPIs): investments, stakeholder satisfaction, accessibility, modal split, CO2 emissions, air quality, green energy, market share, employment
#O4	1. Time slot allocation of truck platoon driving connected and automated in the logistics trial corridor and the connected optimized traffic light signalling 2. Extrapolation of the potential CO2/NOX savings based on the real traffic volume to the port terminals 3. Reduce emissions (at least 15%) and noise (at least 10%) produced by trucks delivering/picking up containersReduce waiting time for inland containers transported via rail or barge by 10% 4. Improve the modal split ratio in favour of rail and inland waterways by more than 10%
#O5	1. Attract at least 10 Small Medium Enterprises (SMEs) and entrepreneurs in 5G, IoT, renewable energy & circular economy for improving port environmental footprint per pilot 2. 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
#O6	1. Co-operation with the suitable working groups in CEN/ISO 2. Contact responsible standardization officer of Deutsche Telekom Group Affairs for standardization activities 3. Contact responsible standardization officer of ISO, ETSI, CEN for standardization activities-at least 1WG
#O7	1. Deploy the logistics and CAD innovative advanced use cases. 2. Promote 5G-LOGINNOV project at the World Port Conference, ITS Congresses, 5G, IoT conferences and international events 3.Cooperation with Hamburg, Athens and Luka Koper Port Authority international partners management

Table 10: Main project measurable objectives & indicators, top-level analysis

[12] Source: 20201014_5G-LOGINNOV

The most significant costs associated with all these initiatives will be linked to:

- Use Cases and Living Labs generic development
- Deliverables development
- Reaching stakeholders and local authorities
- MANO platform Management
- Optimal truck platooning selection
- Optimal surveillance cameras and video analytics
- Predictive Maintenance
- Live demos (also with dispatcher and 5G automated truck platoon waiting for the slot)
- FTED, LCMM, Entruck, GLOSA & ATP: measured fuel savings of all participants of the truck platoon, or measured fuel savings of trucks alone driving with 5G-GLOSA
- Open Call & Involvement of 5 high-tech startup/SMEs in all Living Labs
- Complementary, improvements, new standards to be applied
- Project presentations (Webinars, International Conferences, Hackathons, etc..)

Obviously, the management costs of the project itself will also be particularly high, since it is made up of numerous components; precisely for this nature, it is also natural that the different components are found, among themselves, at different levels of TRL, as can be seen from the image (it should be noted that this image was taken from the usual document 20201014_5G-LOGINNOV, document dated 02/07/2020).

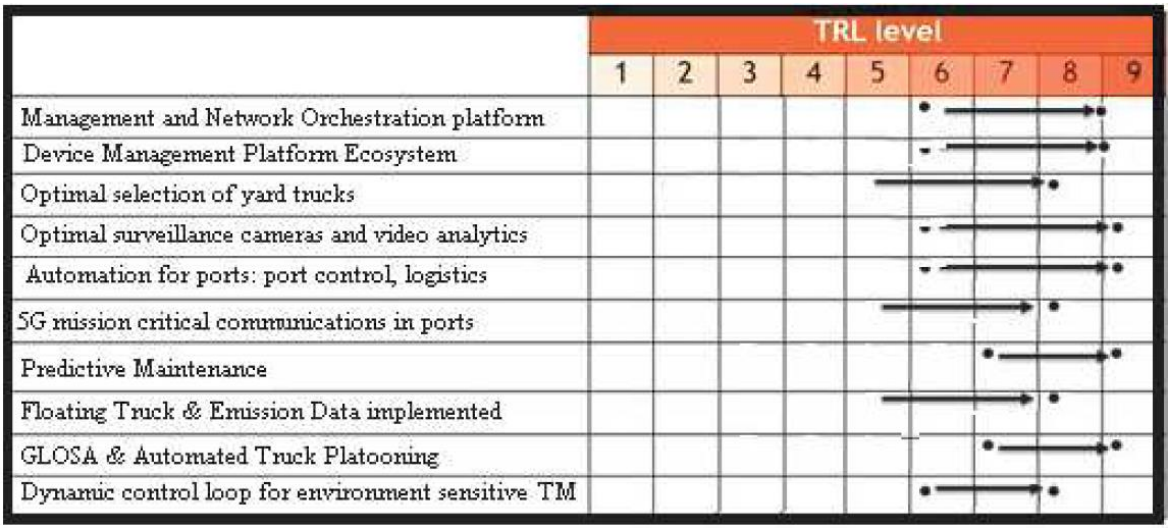

Figure 6: 5G-LOGINNOV TRL levels per component

The same argument (it is meant of a generic nature) can be carried out with regard to the "Revenue Streams": to date it is impossible to quantify them; the only reflections that can be made are in fact related to the assumptions about the impacts brought with them by the innovations of this project

Strategic Impact[13]

5G-LOGINNOV will create a strategic impact to support the emergence of new markets with new and existing actors, aiming at the improvement of port operations and goods enabled for 5G and the maintenance of port and logistic hubs operations at logistics hubs: this should offer significant cost reduction and positive opportunities impacts on the ecosystem.

It is precisely here that you will notice the importance of the Use Cases, which will have the task of testing and evaluating the new services enabled by 5G. Living Labs will test and evaluate 5G-enabled services during the project.

5G-LOGINNOV will not only create and lead a start-up network, but will have a strong interest in new market players, whether they are SMEs or start-ups, for the entire duration of the project.

In addition to this, five startups resulting from Open Call will be selected as winners and will be able to enjoy the integration in project for the development and implementation of innovative applications, using increased and integrated 5G capabilities in 5G network architectures at three EU Living Labs. This should create a concrete impact on both the existing logistics ecosystems but also for future innovation actors, during the second half of the project.

By showing the importance of 5G for the entire logistics industry, 5G-LOGINNOV will contribute to pre-distribution of the future 5G logistics corridor, where ports are the end points and relevant positions to control freight traffic.

Speaking instead of standardization, the project will contribute to the emergence of new global standards and contribute to the harmonization of the spectrum for the 5G frequency bands taking into account the port environment and logistics hub.

In order to strengthen the competitive position of SMEs and start-ups, 5G-LOGINNOV networking and advocacy activities will leverage the lessons learned and recommendations identified from previous projects, as well as the project roadmap itself from the resulting white papers or position papers.

Commercial Impact

Logistic Hubs Management/Operators

5G-LOGINNOV aims to offer everything (infrastructural resources, connectivity and all network functions) as if it were a single service. The various operators who can take part in the long value chain will therefore have the opportunity to increase the value of third-party services.

[13] Here we briefly resume what is reported in "Customer Relationship"

Partnerships will be established on several levels: there will be the opportunity to share the infrastructure, expose the capabilities of the network as an end-to-end service, integrate partner services into the 5G system.

Network and Telecom Operators

Due to the entry of new actors and the emergence of new roles (especially intermediaries) in the value chain, the project will have to deal with identifying and evaluating the new relationships that could arise between the stakeholders, which in turn could lead to partnerships. and new development ecosystems.

The way in which the logistics corridors related to the three Living Labs will be managed will make it clear how much Connected and Automated Platoon could benefit the three stakeholders.
Revenues are analysed for:

1) Dynamic slot booking systems;
2) Pre-Port Parking fee revenue;
3) Value-Added services for logistics service operators.

Creating a logistics corridor where 5G is used for the connected and automated truck platoon will show how 5G supports logistics hubs, reducing emissions up to an expected result of 30% only in Hamburg.
Oss: we are talking about highly innovative truck platoons, for which we will need the traffic light priority, GLOSA and so on; in fact, during this project the two companies will make investments (public investments and tenders) for a total of 1.5 billion euros.

Impact for SMEs, start-ups and other stakeholder group

We can now list some of the benefits in front of which, thanks to the 5G-LOGINNOV project, start-ups and SMEs are placed, which will be interested in the project to:

- Increase their market opportunities, based on the implementation and experimentation of the use cases of Living Labs (remember in fact that most of the solutions implemented / tested during this project are modular, and therefore, with some modifications, can be developed in any other existing port);
- The start-ups network will develop and disseminate a strategy that can be periodically reviewed until it "becomes definitive" and can be taken as a standard for new generations of start-ups
- The Open Call 5 winning start-ups, in addition to passing quickly from the idea to the market, will benefit from all the 5G-LOGINNOV networking and business modeling activities.

Societal And Environmental Impact[14]

The innovations of the main 5G-LOGINNOV technologies in the three Living Labs will provide time savings and cost reductions, as well as knowledge acquisition and full exploitation of the available network capacity:

- day-to-day operations will result in fewer freight trips and fewer vehicle-kilometers;
- this will increase the quality of the delivery service, also resulting in safer working conditions for staff and greater safety for transport;
- given the approach of the project, it will positively influence the movement towards "Safe Societies that protect the freedom and security of Europe and its citizens";
- as regards the Green Deal (reduction of greenhouse gas emissions from transport by 90% by 2050, the main measures adopted concern the movement of 75% of the movements of goods transported by road today to railways and inland waterways;
- Living Labs therefore aim for significant cost savings and environmental alleviation in terms of CO2 and NOx mitigation; it should also be noted that reducing the number of freight trips would also reduce the total fuel consumption (as already mentioned, with the calculation extended to 5 logistic corridors and 10 major seaports, savings of 1 Giga-Ton of CO2 are possible in the port sector only, without considering the reduction of NOx emissions).

[14] Here we briefly resume what is reported in "Value Proposition"

2. 5G-Logistic Corridors[15]

Business Model Canvas

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relationships</th><th>Customer Segment</th></tr>
<tr><td rowspan="2">• European Commission CCAM
• 5G-LOGINNOV Consortium and Open Call winners
• Public authorities
• Network and telco operators
• Transport operators
• ALICE
• Complementary research projects</td><td>• Implementation of 5G network architecture
• Implementation of 5G green light solutions
• Implementation of 5G solutions for traffic management and controlling
• Define logistic corridors in close cooperation with port's stakeholders
• Development of a modular solution (i.e. adaptation to each port needs)</td><td rowspan="2">• Cooperative, Connected and Automated Mobility 5G logistic corridor
• Support a long-term roadmap towards the pan-European deploymet of 5G
• 5G Corridor CEF Digital
• Support Standardization of 5G enabled port e logistic hub operations system, interoperability and harmonization arounf future 5G logistic corridors</td><td>• Stakeholder driven approach
• Open call
• Exploitation and Dissemination</td><td rowspan="2">• Port Authority
• Terminal Operators
• Transport Operators
• Public Authority (regional authority)
• Local industries and associations
• Traffic management authorities</td></tr>
<tr><td>Key resources
• Infrastructures and technologies hardware and software (e.g. telematics and telemetry sets, Entruck on boards unit, eMBB, mMTC and uRLLC capabilities with 5G network slicing support; LCMM, D-GPS and MEC)
• Financial Resources
• Data (Traffic Monitoring Data. and FTED collected By LCMM)
• Traffic management algorithms
• Intellectual resources</td><td>Channels
• Living Labs testbeds and use cases
• Exploitation and Disssemination (e.g. conferences, workshops, collaborative innovation days, hackathons)</td></tr>
<tr><td colspan="2">Cost Structure
• Development costs (e.g. hardware and software costs)
• Maintenance costs</td><td colspan="3">Revenue Streams
• Usage and Licensing fees</td></tr>
</table>

Table 11: Business Model Canvas - 5G logistic corridors

[15] As we already said (see note 4), since the two topics are basically two sides of the same coin, some of the 9 sections ("Customer Relationship" "Channels", "Customer Segment", "Key Partners", "Cost Structure" "and "Revenue Streams") into which the scheme used for the analysis (Business Model Canvas) is divided will be effectively shared; therefore, having already been presented during the exhibition of the first BMC, they will not be repeated in this one.

2.1. Value Proposition

Thanks to its Innovation Palette, 5G-LOGINNOV will be perfectly able to highlight the importance of 5G for the entire logistics sector, given the large number of devices that will gradually become necessary (and therefore make it obsolete 4G); the project will therefore contribute to the pre-distribution of the future 5G logistics corridor; logistic corridors (5G) are simply "corridors" created in order to help and speed up logistics: in fact, along these corridors there are points of interest (ports are the end points of these corridors, they are also present relevant positions to control freight traffic).

Thanks to the innovations brought to the port by this project, we will finally reach the optimization of port operations and maintenance; it would also benefit the management of vehicles and goods in logistics hubs (these 5G devices will be deployed at the port infrastructure and in vehicles, including 5G smartphone tablets and other devices that use Augmented Reality to monitor and control).

Not to forget the fact that the project will be fundamental to say the least in bringing out new global standards, contributing to the harmonization of the spectrum for the 5G frequency bands, taking into account the port environment and the logistics hub.
The value proposition of 5G-LOGINNOV project related to “5G-Logistic Corridors” is structured as follows:

- Cooperative, Connected and Automated Mobility 5G logistics corridor
- Support a long-term roadmap towards the pan-European deployment of 5G
- 5G Corridor CEF Digital
- Support standardization of 5G enabled port & logistics hub operations system, interoperability and harmonization around future 5G logistics corridors

2.1.1. The context in which to integrate

The project obviously intends to use the numerous related projects and complementary research carried out across Europe, which are directly relevant for the optimization of corridors for logistics services (5G logistics corridors), as a strong starting point in this challenge. Indeed, it should be noted that the use (and obviously the availability) of data is developing at an unprecedented level.
All of this can be achieved by improving core technology (sensors, data sources, devices, etc.), 5G key technology blocks, new generation of 5G CAD terminals, IoT-5G connectivity devices, platforms and data services (AEOLIX, SELIS, port community systems, etc.) and interconnecting them,

Particularly interesting for 5G-LOGINNOV from these core projects is the identification, steps and 5G technologies as a subset of 5G network functions that can be tested and pre-deployed in the logistics and Industry 4.0 domains.

In the past few years we have already seen an interest in optimization; again, there are already several examples of systems and solutions developed to decongest traffic:

- The establishment of a two-way relationship with the surrounding urban space was of the utmost importance for COREALIS, a project that aimed at the satisfaction of citizens and stakeholders by improving the quality of life and the connection with the hinterland. In fact, the main objectives were: - to establish efficient connections with the inland transport network - to promote the use of the most energy efficient modes of transport.

- Brokerage Platform: is a Cloud based marketplace for leasing and exchanging intra-port Assets; Port of Antwerp indicated the need for a dedicated platform where their stakeholders could exchange offers of their assets on time bases to reduce unnecessary investments in equipment used occasionally. So, the system has been built on the basis of the requirements from the Port of Antwerp.

  On the basis of plans delivered by ports **it calculates needs of the equipment** in numbers as well as in space as the Marketplace **offers a localization service** that can be set to a particular place in the port and linked to the assets also being localized on real-time bases. As a result of the **enhanced planning of equipment and services the port** will receive information over the more efficient layout of containers and knowledge on operators picking them up. This results in a shorter time of container staying at port and a better yard utilization on the terminals; For a carrier or shipper, the equipment optimisation and availability information lead to a shorter waiting time at the port and a lower demurrage risk due to better planning and real-time equipment localization monitoring.

- Just-In-Time Rail Shuttle Service: is a feasibility study for key port-hinterland corridors. The growth in container transport volumes and the increment of vessels' size make necessary to increase the capacity of port-hinterland connections to manage cargo concentration.

  Currently, road transport represents the highest share in Europe´s port-hinterland connections, resulting in port congestion (associated with delays, queuing and dwell of ships and cargo in ports→extra costs and negative environmental impacts). Therefore, in response to this major challenge of ports, rail transport should play a key role as a sustainable response to this need, making necessary the development of innovative solutions able to face the current problems and limitations through a more collaborative approach between port stakeholders.

  The Just-In-Time Rail Shuttle Service feasibility study pursues to boost the rail transport mode and increase its modal share in the Port of Valencia by assessing new services and business models for key port.

  The JIT Rail Shuttle service proposes to operate as an "air bridge" at airports but for container cargo instead of people.

- Cargo Flow Optimiser: is an optimization tool for ocean/rail/inland/waterway cargo flows.

It consists in a complete overview of the most efficient connections from Port of Antwerp to its hinterland by rail, barge or truck: it calculates the optimal door-to-door container routes comparing the duration, distance, price and CO2 emissions.
Forecast model of the flow of containers departing from the Port of Antwerp, it predicts the container destination and mode of transport by means of historical and real-time data.
The accuracy of predicting cargo operations contributes to the planning and control in port terminals and increases reliability and resiliency of port operations in an ecosystem with high uncertainties and a turbulent and ever-shifting demand.
"Bringing the demand together makes the demand visible".

- As part of the 5G-MoNArch (Mobile Network Architecture) project the Smart Sea Port testbed in Hamburg was implemented. It contributed to the verification of performance targets and served as a baseline for the techno-economic validation, comprising, as use cases:
    - (i) mobile sensor connectivity (barges in the port),
    - (ii) high reliable traffic management (connected traffic light) and
    - (iii) mobile broadband augmented reality applications, each of them having its own slice on top of a common infrastructure.

The project has fully achieved or even exceeded its objectives both in terms of technical results as well as with respect to the testbed implementation.

2.1.2. 5G cross-border corridors projects

EU countries are cooperating to develop large-scale test sites of connected and automated driving on European motorways in the form of cross-border corridors.
In particular, a brief reference will be made below to the three new 5G cross-border projects (5GMed, 5GRoutes & 5GBlueprint): these projects will have the objective of validating and testing use cases in the field of mobility and transport and therefore of expanding the validation of connected and automated mobility capabilities on roads, trains, ports and sea routes. Each of these projects will provide a 5G network infrastructure that offers multi-service and multi-application capabilities to various means of transport (such as cars, trucks, trains, pods, barges and boats), as well as improved connectivity to public users.
They will operate in different geographical conditions and associated meteorological constraints: the Baltic and the North Sea (5G-Routes and 5G-Blueprint) and the Pyrenees Mountains (5GMED).[16]

The three projects will be complementary to the three experimental projects on 5G corridors launched in November 2018, and their results will provide the necessary know-how in view of

[16] Two of the three projects will take place on sections of 5G cross-border corridors which are supported by a cross-border cooperation agreement., With Via Baltica between Estonia, Latvia and Finland (5G-Routes) and the recently signed memorandum of understanding between the Netherlands and Flanders (Belgium) covering Rotterdam, Antwerp and the North Sea port area.

the planned large-scale deployment of 5G corridors in Europe, which will be supported by the digital program of the mechanism. to connect Europe (CEF) in the period 2021-2027.

The projects bring together a wide variety of stakeholders: telecommunications operators and suppliers, road operators, railway infrastructure managers, transport and logistics companies, vehicle manufacturers and their equipment suppliers, railway equipment manufacturers, innovative SMEs and centers of public and private research, with the direct participation of transport authorities and the support of national and regional governments.

2.1.2.1. 5GMed: The future of mobility in the Mediterranean cross-border corridor

Through 4 rail and motorway pilot tests between Figueres and Perpignan, 5GMed will demonstrate advanced cross-border experiments of 5G application scenarios in Cooperative Connected and Automated Mobility (CCAM) and Future Railway Mobile Communications System (FRMCS) services.

The 5GMED project, with a global investment of 16 Million € of which 75% funded by the European Commission, aims to bring a sustainable 5G implementation model for future mobility in the Mediterranean Cross-border Corridor. The project started in September 2020 and will be implemented until November 2023.

The services to be tested will rely on a broad range of technologies beyond 5G, including:

- on-board sensors and Artificial Intelligence (AI), providing advanced connectivity services in a scalable and replicable manner across transport paths;
- a remote driving use case;
- advanced traffic management.

The use case demonstrations will be carried out in three small scale testing facilities in order to replicate real conditions, based on the outcomes of the tests, a final integration and validation will be carried out in the cross-border section between Figueres and Perpignan. A strategic section in the Trans-European Transport Network since it sustains 55% of the road traffic between the Iberian Peninsula and the rest of Europe and 65% of the rail traffic.

One of the key objectives of the 5G strategic implementation agenda for connected, cooperative and automated mobility is to improve the routes of the trans-European transport network with 5G capabilities.

5GMed brings together key partners to provide advanced CCAM and FRMCS services in the Figueres - Perpignan section of the Mediterranean corridor. The consortium, coordinated by Cellnex Telecom, includes 21 partners from 7 countries representing the telecommunications, transport and mobility sectors, technology and solution providers, consultancy service providers and research institutes.

2.1.2.2. 5G-Routes

The aim of this project is to carry out advanced field trials of the most representative and innovative fully functional CAM applications through a designated 5G cross-border corridor ("Via Baltica-Nord") that crosses the borders of 3 EU Member States (Latvia-Estonia-Finland) in order to validate the latest 5G and specific 3GPP functionalities under realistic conditions, so as to accelerate the widespread deployment of 5G E2E interoperable CAM ecosystems and services on highways, railways and digitized ships across Europe. 5G-Routes will test and validate over 150km of the Via Baltica corridor, with an extension of the ferry to Helsinki, including ports and sea routes, several CAM use cases enabled by the high-performance capabilities of 5G, covering different scenarios of automated driving cooperation, awareness and tracking. The project approach is structured along the following 3 pillars:

1. Design and validation of a wide range of innovative advanced use cases, directly relevant for CAM and cross-border mobility through the 5G "Via Baltica-Nord" corridor (Latvia, Estonia and Finland).
2. Provide technological enablers to facilitate the execution of field tests, and in particular:Providing the technological enablers for facilitating the execution of the field trials, and in particular:
    - Integrate a number of innovative enabling technologies into cross-border CAM field trials, such as AI-based network cutting and optimization, AI-based positioning enhancements for V2X, AI-based distributed MEC for CAM services, the 5G radio interface based on artificial intelligence for an innovative use of shared spectrum for CAM services, cross-domain integration fabric for multi-domain interaction and roaming of services, combined with commercial 5G base stations and other complementary CAM technologies;
    - Take advantage of the KPI visualization system of the 5G-SOLUTIONS project and extend its functionality to incorporate CAM use cases, thus allowing the parallel execution of use cases, making the analysis and presentation of the results obtained by the tests and presenting them through an intuitive, easy-to-use dashboard in near real time.
3. Align the implementation roadmap of the 5G-ROUTES project with the latest versions of the 3GPP standardization.

The 5G-ROUTES technical approach is based on a modular architecture with open interfaces, through which the various enablers of 5G CAM technology are integrated; these will facilitate measurement and visualization of the 5G network and service-level KPIs of use cases, in

parallel and near real-time during field operations, as well as benchmarking and access from multiple locations.

2.1.2.3. 5GBlueprint

5G-Blueprint plans to design and validate a technical architecture and business and governance model for seamless cross-border teleoperated transport based on 5G connectivity. The 5G-Blueprint will explore and define:

- the taking into account of CAPEX (capital expenditure) and OPEX (operating expenses), both on the supply side (telecom) and on the demand side (transport and logistics) for the transformation of current business practices / new proposals for value;
- Governance issues related to responsibilities and accountability within the value chain dependent on cross-border connectivity and seamless services related to the Dutch and Belgian regulatory framework (laws, contracts, value chain) on telecommunications testing, traffic and CAM (Connected and Automated Mobility) Management;
- the preparation of teleoperated and telemonitored transport on roads and waterways, helping to alleviate the growing shortage of labor and bringing transport and logistics to a higher level of efficiency by sharing data in the supply chain and use of AI;
- Teleoperation will be made possible by the qualities of 5G, such as low latency, reliable connectivity and high bandwidth. The outcome of the project will be the model for pan-European operational distribution of teleoperated transport solutions in the logistics sector and beyond;
- The possibilities to increase the volume of goods transported during the night where the overcapacity of the physical infrastructure is abundant; reducing personnel costs would make this feasible on a cost-effective basis

2.1.3. Cooperative, Connected and Automated Mobility 5G logistics corridor

Among the various projects launched as part of the implementation of the European vertical 5G strategy, connected and automated mobility (CAM) is considered fundamental for the implementation of 5G along European transport routes, in view of the creation of complete ecosystems around vehicles, from road safety or digital rail operations to high-value operations commercial services for road users and train passengers.

In March 2017, Member States, in order to prepare the implementation of 5G cross-border corridors for CAM, signed a letter of intent (LoI) in order to step up cross-border cooperation for large-scale testing and pre-deployment. This agreement was preceded by bilateral initiatives between Luxembourg, France and Germany, and between the Nordic countries, and

has since been followed by a series of agreements between Spain and Portugal, between Bulgaria, Greece and Serbia, and between Estonia, Latvia, Lithuania and Poland on the "Via Baltica", with an extension between Lithuania and Poland.

In addition to these initiatives, three Horizon 2020 projects were launched in November 2018 to conduct large-scale testing and trials of 5G connectivity for CAM on cross-border corridors, as part of the 5G public-private partnership (5G PPP). Benefiting from funding of almost 50 million euros, for a combined total budget of 63 million euros, the three projects cover three 5G cross-border corridors: Metz-Merzig-Luxembourg (5GCroCo), Porto-Vigo between Spain and Portugal (5G- Mobix), and Bologna-Monaco via the Brenner Road (5G-CARMEN). In addition, a small 8km cross-border segment between Greece and Turkey will also be used for testing.

In September 2020, the three new projects discussed above were launched, which will provide applications in connected and automated cross-border mobility.

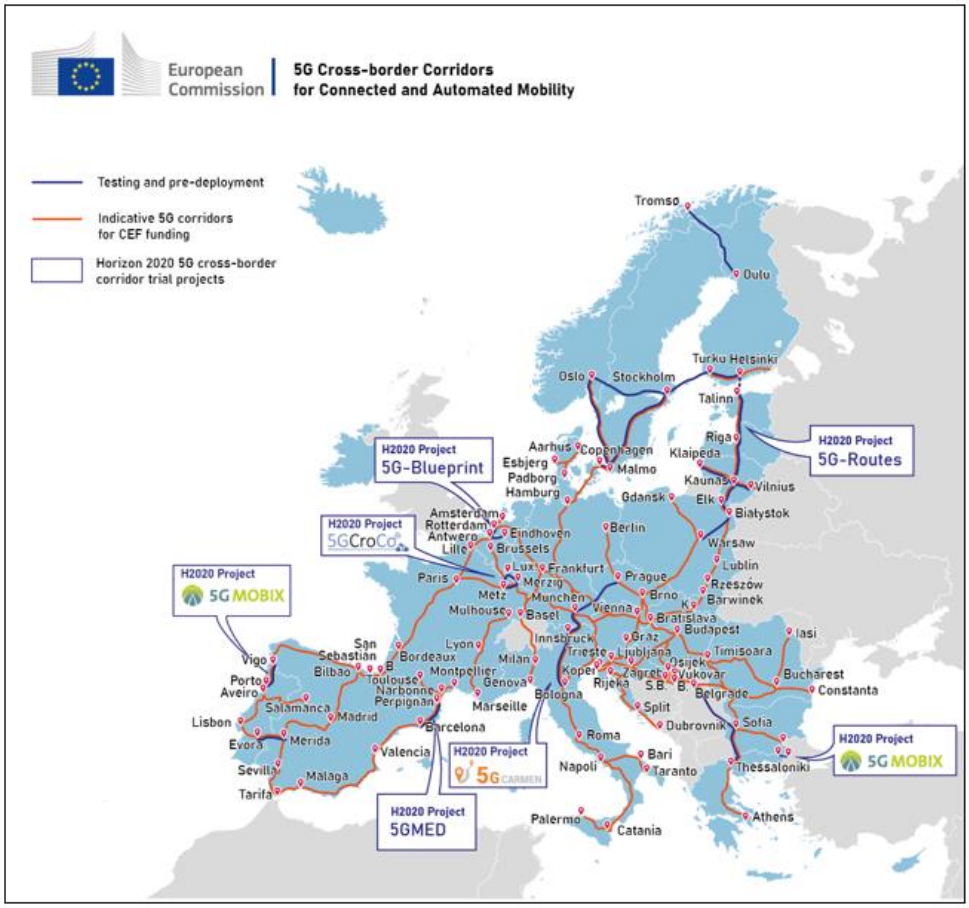

Figure 7: All the main public-private initiatives in Europe.

2.1.4. Support a long-term roadmap towards the pan-European deployment of 5G

The 5G-LOGINNOV project, based on the possibility of exploiting key 5G technological blocks, new generation of 5G CAD terminals, IoT-5Gconnectivity devices, platforms and data services, will be able to guarantee the tractability of the Supply Chain and, above all, anticipatory progress in the "physical Internet roadmap towards zero-emission logistics 2050".

According to the International Transport Forum (ITF), freight transport accounts for around 39% of the CO2 of transport emissions and about 8% of CO2 emissions worldwide. It also constitutes an important contribution to air pollution: The road constitutes 62% (50% suburban, 12% urban) of emissions, the sea contributes 27%, air 6%, railways 3% and inland waterways 2%.
At present, total emissions from freight transport must be almost completely decarbonised by 2050 compared to 2015 levels, in order to meet the climate ambitions set out in the Paris Agreement, which entered into force in 2016. The real problem is that, according to forecasts, the demand for freight transport is expected to triple by 2050, and of course the associated CO2.
This means that global and fast change is needed if you want to stay within the terms imposed by the agreement.

Freight transport and logistics go beyond the sphere of influence of individual countries and companies. In fact, there are currently large individual companies that need broader support from the public and private sectors, governments and civil society. Therefore, coordinated efforts within the industry, the partnership with the government, research and development institutes and civil society are certainly not negligible, indeed they are necessary to say the least.
In response to the Paris climate agreement, governments, associations and businesses are looking for ways to transform promises in action, especially considering that, often precisely with regard to the climate, we stopped at promises.
Many have started developing roadmaps towards low-carbon freight and logistics, but only 29% of countries' nationally determined contributions (NDCs) include freight; among other things, many companies and organizations that use or provide freight and logistics services are still a long way from developing their own roadmaps.

While there is still no integrated roadmap that takes into account all modalities, logistic sites and trans-shipment hubs for the whole world, or even for the EU, an attempt has been made that did not go very far, presented by World Economic Forum and Professor Alan McKinnon, who said that achieving significant emissions reductions could involve a combination of solutions along the logistic supply chain.
To succeed in this goal, some points considered key in this path have been set:

- Present an overview of key global roadmaps and studies, especially for Europe, identify gaps and take action for improvement;
- Provide an overview of the available decarbonisation solutions (their potential, what they can be implemented in the short term and which ones require more careful and detailed planning);
- Describe the roles of four stakeholder groups to bring about decarbonisation from now until 2050: private sector,government, research and development and civil society;
- Explain how this transition is to be managed using improved methods of calculating emissions, targets, actions plans, collaboration and advocacy

Figure 8: Smart Freight Leadership to drive the transition towards zero logistics emissions

Mission can be detailed as follows:

- Development of new logistics and supply chain concepts and innovation for a more competitive and sustainable industry;
- Contribute to a 30% improvement in end-to-end logistics performance by 2030;
- The Logistics ETP aims to accelerate the deployment of more efficient, competitive and sustainable supply chains.

We want to achieve an increase in efficiency (in particular, from 10% to 30% in the EU logistics sector) because this would directly translate into huge cost reductions for the entire European industry (according to estimates, we are talking about sums between 100 and 300 billion euros).

The challenge, from now on, will therefore be the construction of a real logistics and supply chain sector oriented to "people, planet and profit", that is a sector that is sustainable from an economic, environmental and social point of view. contributing both to the competitiveness of industry and to EU policy objectives.

2.1.5. 5G Corridor CEF Digital

The Connecting Europe Facility (CEF) is a key EU funding tool for promoting growth, jobs and competitiveness through targeted investments in infrastructure at European level. Its objective is to support the development of high-performance, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services. In practice, the investments of the CEF fill in the missing links in the European energy, transport and digital backbone.

CEF benefits people in all Member States, as it makes travel easier and more sustainable, improves Europe's energy security by enabling wider use of renewable energy, and facilitates cross-border interaction between public administrations, businesses and citizens.
In addition to grants, the CEF offers financial support to projects through innovative financial instruments such as project guarantees and bonds. These tools create significant leverage in their use of the EU budget and act as a catalyst for attracting additional funding from the private sector and other public sector actors.

The European dimension of CEF2 Digital should be reflected in the following strategic objectives:

- Contribute to the construction of pan-European and cross-border infrastructures: CEF2 Digital could help implement 5G infrastructures along the main transport routes, allowing continuity of service and interoperability of 5G services across the continent;
- Accelerate the implementation of digital connectivity policies, involving society at 360° within the digital transformation: CEF2 Digital can contribute to the achievement of the "2025 Gigabit objectives"[17] integrating a wide range of EU funding instruments,

[17] https://wayback.archive-it.org/12090/20210726211645/https://digital-strategy.ec.europa.eu/en/library/communication-connectivity-competitive-digital-single-market-towards-european-gigabit-society

including the European Regional Development Fund (ERDF), European Agricultural Fund for Rural Development (EAFRD) and financial engineering tools.

- Contributing to innovation and competitiveness in the EU digital ecosystem: CEF2 Digital can reinvigorate the competitiveness of EU business and industrial community. First, it can speed up the modernization of vertical sectors (health, energy, agriculture, public administration, education, transport).

  Second, the roll-out of Gigabit networks is expected to generate greater aggregate demand

  for very high-quality connectivity and user experience ("application pull"), eg. use of the virtual and augmented reality in e-learning applications, teleoperated robotics in surgery.

  These application scenarios should generate a spillover effect on the supply side of the value chain, resulting in the use of innovative technologies and infrastructures, which in turn will stimulate new and unexpected use cases and applications;

- Strategic autonomy and digital sovereignty: Europe in order to be ready to face the digital age, needs advanced and robust digital technologies, connectivity infrastructures, technological strengths, essential to support the functioning of digital platforms and services.

  The resilience of the digital infrastructure (and of course their protection from cyber attacks) is a precondition for the EU digital economy. Investments in robust high-capacity networks at EU level go hand in hand with the development of cybersecurity policies and programs.

2.1.6. Support standardization of 5G enabled port & logistics hub operations system, interoperability and harmonization around future logistics corridors

As can be seen from the summary table presented in figure 22, one of the seven declared objectives of the 5G-LOGINNOV project is (highlighted in bold) objective 6: "Support standardisation of 5G enabled Next Generation ports & logistics hubs operation system to ensure interoperability, platform openness and operation harmonisation around future 5G Logistics xborder corridors"

Objective 1	Develop and Deploy Next Generation ports & logistics hubs operation system architecture integrated in 5G networks at three main ports in Europe: Athens (GR), Hamburg (DE) and Koper (SL) utilising new types of 5G IoT sensors and devices
Objective 2	Optimise ports & logistics hubs operation and maintenance, for reducing their operational costs with innovative concepts and use cases
Objective 3	Reduce significantly ports & logistics hubs operation emissions (CO2/NOX) and regulate the resulting freight traffic on the future 5G logistics corridor in EU including CAM truck platooning management
Objective 4	Regulate the freight traffic generated by ports & logistics hubs on the future 5G logistics corridors in EU and integration of future Connected and Automated truck platoons-as 5G-LOGINNOV GREEN TRUCK INNITIAVE according to the EU GREEN DEAL program (December 2019)
Objective 5	Boost ports & logistics hubs operation & maintenance innovation with involvement of new market actors including SMEs and Start-ups
Objective 6	**Support standardization of 5G enabled Next Generation ports & logistics hubs operation system to ensure interoperability, platform openness and operation harmonisation around future 5G Logistics xborder corridors**
Objective 7	Support adoption and take up of 5G enabled Next Generation ports & logistics hubs operation system in Europe and beyond

Table 12: Summary of the 7 objectives of the project 5G-LOGINNOV

2.1.6.1. 5G Action plan

In order to be able to have a homogeneous participation of the whole of Europe, it is evident that a certain harmonization is necessary, to achieve which (in addition to the different and various deliverables connected to the 5G-LOGINNOV project), a 5G action: it is basically a strategic initiative that will make 5G a reality for all citizens and businesses across the EU.
In order to compete in the global market, ultra-high-capacity networks such as 5G will be a key resource: global 5G revenues for mobile operators could reach 225 billion euros per year by 2025, if we can really keep up. the implementation of everything that has been foreseen on schedule.

The Commission had already launched a plan in September 2016 to enhance EU efforts to deploy 5G infrastructure and services across Europe; this plan established a clear roadmap for public and private investment in 5G infrastructure in the EU.
Among the proposed measures, the most important can be summarized in the following bulleted list:

- Align the roadmaps and priorities for a coordinated deployment of 5G in all EU Member States, aiming for the early roll-out of the network by 2018 and moving towards a large-scale commercial roll-out by the end of 2020 to later;
- Make provisional spectrum bands available for 5G ahead of the 2019 World Radio Communications Conference (WRC-19), to be supplemented as quickly as possible with additional bands, and work on a recommended approach for the authorization of specific bands. 5G spectrum above 6 GHz;
- Promote rapid diffusion in the main urban areas and along the main transport routes;
- Promote pan-European multi-stakeholder trials as catalysts for transforming technological innovation into complete business solutions;
- Facilitate the implementation of an industry-led venture fund to support 5G-based innovation;
- Unite the main actors in working towards the promotion of global standards.

2.1.6.2. Multi-access Edge Computing (MEC)

Edge computing is a key technology to meet the end-to-end latency requirements introduced by the new 5G services and to improve the efficiency of the entire network operation through the implementation of compute and storage resources at the edge of the network. , ensuring greater proximity to mobile users. Taking advantage of the exploitation of edge resources, it is possible to perform processing activities in a distributed way directly at the edge of the network, reducing the traffic load on the infrastructure core and ensuring faster service responses. This approach allows for high scalability.

To date, Edge technologies are particularly suitable for all use cases with ultra-low latency requirements and high bandwidth availability in the mobile network. The main standardization work for MEC is provided by 3GPP and ETSI.

You can see in Figure 23 a general overview of the system with MEC, in which the architecture of the same can be mapped into the 3GPP 4G Evolved Packet System (EPS) architecture with Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and EPC; the RAN includes the eNB and user equipment (UE) in the truck or vehicle.

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 efficient integration, ensuring continuity solutions to different suppliers through distributed platforms located on the edge of the network.

Properly, MEC identifies two main components in a typical MEC architecture, namely the "MEC Host" and the "MEC System".

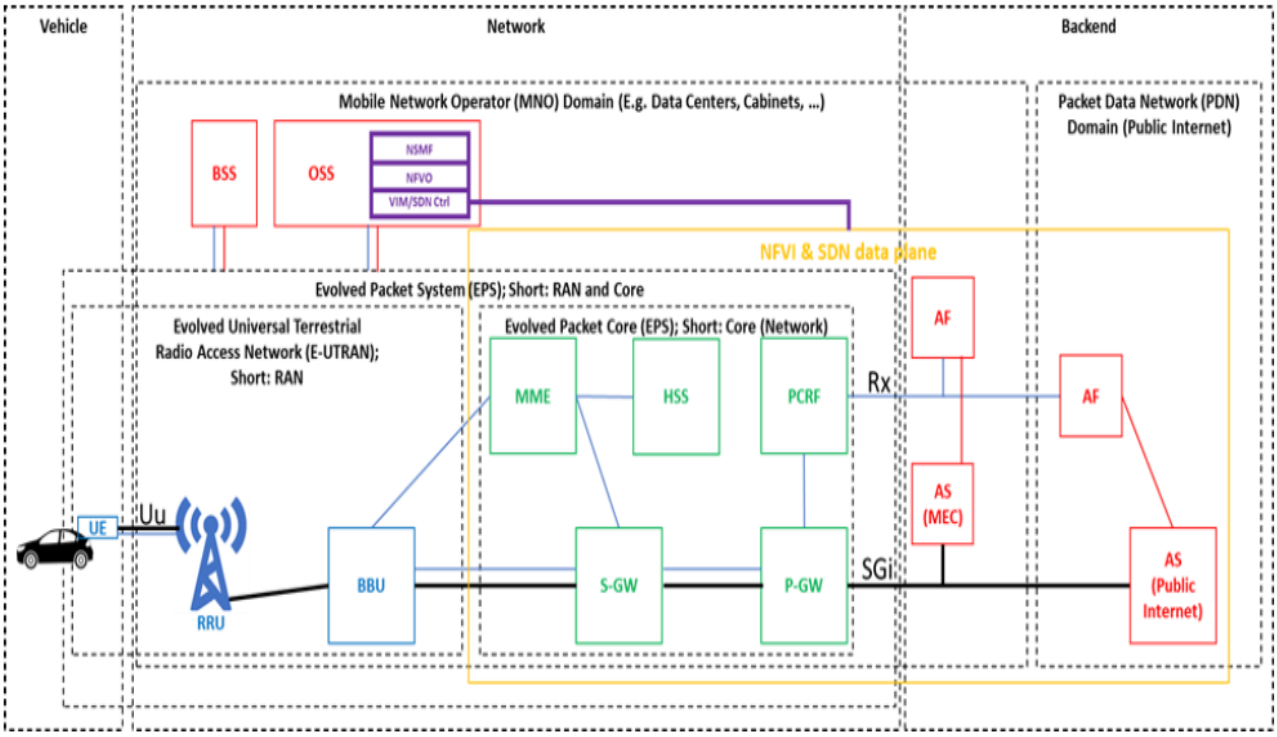

Figure 9: Mapping of High-Level Architecture to 3GPP 4G Evolved Packet System Architecture in LL Hamburg

2.2 Key Activities And Resources

2.2.1. UC11: 5G-LOGINNOV dynamic control loop for environment sensitive traffic management actions (DCET)

Stop & Go accidents cause ~ 30% more fuel consumption in any port than regular extra-urban traffic, which unfortunately translates into 30% more CO2 emissions! Furthermore, due to the characteristics of the engines used and the inertia forces acting on the vehicle, the Stop - & - Go causes a net increase in NOx emissions.
To avoid such disasters and achieve such emission reductions, it is certainly essential:

- To define, in collaboration with the stakeholders of the port, the logistic community, the traffic management authorities and the environmental agencies, of the logistic corridors set up for this purpose;
- To exchange complex V2X information via 5G using precise positioning, real time data and all other eMBB, URLLC and mMTC functionalities of the mobile network;
- To show how 5G GLOSA can be applied in other logistics corridors by reducing air pollution, i.e. for NOx and CO2.

The SWARCO Virtual Traffic Management System (SWARCO V-TMS) is located in the SWARCO-Cloud and has several application areas, many of which are aimed at reducing air pollution from motorized traffic.
This environmentally sensitive traffic management is configured as a control circuit that involves:

1. Vehicle dynamics (driving parameters) and vehicle (engine) characteristics;
2. Evaluation of the vehicle dynamics and calculation of the emissions caused by the dynamics;
3. Consideration of atmospheric and atmospheric conditions, measurements of pollutants to model the input of present and future time;
4. Consideration of the intake and the overall traffic situation (current and future):
   - To Select defined traffic management strategies;
   - Activate Action Packs.
5. Activate traffic management strategies, involving:
   - Change of traffic light control parameters;
   - Modification of speed limits or access rules (change of route, restriction of engine types, speed limits, etc.);
   - Change the cooperative control interaction;
   - Disseminating information on travelers (informing about restrictions, encouraging modalities or other changes in mobility behavior);
6. Resulting impacts on vehicle dynamics / mobility behavior / types of engine running in the polluted zone.

Figure 10: UC11 (Hamburg) - Environmental Sensitive Traffic Management circle

Use case 11 is divided into the following 3 phases:

- Phase 1: definition of the logistic corridors in collaboration with all interested parties;
- Phase 2: real-time test with data (Entruck, LCMM GPS, Continental) with small sample fleets (> 2)
- Phase 3: demonstration operation according to the project planning.

Starting from phase 2, the Virtual Traffic Management Center will deal with the management of environmental data (highly accurate and precise) from the other Living Lab partners, merged into a common format. the Virtual Traffic Management System (V-TMS) then makes decisions by exploiting the information obtained from such data and develops strategies to modify the management of the motorized traffic flow for the benefit of air quality (for example switching of traffic lights; moreover, V- TMS can provide MNOs with information about traffic lights, which can be offered to road users of the GLOSA service. Note that SWARCO V-TMS, by managing and implementing such sophisticated strategies and providing such high and accurate data, has a great impact on environmentally sensitive traffic management.

2.2.2. Trans-European Transport Network (TEN-T)

The need for the creation of an efficient infrastructure, which would facilitate the internal market, economic and social cohesion, became evident through the 2013-2020 political evaluation of the trans-European transport network (TEN-T), based on the Regulation (EU) n. 1315/2013.

The objectives of greater sustainability and greater benefits for users, on the other hand, require a substantial strengthening of current measures.

This assessment was carried out almost halfway between the entry into force of the TEN-T Regulation in 2013 and the first milestone of the TEN-T policy, the completion of the core network in 2030: it focused in particular on the extent to which the implementation efforts have led to the expected results and benefits, trying to take stock of the correctness of the path taken (to reach the targets set for 2030 and 2050).

Transport in Europe is facing unprecedented challenges, in particular with regard to sustainability, user-driven mobility and technological progress (not to mention all the problems related to the recent Sars-Cov2 pandemic)[18].

The TEN-T policy concerns the implementation and development of a European network of railway lines, roads, inland waterways, sea routes, ports, airports and railway terminals: in practice we have moved from a predominantly project-based approach to a complete networking process.

The intense attention to the practical aspect of the network has strengthened the link between the infrastructures and the objectives of the transport policy and the quality of the service. All of this suggests that the 2013-2020 EU TEN-T policy has succeeded in supporting the development of the infrastructure needed by the EU to achieve its broader transport policy goals.

The evaluation also highlighted the need for an in-depth assessment of the progress of the implementation of projects, in particular of projects located on the core network completed by 2030. This assessment would allow to identify possible measures to ensure the completion of the network on time and in line with EU standards.

The evaluation also highlighted a need for a thorough assessment of progress on implementing the projects, particularly the projects located on the core network completed by 2030. This assessment would enable the identification of possible measures to ensure the completion of the network on time and in line with EU standards.

So, what is the problem?

In order to achieve the ambitious climate objectives that we have set ourselves, we certainly cannot concentrate solely on a recalibration of the standards or of the necessary

[18] The scope of this evaluation does not include concrete network planning, nor EU funding programs. During the evaluation process, stakeholders are therefore invited to focus their contributions on methodology and policy issues.

requirements; this would not in fact be sufficient to guarantee a complete transition to green and digital, but we should also proceed with an acceleration of the digitalization of transport itself, paying attention to the ever-changing expectations / needs of users.

The EC notes that an integrated network approach focusing on interoperability and increased efficiency is needed, while addressing all shortcomings, as it would help to achieve the milestones and objectives set out in the European Green Deal and Sustainable Mobility Strategy and intelligent.

In addition to building new physical infrastructures, the TEN-T policy supports the application of innovation, new technologies and digital solutions to all modes of transport. The aim is to improve the use of infrastructure, increase energy efficiency, reduce the environmental impact of transport and increase safety.
TEN-T comprises two network "layers":

- The Core Network includes the most important connections as it constitutes a network of connections between the major European nodes, and must be completed by 2030;
- The global network covers all European regions and must be completed by 2050.

The backbone of the Core Network is represented by nine Core Network Corridors, which have been identified to streamline and facilitate the coordinated development of the Core Network, complemented by two horizontal priorities, the European Rail Traffic Management System (ERTMS) and the motorways of the sea (whose supervision is the responsibility of the European Coordinators, appointed by the European Commission).

2.2.3. Cooperative, connected and automated mobility (CCAM)

In many ways, today's vehicles are already connected devices. However, in the very near future they will also interact directly with each other and with the road infrastructure. This interaction is the domain of Cooperative Intelligent Transport Systems (C-ITS), which will allow road users and traffic managers to share information and use it to coordinate their actions. This cooperative element, made possible by digital connectivity between vehicles and between vehicles and transport infrastructures, has been developed to significantly improve road safety, traffic efficiency and driving comfort, helping the driver to make the right decisions. and to adapt to the traffic situation.

Communication between vehicles, infrastructure and other road users is also key to increasing the safety of future automated vehicles and their full integration into the global transport system.

Cooperation, connectivity and automation are not just complementary technologies; they reinforce each other and over time they will merge completely.

These considerations were all made by the European Commission, which already in November 2016 adopted a European Strategy on Cooperative Intelligent Transport Systems (C-ITS), aiming at the convergence of investments and regulatory frameworks across the country. 'EU, in order to see the deployment of mature intelligent transport systems.

The initiative, divided into two phases that took hold in 2016 and 2019, can now be said to be concluded and some conclusions can be drawn.

The European Commission, during this initiative, had also started a discussion with the aim of drafting a European roadmap with short and long-term objectives for the testing and implementation of the CCAM.

The analysis carried out on this initiative clearly suggests that there are transnational aspects throughout the European Union relevant for the revision of the Delegated Regulation (for example the fact that most of the charging and refueling points and stations are on roads that are not part of the TEN-T network).

However, cross-border travelers in the European Union must have access to UVAR and recharge and refueling data in order to optimally plan your trips and avoid unknowingly violating any regulations.

Also, due to the nature of the data generated in the vehicle, the costs of making the data available

accessible through the NAPs would only marginally increase as a consequence of the increase in

geographical coverage, while helping to enhance ITS services both nationally and cross-border.

On the basis of the considerations on which this study is based, it can be concluded that, taking cross-border travel into account, it is necessary for road authorities to provide better traffic management services in order to ensure real-time traffic data on motorways and roads. a part

of the network in neighboring countries.
Even though some Member States have the capacity to implement their policies independently, to implement such a large initiative requires homogeneous data accessibility across the EU, and therefore requires the collaboration of each of the Member States, the more possible.

Several stakeholders consulted, including service providers, OEMs and public authorities, described the current situation as producing "black holes" of data that undermine ITS services. OEMs in particular indicated that Member States do not systematically take into account the cross-border dimension and end-user experience using cross-border mobility.

3.Conclusions

Please note that the aim of this work is to constitute a valid tool for analyzing the current state of the art and synthesizing it through the use of the Business Model Canvas (BMC) tool. Taking advantage of the reclassification of the same, it was in fact proceeded by analyzing the different characteristics and initiatives of the 5G-LOGINNOV project according to the two groupings "Environment-Oriented Traffic Management" and "5G - Logistic Corridor".

This subdivision made it possible to dismember some of the initiatives included within the 5G-LOGINNOV project to analyze them in a different perspective, which aimed precisely at the analysis of the proposals more oriented to traffic management and its transformation into green in the first case, and to the "construction" of the so-called logistic corridors, fundamental in a state of transition such as the one in which we find ourselves today, in the other.

It should also be noted that while in some cases, especially in identifying and explaining the different initiatives, it was easy enough to manage the separation "between the two worlds", in some cases the discussion on the two issues was instead very close, precisely because of the proximity of the initiatives, which managed to go "in both directions", but in general the work carried out, also thanks to the availability of multiple information as well as clarity, more often than not, proceeded very fluently.

The way in which the project presents itself finally makes Europe look like an organism that, in addition to having given itself a common name, has actually decided to collaborate in order to obtain a common good.
Indeed, among the many fundamental characteristics of this project we find the collaborative approach, achieved not only through the collaboration of the various states and companies, but also by exploiting the involvement of the largest possible number of stakeholders; this approach had already been characteristic of some other projects and initiatives (always included under Horizon 2020-EU), such as:

- COREALIS project, has been developed through the implementation of a 3-step 'Stakeholder driven approach' methodology; moreover, within the Innovation Palette of the COREALIS project PoSFG (Port Of The Future Serious Game) was also present: an innovative and interactive training and simulation game that is used to explore the feasibility and sustainability of port-city developments, aiming to raise awareness on present and future port-city challenges (such as the energy transition, digitization and climate change adaptation), by letting stakeholders explore the impacts of their actions in a virtual but realistic port setting;

- For instance, in Valencia port wanted to develop innovative solutions able to face the current problems and for this reason the Port Authority of Valencia organized a Hackathon in the framework of the COREALIS project to foster the collaboration among the port-logistics cluster and SMEs/start-ups;
- Hackathons: The aim is to mix-up the innovation and entrepreneur ecosystem with the port-logistics community to work together on collaborative projects that face the challenges proposed;
- Webinars: through them, even in the course of previous projects, a discreet dissemination has taken place that has brought different types of possible stakeholders to the project itself, linked to the problem at one or another level of the supply chain;
- Hackathons: they represent a great opportunity to put together stakeholders of a particular sector with the innovation ecosystem to generate new ideas, solutions and business models in a short amount of time. They mixe different professional profiles in teams facing specific challenges and that forces the participants to translate their visionary concepts down to actionable solutions;
- Partnerships: obviously they will be present in the case of sharing, by two or more stakeholders of objectives, long-term vision, etc.
- Large Scale Events: presentations, interviews, congresses that contribute to the dissemination of the result

All of these initiatives underline the inclusive nature of these projects, which increasingly seek to contribute to standardization, open source and community building.

This project has one of its cornerstones precisely on standardization: 5G-LOGINNOV is in fact part of a context already prepared by the 5G-PPP (Public Private Partnership) initiative; the latter, through the implementation of the various projects envisaged in its 3 phases, has determined for example:

- The search for a common and reliable infrastructure to be able to afford the use of 5G, entrusted to the 5G-MonArch project: the socio-economic analysis conducted within this project (WP6) and the results of the analysis obtained have begun to be used for various descriptions of business cases of external analysis companies of the consortium, serving as models for subsequent studies and tests;
- An innovative framework for design, development and orchestration of 5G ready applications and network services on sliced programmable infrastructure (MATILDA project);
- One5G: optimizations and improvements for the 5G New Radio edge network;

- Integration between different systems (5G-GENESIS), with study of procedures for the implementation and verification of the evolution of 5G standards;
- 5G Cross Border control (5GCroCo, border corridors)
- Cooperation and Automation of mobility on cross border corridors (5G MOBIX)

As we said earlier, therefore, this approach will be the same with which the 5G-LOGINNOV project will start: as we have said, 5G-LOGINNOV is from the conception phase, following a stakeholder driven approach, considering the main challenges of ports and port cities in view of the important changes brought by sea carriers and the transition to the new era of Industry 4.0 logistics based on extended 5G functionality; having together transport and logistics companies, local authorities, network and telecommunications operators, SMEs / start-ups and research institutes and, last but not least, port infrastructures, allows to have a complete understanding of the problem, under the multiple points of view from which it can be grasped, analyzed from all possible perspectives, so that each of the different participants can offer even just a further starting point for conversation.
As can be seen from figure 11, the Value Ring around the project is very extensive, as there are numerous stakeholders involved in the project.
Since there are so many people potentially reachable through the initiatives of these projects, the impacts that they could reach, both economic and environmental, are decidedly significant.

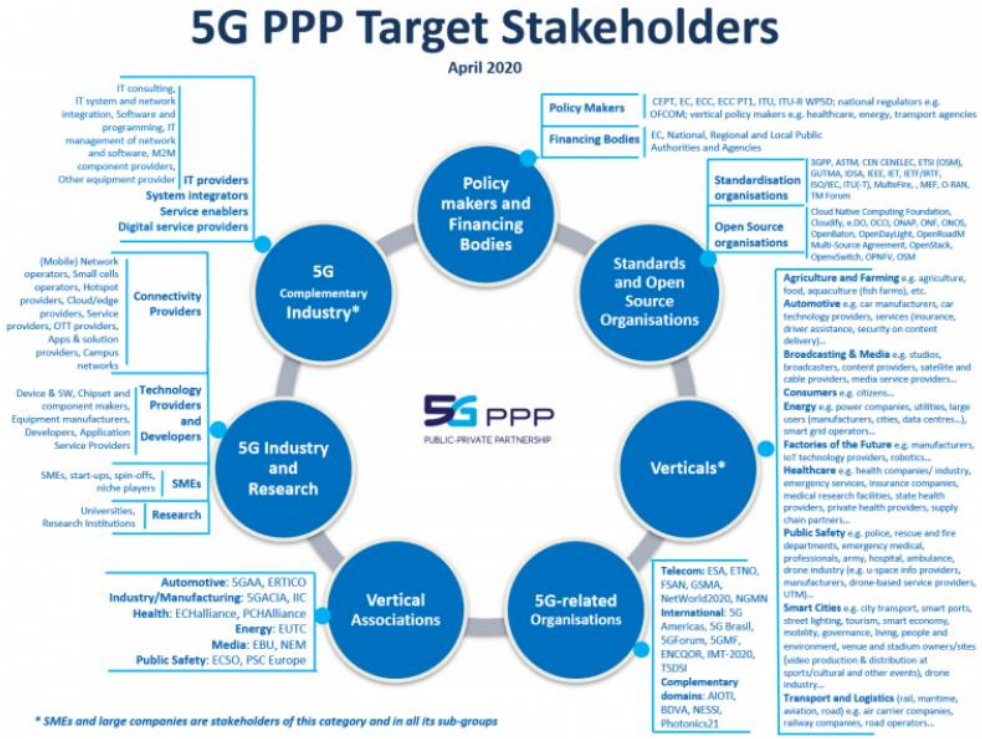

Figure 11: The 5G-PPP Stakeholders Glossary

At present, typical port operations tend to be limited due to the ever-increasing amount of data and therefore traffic produced by distributed sensors.
However, in order to proceed with an increasingly inclusive digitization, current technologies such as fiber optic connections or mobile networks based on 3G / 4G standards are not able to fully satisfy the needs, especially as regards automation. of operational and logistic processes. From this point of view, 5G is an indispensable technology for the development and implementation of the Smart Port concept.
The speech, however, is more complicated than it might seem: in order to be able to understand the significant impact that the 5G-LOGINNOV project, as well as those in which it has entered the path, intends to bring, one must first of all be able to understand the main characteristics of 4G and 5G networks (see Figure12[19]); one must then be aware of what the KPIs are, which ones are related to the project and how to analyze them.

Parameter	IMT-Advanced (4G)	IMT-2020 (5G)
Peak data rate	DL: 1Gbps UL: 0.5Gbps	DL: 20Gbps UL: 10Gbps
User experienced data rate	10Mbps	100Mbps
Peak spectra efficiency	DL: 15bps/Hz UL: 6.75bps/Hz	DL: 30bps/Hz UL: 15bps/Hz
Mobility	350km/h	500km/h
User Plane latency	10ms	1ms
Connection density	1 000 devices/km²	1 000 000 devices/km²
Energy consumption	1 (normalized)	1/10x of 4G

Figure 12: KPIs comparison among 4G and 5G

One of the key features of the 5G network is that it is the first to enable the support of many of the industry's processes; the latency is therefore very low: we are now talking about ultra-reliable and low latency communication (uRLLC).
Considering also the net increase in the number of IoT devices that will exchange information among themselves, in terms of connection density, despite the fact that a lot can be done in 4G (1,000 devices per square kilometer), 5G will allow the management of even millions of devices for square kilometer: this necessarily leads to the chance of having an incredible amount of real time data available per second.

However, it must be emphasized that, although mobile operators have already started to roll out 5G, this does not necessarily mean that 5G will be ready to be widely used by transport and logistics companies; certainly it will take some time for all requirements to be met, and some 5G features relevant to transport and logistics use cases may not be available for at least 2-3 years, without considering coverage in remote areas, which at least initially it could be a

[19] Source: techbylight.com, https://techbylight.com/5g-technical-guide-with-overview-details-specifications/

problem. Certainly, with the passage of time and the spread of this "new" collaborative mentality, the number of participants in the different initiatives would be destined to increase more and more, guaranteeing a clear push towards innovation.

Through the type of approach we were saying, it was also possible to involve a wider audience; SMEs, start-ups and research institutes can contribute to project experiments with dynamic and innovative ideas and, taking advantage of the growing adoption of 5G technologies, make open innovation possible at the service level. Thanks to open innovation and the support provided, it is possible to develop economic opportunities of 5G but also to develop and implement innovative applications that offer new business opportunities for consolidated SMEs and create start-ups with a high technological content. Transport and logistics companies want to improve freight transport and deliveries in the first place.

This project can allow these companies to better manage vehicles and goods thanks to the technologies related to 5G, connectivity and all the network functions, which living labs can experience and provide. Indeed, transport and logistics companies need a certain amount of data and information to achieve cost and transport efficiency. Even the physical infrastructure of the port can achieve an optimization of port operations and maintenance thanks to the 5G-LOGINNOV project, thinking, for example, of locating trucks in real time.

Still about this "new" open mentality, we can mention the Open Call. First of all it can be noted that the Open Call has been deliberately left as open and general as possible, given that all the candidate solutions will apply to the physical and infrastructural context of (one of the) three Living Labs; this decision is in full accord with the spirit of the 5G-LOGINNOV project, which once again tries to be as inclusive as possible.
It should also be noted that this choice could be a double-edged sword, as it will still be necessary to proceed, with the 5 start-ups that will be the winners of the Open Call, to integrate them into the 5G-LOGINNOV project, making them work directly on the service of the same.

It should certainly be borne in mind that the objectives set by the 5G-LOGINNOV project are not low, yet the difficulties that could be encountered are different and concrete:

- Regarding the port of Athens, the main problems/weaknesses to be found are traffic jams and queues on the quay inside the container terminal, the suboptimal allocation of container work based only on the truck pool of availability, the high risk of serious personal injury for dockside and rail workers terminal, the significant environmental footprint of the port in the surrounding urban area
- Regarding Hamburg, alignment of private and truck traffic within the overall traffic management in real time, missing green light solution to huge vehicles and for automated truck platoons, transparency on Floating Truck & Emission Data;

- Regarding Luka Koper, Traffic jams and quay side queues within the container terminal, sub-optimal container job allocation based only truck availability pools, high risk of serious bodily injuries for workers operating at the quay side and the rail terminal, significant environmental footprint of the port in the surrounding urban area

The project certainly proposes certain and high objectives, but it will then be seen how the achievement of the same will be posed in the three main LLs, through the different Use Cases that will be developed and analyzed.

While it is true that some problems, such as the risk of harm to people, the resolution of endless queues, or even the sub-optimal allocation of containers, could be achieved even with less effort, to be able to affect the total environmental footprint of the port. instead, we must commit ourselves with all possible strength, considering not only the goodness of the goal, but above all the challenges to be faced in order to achieve it.

With more flexible infrastructures with system integration, it is possible to improve the control of traffic or queues at the quay along the terminals, resulting in a better organization and a safer and more adaptable working environment. Network and telecom operators appear to be the most important stakeholders among 5G-related connectivity providers. They can be considered partners for living labs because different providers provide 5G network architectures at the three European living labs of the project considered (such as MNO, eMBB, mMTC, M2M), they provide capabilities but also resources. In this way, network and telecom operators can gain an economic advantage and earn a good reputation for the market and other 5G-related projects, indirectly expanding their market possibilities.

These 5G network architectures can of course be integrated with new augmented 5G features. Naturally, all the activities carried out are controlled by the authorities in respect of the safety and security of all the actors involved. A relationship between the local government and the port is important to cooperate and create an innovative environment that also has a positive impact on the urban area, in doing so the authorities must supervise the businesses and establish rules to follow. In this way, important advances in policies and standards can be achieved.
Thanks to this project, the authorities themselves can help identify the emergence of new global 5G standards taking into account port logistics and circumstances, providing active support to the penetration of the project.

Although the different initiatives envisaged by the project are directed partly towards the transition to a green, zero-emission Europe, and partly towards logistical optimization, and although they often seem to go hand in hand, it must be considered that each problem The fight against climate change is becoming more and more daily: the 5G-LOGINNOV project is in fact part of the European Green Deal.

Fortunately, air pollution has now become an integral part of daily discussions, as it has almost reached the fateful "point of no return".
An important objective that Europe has set itself, and which can certainly be achieved with the considerable contribution of the 5G-LOGINNOV project, is the reduction of CO2, and more generally of all emissions also linked to NOx: in fact, the project contributes to the decarbonization of transport by providing 5G solutions for a significant reduction in emissions, satisfying not only important local but also European policies, such as the European Green Deal.

Through the distribution of the project in the three Living Labs, we will try to reach:

- 10% higher load factors with the best combination of transport-routed mode reducing CO2 (potential > 15% reduction) measured through the increased use of more efficient means of transport (10% improved reliability on synchro-mode linked to Service Level Agreements (SLA))
- reduction of CO2 emissions, congestion and air pollution in order to improve the quality of life of European citizens and to achieve the objectives set by the Paris Agreement and the European Green Deal (December 2019).

However, it is important that all the words spent to date, all the ideas to allow Europe to truly become zero emissions, do not remain just words in the air but are quickly transformed into initiative, but rather to put a stop to climate change.

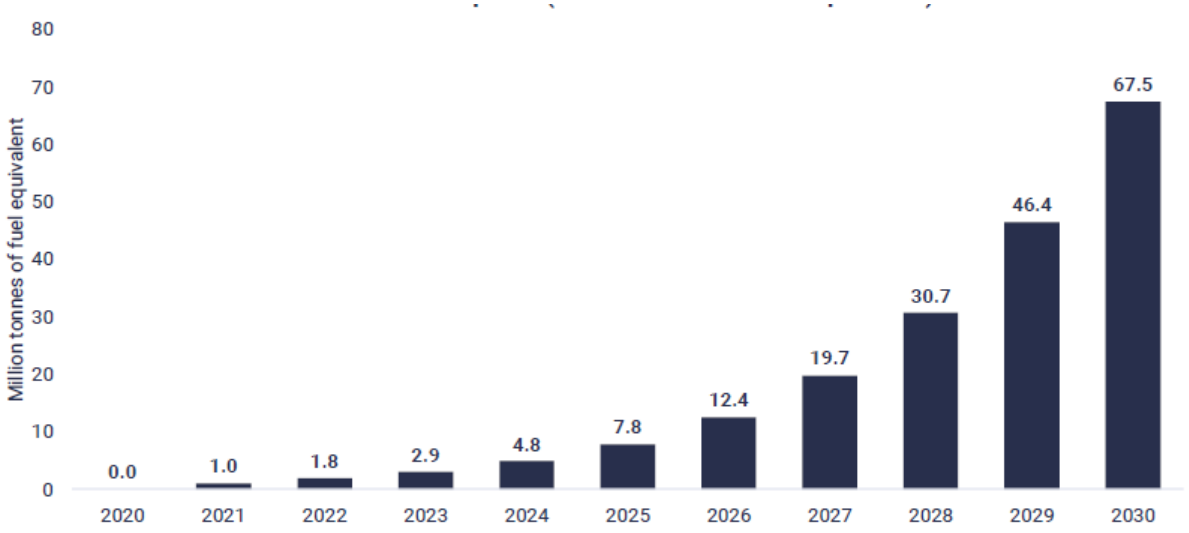

Figure 13:Decrease in fuel required (million tonnes of fuel equivalent)

By decreasing the distance traveled by vehicles and minimizing the time they spend in traffic, the amount of fuel consumed is reduced. By withdrawing for a moment from the 5G-

LOGINNOV project and generalizing to all projects in Europe, the connected traffic infrastructure alone could save 67 million tons of fuel in 2030 globally[20].
In addition, collecting more information throughout the supply chain can help to protect perishable goods and reduce waste in food supply chains.

To conclude, it is once again underlined how the advantages brought to the field by the project, and more generally by the presence of 5G as a basic network on which to build a pan-European infrastructure, are both direct and indirect, as well as environmental and economic as in other sectors. Indeed, any industry and indeed any person who uses the road infrastructure (driving, passenger in a car, bicycle, bus, etc.) will benefit from the development of different use cases.

If instead we focused for a moment only on use cases with a direct impact on the transportation and logistics sector, we would notice that 5G-enabled use cases could provide an increase in GVA (gross value added) of $ 70 billion in the 2030.

The possibilities offered by the 5G network are therefore exaggeratedly numerous: the 5G-LOGINNOV project represents a set of initiatives that attempt to exploit some of the many potentials of 5G networks, building on previous projects and continuing to pave the way for the future.

[20] Source: Mira Gilmore. (2020). *5G'S IMPACT ON TRANSPORT AND LOGISTICS: $280BN OF BENEFITS IN 2030.*

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