5GLOGINNOV

D4.1

Plan for boosting marketplace and emergence of new actors

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Authors	Michela Apruzzese (ICOOR) Stefano Musso (ICOOR) Mariangela Rosano (ICOOR)
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Authorised by (Technical Coordinator)	Eusebiu Catana	ERTICO	24/02/2021
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Abbreviation	Meaning
5G	5th Generation (of broadband cellular networks)
5G PPP	5G Public-Private Partnership
5GMF	Fifth Generation Mobile Communication Promotion Forum
AI	Artificial Intelligence
AR	Augmented Reality
ATP	Automated Tuck Platooning
CAD	Connected Automated Driving
CAM	Connected Automated Mobility
CAWI	Computer Aided Web Interview
CCTV	Closed Circuit Television
E2E	End-to-End
eMBB	enhanced Mobile Broadband
HPA	Hamburg Port Authority
IoT	Internet of Things
ITU-R	International Telecommunication Union – Radio communication sector
MEC	Multi-access Edge Computing
mMTC	massive Machine Type Communication
NB-IoT	Narrow Band Internet of Things
NZP	China's Ningbo-Zhoushan port
PG	Promotion Group
RRM	Radio Resource Management
RTPORT	Real Time Port
SME	Small Medium Enterprise
URLLC	Ultra-Reliable Low Latency Communication
VR	Virtual Reality
WP	Work Package

EXECUTIVE SUMMARY

The purpose of the present deliverable is to provide the baseline information to implement the 5G-LOGINNOV activities to boost market possibilities and involve new actors and start-ups in the project process. Thus, the document reports the main findings from the Task 4.1 “Strategy supporting next generation logistics operations”, mainly by analysing and assessing:

- The state-of-the-art of relevant past and current applications and ongoing projects (chapter 2).
- The level of knowledge of innovative technologies of the 5G-LOGINNOV living lab stakeholders (chapter 3).

As a result, this document highlights the stakeholders’ needs, gains and pains, and interactions needed to enhance the uptake of 5G-enabled core technologies and of other linked innovations. Based on these results and on parallel 5G-LOGINNOV activities (mainly within Task 1.1), this deliverable defines the 5G-LOGINNOV collaborative approach to enhance market opportunities of the new actors that will be involved in the project timeline (chapter 4).

Starting from a high level of knowledge and implementation of Logistics 4.0 enabling technologies, the most important activities for the panel of respondents are related with data collection and analysis and improvement of flexibility. The main expected benefits relate with the improvement of efficiency and service quality, thus optimising times and costs. Considering these results, real time data collection and information sharing are the most important implementations, and 5G and Cloud Computing are considered the main enabling technologies.

The development of new products and services need the creation of a collaborative network between different actors of the logistics chain, in which data and information are shared to create value. The low level of knowledge and trustiness of the respondents in data sharing technologies (in particular Blockchain) is a potential barrier for future implementations. For these reasons, the proposition of new 5G-based products and services must focus on the definition of collaborative environments within the Living Labs, with the aim of improving the effectiveness of the processes through an optimisation of the overall logistics chain, at the same time ensuring a high level of data protection. Moreover, all the new products and services proposed by the open call participants must provide a clear economic assessment of the potential benefits, through the development of collaborative and sustainable business models. The 5G-LOGINNOV Living Labs are, in this perspective, a very important chance to develop and test new products and services, as well as new collaborative business models, in a limited scale, with the aim to assess their future scalability and replicability on wider markets.

1 INTRODUCTION

1.1 Project overview

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

1.2 Purpose of the deliverable

Attainment of the objectives and explanation of deviations

The objectives of the deliverable are to provide an assessment of the current applications of technology-based innovations in the logistics field, with particular focus on port operations. Moreover, the current level of knowledge and implementation of Logistics 4.0 enabling technologies has been assessed through a survey administered to a set of companies involved in the activities of the Living Labs.

The present deliverable will provide input for Task 4.2 “Emergence of New Actors”, specifically for the design of the Open Call and to foster the integration of new actors in the project consortium and in the market. It will be relevant as it represents the baseline source of information to build new business models in Task 4.3 “Boosting economic opportunities”. The outcomes of D4.1 will feed the definition and development of the exploitation strategies in Task 5.3 “Exploitation” and will contribute to Task 5.4 “Standardisation and Spectrum” to foster the interoperability between existing stakeholders and new actors (SMEs and start-ups).

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

1.3 Intended audience

The present deliverable is the primary source of information on market opportunities to new actors (i.e., start-ups) and established actors of the project to create new businesses and emerge in the market. It provides a detailed qualitative and quantitative analysis of the market scenario and requirements in the use cases that will be implemented and demonstrated at the three Living Labs of the project. Furthermore, the document provides the industrial stakeholders with market and business models, as well as strategies allowing 5G core technologies for logistics to enter in the market in the

short to medium term. This document provides relevant advice to project partners that will implement engagement strategies in the project activities.

1.4 Structure of the deliverable and its relation with other work packages/deliverables

The present deliverable is the output of the first phase of Task 4.1 “Strategy supporting next generation logistics operations”. The document has the following structure:

- Chapter 2 provides an overview of 5G applications in logistics, with emphasis on main products and stakeholders involved in the different projects and initiatives and a detailed analysis of the lessons learnt.
- Chapter 3 explains the methodology used in 5G-LOGINNOV Living Labs to assess stakeholders’ needs, requirements and current business habits, including the analysis of the assessment results.
- Chapter 4 summarises all learnings from the Task 4.1 analysis up to M6 of the project and provides a plan to boost next generation logistics operations, in the 5G-LOGINNOV context.
- Chapter 5 illustrates the main conclusions and the final remarks.

2 CURRENT MARKET SCENARIO OF 5G APPLICATIONS

The movement of freight across the world increases to face the requirements of the modern economy. This implies the collection of data through a multitude of different sources across the supply chain, as well as the need of connectivity solutions to improve the sharing of data in a secure and reliable manner, and the efficiency of operations in logistics and transportation. Indeed, the sheer amount of fast-moving assets (e.g., vehicles, trains) requires maintaining a stable connection. Thus, 5G technologies are gaining momentum to cope with these issues and support the digital transformation in logistics and transportation. The key benefits that 5G technologies can provide to the transportation and logistics industry are:

- **Device density and data volume**. 5G technologies are able to connect and support more smart devices (from temperature-monitoring sensors to vehicles) than the predecessors, with a huge amount of data collected and shared through the network.
- **Low latency**. Latency refers to the end-to-end communication delay. 5G technologies have good latency performance so that data is captured real-time, allowing the highest mobile connection speed, even when the number of objects connected to the network is large. With faster speeds and low time gap, smart devices can communicate faster with one another, close to real-time, fostering the adoption of time-sensitive Internet of Things devices applications relevant in the logistics and transportation field.
- **Network slicing**. Network slices are separate virtual networks that run on the same physical network infrastructure to meet different connectivity needs.
- **Minimizing supply chain risks improving the visibility**. With 5G implementation supporting a large number of sensors, it will help provide end-to-end communication and improve the supply chain visibility that, according to 90% of logistics and shipping providers [1], represents one of the biggest challenges in the logistics industry today.
- **Faster and safer port operations**. 5G technologies' performance allows fast and reliable connection, helping to create lean, secure and effective operations in ports.
- **Enhanced communication, repairs and problem solving** through virtual reality or augmented reality technologies.

A study by the STL Partners [2] provides some of the key use cases that 5G will enable and maps the 5G capabilities that are most relevant to each use case (Figure 1).

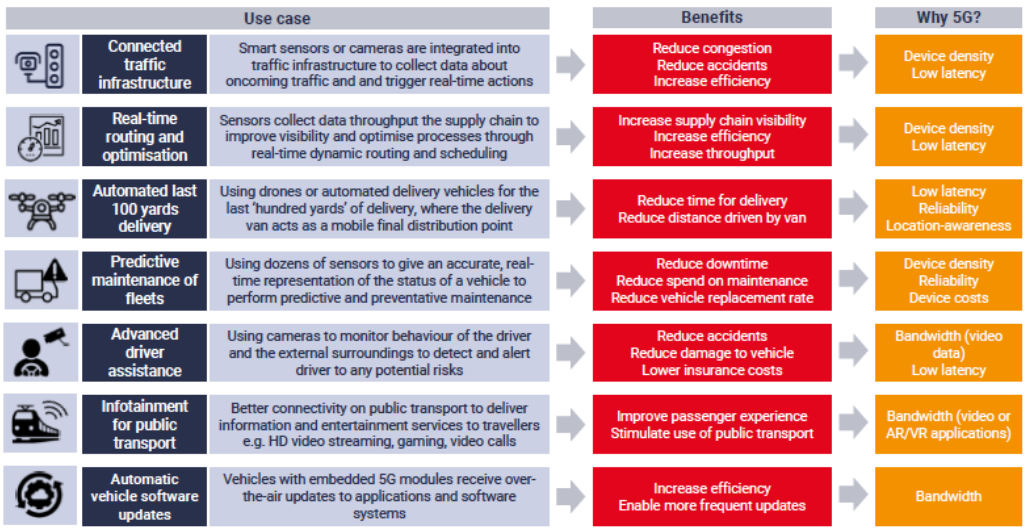


Figure 1. Use cases in the transport and logistics industry enabled by 5G [2].

The next sections provide an overview of the state-of-the-art on the application of 5G technologies to the transportation and logistics industry. Section 2.2 provides a description of linked initiatives, projects and implementations; while section 2.3 presents the lessons learnt, using a quantitative and qualitative analysis of the most relevant characteristics of the analysed projects, to derive patterns and trends and identify market opportunities.

2.1 Linked initiatives, projects and implementations

Several initiatives, projects and implementations have been funded from national and European bodies to deal with the applications of 5G technologies in the supply chain, and in particular in the port domain. 5G technologies, integrated with other innovative technologies (AI, Big Data, IoT, and autonomous vehicles), are expected to increase the development of ports' automation. Currently, high-level automation has already been used for container terminals to improve productivity and efficiency, and is considered to be essential to maintain competitiveness over the next years. Therefore, automation will become a key element to ensure a competitive advantage among innovative ports. 5G implementations for port operations will enable massive real-time data collections and analyses, increasing intelligent automation and laying the foundations for better coordination between humans and devices. This transformation will allow an increase of competitiveness by offering reduced costs and greater efficiency.

The next sections will provide examples of projects linking 5G potentialities with (port) logistics.

2.1.1 5G Public-Private Partnership (5G PPP)

The 5G Infrastructure Public-Private Partnership (5G PPP) [3] is a joint initiative between the European Commission and the European ICT industry (ICT manufacturers, telecom operators, service providers, SMEs and research institutions) aiming to provide solutions, architectures, technologies, and standards for next-generation global communications. The challenge for the 5G PPP is to ensure the European leadership in the areas in which Europe is strong or where there is the potential for creating new markets such as smart cities, e-health, smart transport, education or entertainment, and media. This initiative aims to strengthen the European industry to successfully compete in global markets and open new opportunities for innovation. It will facilitate the creation of "*a platform that helps in achieving the common goal of maintaining and establishing global technology leadership*" [3].

The main challenges for 5G PPP are:

- To provide 1000 times the wireless area capacity and more varied service capabilities than in 2010.
- To reach up to 90% energy savings per service provided.
- To reduce the average service creation time cycle from 90 hours to 90 minutes.
- To create a secure, reliable, and trustworthy internet connection with "perceived zero" downtime for service delivery.
- To facilitate very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people.
- To ensure everyone and everywhere the access to a larger board of services and applications at a lower cost.

The key objective of the 5G-PPP enabled system is to support new implementation scenarios to address different market segments, and to provide optimised support for a variety of different services, different traffic loads, and different end-user communities. The stakeholders involved in the 5G PPP initiative (Figure 2) come from different sectors, both public and private, in order to provide all the different competencies needed for the achievement of the goals.

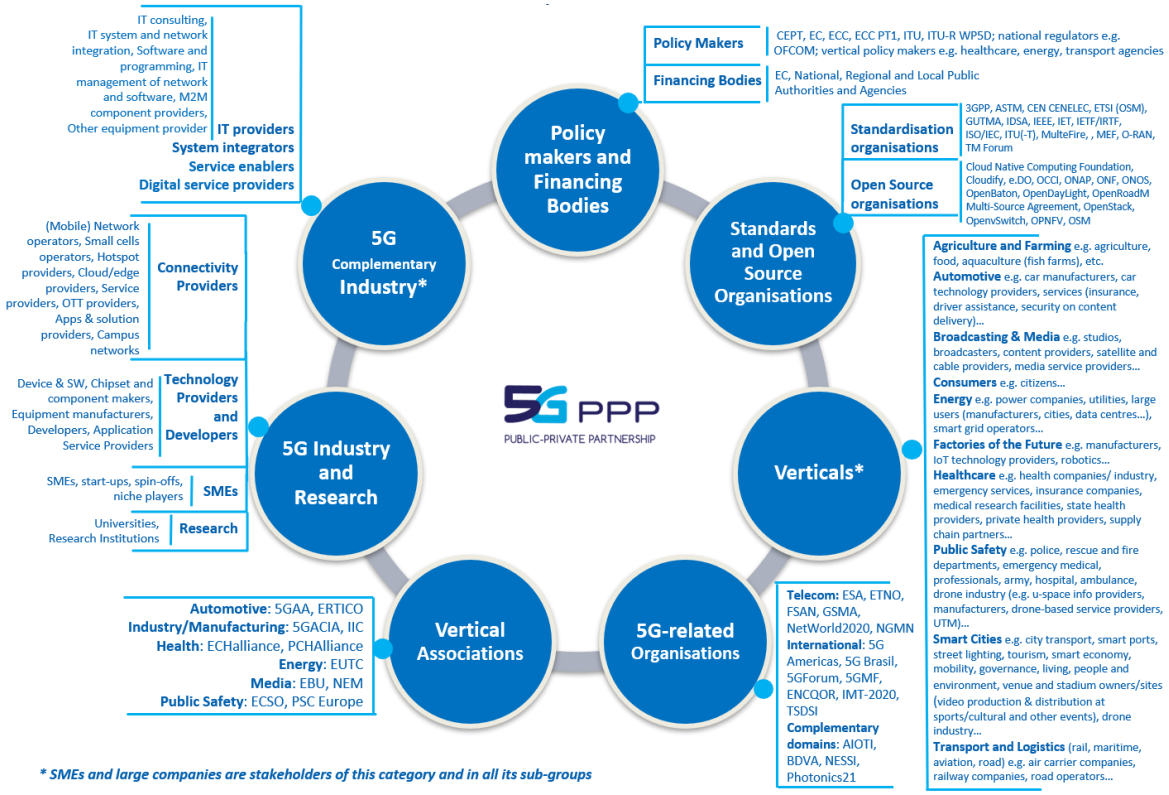


Figure 2. Stakeholders involved in 5G PPP initiatives [3].

Based on the results of surveys conducted in February-April 2016 [5], the most important stakeholder groups are the standardisation organizations, which aim to define the technical standards that are intended to meet the needs of a relatively large base of interested adopters. The second important actor within the 5G PPP initiative is the end user (this term considers the end-users, the application services providers, the media and entertainment providers, the content producers, and the research organizations). At the third place of the importance ranking stands the 5G industry, which is comprised of all general business or commercial enterprises that use or are interested in fifth generation (5G) technologies. The 5G sector incorporates connectivity providers, service providers, technology providers, SMEs, and start-ups (market integration of SMEs and start-ups are also main goals of 5G-LOGINNOV project).

2.1.2 Other global 5G initiatives

At the global level, the 5G Infrastructure Association [6] cooperates with the different global 5G institutions, summarised in the following **Error! Reference source not found.**.

Institution	Site	Members	Nature	Goals
5G Brasil [4]	Brazil	65 institutions: industries, universities, research centres, telecom operators and industry associations	Private	Promote the development of 5G ecosystem in Brazil through the following activities: • enabling and establishing the communication between the ICT sector and all spheres of government and regulatory agencies in Brazil; • looking for financial support for the promotion and use of 5G technology; • promoting national and international

				cooperation agreements for 5G technology development and adoption; • establishing and maintaining open interaction with non-ICT organizations; • sharing information regarding 5G.
Fifth Generation Mobile Communications Promotion Forum (5GMF) [7]	Japan	158 institutions: industries, universities, research centres, telecom operators, local administrations	Private and Public	Conduct research and development on 5G including the following activities: • engaging in research & development concerning 5G, as well as research and study pertaining to standardization thereof; • collecting information on 5G Mobile Communications Systems and exchange thereof with other organizations; • acting as a liaison and coordinating with related organizations concerning 5G Mobile Communications Systems; • promoting education and awareness about 5G.
5G Forum [8]	Korea	Mobile network operators, global manufacturers, universities, research centres, government	Private and Public	• Provide an open platform where different actors can contribute and collaborate to 5G research and development. • Assist in the development of standards and contribute to its globalization.
5G Americas [9]	America	17 industry-trade institutions: telecommunications service providers, wireless carriers, device manufacturers, network operators	Private	Foster the advancement and full capabilities of LTE wireless technologies and their evolution to 5G in the Americas.
International Mobile Telecommunications IMT-2020 [10]	China	Telecommunications service providers, universities, research centres	Private and Public	Promote research on 5G in China.

Table 1 5G Global actions

2.1.3 Port of Ningbo-Zhoushan

- Type: Pilot project
- Start and End dates: 2018-2019

Particularly relevant is the case of the Chinese Port of Ningbo-Zhoushan (NZP) [11], one of the top three busiest ports globally and first in the world by volume of goods for 11 consecutive years. Due to the high volume of cargo that transits in this port as well as the high daily rental costs for large vessels, it had the strong need for improving the operational efficiency, while reducing costs and at the same time boosting the automation. In this direction, a pilot project for the adoption of 5G technology in this port started in 2018, with the collaboration of Huawei, China Mobile Zhejiang, and a team of partners working with the port operator, Zhejiang Seaport Investment and Operations Group. The pilot project at NZP was devoted at improving remote gantry crane operations, management and video backhaul applications based on the 5G network.

Due to this innovative application, the port was one of the first places to resume operations during the COVID 19 pandemic, representing a massive step in stimulating the recovery of national and global logistics systems. Nowadays, the port reaches a full 5G coverage and the pilot application has been scaled in regular commercial use, realizing huge cost and efficiency gains [12]. The port of Ningbo-Zhoushan can rely on three main 5G applications for cargo ship unloading:

- *Smart cargo handling*. The 5G-based solution implemented in the port allows operators to manage the processes related to cargo handling through video images captured by 15 channels of high-definition cameras, which are distributed locally through multi-access edge computing (MEC) deployed in the port server room. Moreover, an Artificial Intelligence (AI) object recognition system provides information on the port's status, including the number and type of containers, the number of terminal truck operations, the single container's loading position, and the lane number. The main benefits are the improvement of the smart cargo handler working environment and efficiency in terms of temperature, movement of trucks, damage checks and stowage.
- *Automated self-driving trucks' logistics*. To cope with the need of having high-skill-container trucks drivers working in three shifts a day to cover port operations 24/7, this application aimed at positioning capabilities and MEC fostering the adoption of automated guided vehicles. In doing so, a 360-degree video of the interior and exterior of self-driving trucks is transmitted in real-time to the control room through a dedicated 5G end-to-end network, combined with vehicle-road coordination, high-precision positioning, and an automated control positioning that improves the trucks' accuracy of positioning. The main benefits of the adoption of 5G unmanned trucks are the reduction of labour costs, while improving the port's operating efficiency and safety, evolving the port from a labour-intensive industry to automated, smart, and unmanned.
- *Remote control of gantry cranes and port cranes for containers*. When the unmanned truck is parked in the yard, the gantry crane operator grabs the container on the truck and places it in a designed area. A 5G private network with very low latency, very high reliability, and wide upstream bandwidth allows operators to manage all the processes in real-time from a remote-control room.

2.1.4 5G-MoNArch – Mobile Network Architecture

- Type: 5G-PPP project (Research and Innovation action)
- Start and End dates: 2017-2019

The **5G Mobile Network Architecture for diverse services, use cases, and applications in 5G and beyond** (5G-MoNArch) [13] is a project conducted within the 5G-PPP initiative and has been funded by the European Commission under contract number 761445 within the Horizon 2020 Framework Programme. This project focuses on developing a flexible, adaptable and programmable mobile network architecture for 5G. The architecture and the innovative enablers (i.e., Inter-slice control and cross-domain management; experiment-driven modelling and optimisation; and native

cloud-enabled protocol stack) are brought into practice through prototype implementations in two testbeds. The aim is to gain knowledge and experience from using 5G network slicing in a real-world environment, prove and improve the underlying technical concepts and methods. Indeed, the Smart Sea is a testbed implemented by the collaboration of Nokia and Deutsche Telekom, which integrates 5G into control and monitoring systems for traffic and infrastructure in an industrial sea-port environment, as the Port of Hamburg (Germany). The overall goal of the testbed is to provide a wireless infrastructure that can handle a large number of the use cases of the port's day-to-day work. As shown in Figure 3, the testbed deploys three network slices:

- An Ultra-Reliable Low Latency Communication (URLLC) slice for connecting a traffic light to the port's traffic control centre, to enable the improvement of the traffic flows for trucks within the port area.
- An enhanced Mobile Broadband (eMBB) slice serving interactive Augmented Reality (AR) for engineering teams to improve certain port operations such as asset maintenance and repair.
- A Massive Machine Type Communication (mMTC) slice to connect environmental sensors installed on mobile barges to the application cloud of Hamburg Port Authority (HPA) for measuring air quality in the port and emissions.

These slices are used to implement three different use cases and requirements:

- Improve port traffic management with a reliable and resilient network, through the integration of the existing traffic light control with 5G modem that supports network slicing. These traffic lights are connected to the port's central road traffic control management through the 5G mobile network.
- Improve port operations using 5G technologies and VR or AR.
- Mobile sensors on barges for emissions measurement. Environmental measurement sensors are installed on three HPA ships to provide data related emission and current air quality in port area in real time.

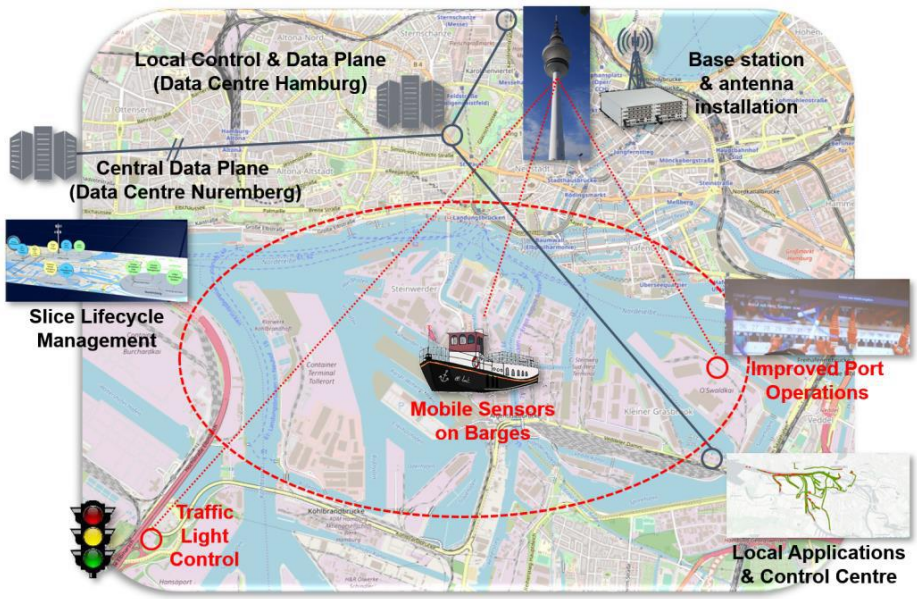


Figure 3. Hamburg Smart Sea Port testbed schematic setup and use cases [13].

2.1.5 Port of Zeebrugge

- Type: Project
- Start and End dates: 2019-2020

The **Belgian Port of Zeebrugge** started in 2019 a project with Citymesh and Nokia to develop a 5G network that provides wireless connectivity to more than 100 endpoints (e.g., tugboats, air pollution detectors, security cameras and quay sensors) across the entire port operations [14]. The aim of the project is twofold. On the one hand, the data network is used to improve safety, monitor the environment and support the building projects of the port, improving the communication during the construction and maintenance of offshore wind farms. On the other hand, the project aims at driving the acceleration of innovation in the port, with regards to IoT, autonomous vessels, augmented reality and drones, positioning the Port of Zeebrugge as leading innovator in logistics automation, port transformation, and digitalisation. Indeed, the port aspires to test itself in technological innovation and become a real living laboratory for the complete digitalisation of port operations. 5G technology for Zeebrugge is a real investment in the direction of a hyper-connected and automated future, to be achieved through an effective, secure, and real-time information exchange between companies, port authorities, and service users.

2.1.6 5G Port of the Future Living Lab Port of Livorno - COREALIS

- Type: H2020-EU.3.4. (Research and Innovation action)
- Start and End dates: 2016-2021

The **Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era** (COREALIS) [15] research program proposes a strategic and innovative framework for cargo ports, supported by disruptive technologies as 5G networks, with the aim of improving operational efficiency, addressing environmental challenges, and handling capacity of shipyards and rationalising the flow of goods without further infrastructure investments [15]. The proposed innovations are tested in real operating conditions in 5 living labs at the ports of Piraeus, Valencia, Antwerp, Livorno, and Haminakotka. As part of the Corealis program, the Port of Livorno (Italy) hosted the project 5G Port of the Future and the initiative called “Logistics of the future in Sustainable Smart Ports”. The initiative consists in a public-private partnership involving Ericsson, the Port System Authority of the Northern Tyrrhenian Sea, and the National Interuniversity Consortium of Telecommunications (CNIT). The objective is to demonstrate how the integrated information coming from different devices and ships within the port area, coupled with the improvements coming from augmented reality technologies and in connection with advanced control algorithms at a centralised level, can speed up loading and unloading operations and improve personnel safety. Moreover, 5G technologies improve the real-time exchange of information, reducing the unnecessary handling operations at the same time, thus optimising the overall processes and reducing the environmental and societal footprint of port operations. As indicated in Figure 4, this can be achieved by means of a set of IoT devices connected through 5G network and the Real Time Port (RTPORT) solution to improve automation in cargo operations (e.g., identification and registration of arriving pallets in the docking area, finding proper pallet on the crane for the loading). As a key enabling technology for RTPORT, 5G enables the adoption of VR (i.e., Panda3D Carnegie-Mellon University/Disney and Unity 3D) and AR for optimal sorting of freights in the yard and remote quality check.

Figure 4. Livorno Living Lab innovations [16].

2.1.7 5G-EVE - European 5G validation platform for extensive trials

- Type: 5G-PPP project (Research and Innovation action)
- Start and End dates: 2018-2021

Another relevant project is the **European 5G validation platform for extensive trials** (5G EVE) a 5G-PPP infrastructure project with the aim to implement and test advanced 5G infrastructures in Europe, to foster the adoption of AGVs, real-time image processing, 5G end-to-end facilities, and smart transport [17]. 5G EVE is based on developing and interconnecting four existing European sites to form a unique 5G end-to-end facility, which is composed by various elements, such as 5G New Radio, distributed Cloud, MEC, and slicing [18]. The European sites involved as facilities are the following: Torino (Italy), Madrid (Spain), Athens (Greece) and different locations in France. More in detail, according to Gupta et al., 2019 [18], in these cities have been developed the following specific use cases:

- Smart Transport: Intelligent railway for smart Mobility – at 5G EVE Torino facility.
- Smart Tourism: Augmented Fair experience – at 5G EVE Madrid.
- Industry 4.0: Autonomous vehicles in manufacturing environments – at 5G EVE Madrid facility and Athens facility.
- Utilities (Smart Energy): Fault management for distributed electricity generation in smart grids – at 5G EVE France facility and Athens facility
- Smart cities: Safety and Environment – at 5G EVE Turin facility and Athens facility
- Media & Entertainment: UHF Media, On-site Live Event Experience and Immersive and Integrated Media – at 5G EVE France and Spain facilities

2.1.8 5G-GENESIS

- Type: 5G-PPP project (Research and Innovation action)
- Start and End dates: 2018-2021

The **5th Generation End-to-end Network, Experimentation, System Integration, and Showcasing** (5G GENESIS) project aims to develop a set of end-to-end and experimental platforms to facilitate 5G and related experimentations [19]. Each platform is associated to a specific city as follows:

- The Athens Platform demonstrated in the Egaleo city sport event, is based on an edge-computing-enabled shared radio infrastructure, with different ranges and overlapping coverage to support secure content delivery and low latency applications in large public-events.

- The Málaga Platform is implemented within the public safety scenario and it is characterised by the automated orchestration and management of different network slices over multiple domains, on top of the 5G NR and fully virtualised core network to showcase mission-critical services in the lab and in outdoor deployments.
- The Limassol Platform where radio interfaces of different characteristics and capabilities, combining terrestrial and satellite communications, are integrated to showcase service continuity and ubiquitous access in underserved areas. This platform is demonstrated in cargo vessel routes in the city of Limassol (Cyprus).
- The Surrey Platform implemented in the Surrey sport event, with multiple radio access technologies that can support mMTC, including 5G NR and NB-IoT, combined under a flexible RRM and spectrum sharing platform to showcase massive IoT services.
- The Berlin platform is demonstrated in the Festival of Lights and in this platform ultra-dense areas are covered by various network deployments, ranging from indoor nodes to nomadic outdoor clusters, coordinated via advanced backhauling technologies to showcase immersive service provisioning.

Given the field of port application, in this deliverable we focus on the Limassol platform, which is based on two use cases: maritime communications and capacity-on-demand in rural/underserved areas through the management and interconnection of IoT devices and platforms in the 5G environment (Figure 5).

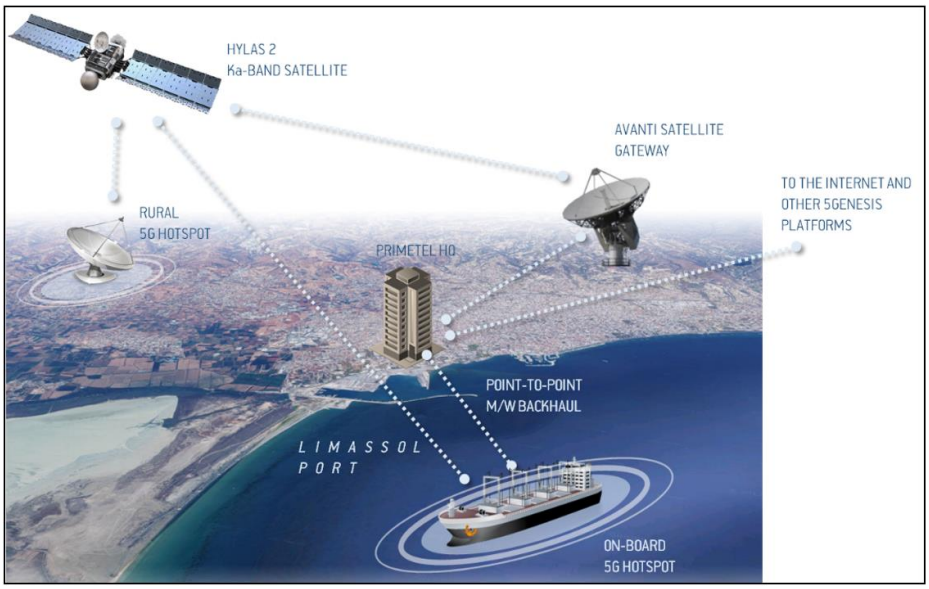


Figure 5. 5G Genesis facility at the Limassol port [20].

2.1.9 5G-SOLUTIONS

- Type: 5G-PPP project (Research and Innovation action)
- Start and End dates: 2019-2022

5G Solutions for European Citizens (5G-SOLUTIONS) [21] is a European project implemented in phase 3b of the 5G PPP roadmap [22]. The aim of the project is to validate that 5G is a prominent technology starting from five significant industry vertical domains in five countries, to exploit the real commercial potential of 5G:

- Factories of the Future, in Belgium, Ireland and Norway.
- Smart Energy, in Italy.
- Smart Cities, in Ireland and Norway.
- Smart Ports, in Norway.

- Media & Entertainment in Greece and Norway.

With focus on the Living Lab in Norway, the project aims at developing innovative use cases (i.e., Autonomous assets & logistics for smart port and Port safety: monitor & detect irregular sounds) regarding smart solutions to optimise and improve the operational efficiency and reduce logistics costs in the port. In this regard, 5G using mMTC, eMBB, URLLC, virtualisation and slicing will be able to respond to the necessities of the ports of the future.

2.1.10 5G-MOBIX

- Type: 5G-PPP project (Innovation action)
- Start and End dates: 2018-2022

The **5G for cooperative & connected automated MOBIility on X-border corridors** (5G MOBIX) project is co-funded by the European Commission and it is part of the 5G-PPP Phase 3. It aims to develop and test automated vehicle functionalities using 5G core technological innovations along multiple cross-border corridors and urban trial sites [23]. One of the main objectives of 5G-MOBIX is to deploy a set of automated mobility use cases such as truck platooning, vehicle remote control, entertainment and media, highway lane merging, road user detection and urban environment driving.

2.1.11 5G CREATE COMPETITION - PORT OF FELIXSTOWE

- Type: Pilot project
- Start and End dates: 2020-2022

5G CREATE [24] is an open competition under the 5G Testbeds and Trials Programme promoted by the British Government. The aim of the programme is investing in testbed facilities and application trials in order to accelerate the deployment of 5G networks that can help in improving the productivity and efficiency in UK, as well as identifying new opportunities. The Port of Felixstowe has been selected within the 5G Trials and Testbeds Programme to manage investment and innovation in 5G based technologies. The UK port is the first national port to deploy 5G technology and integrate the IoT to enhance productivity, efficiency and safety across its core operations. Working with its partners (Three UK, Cambridge University and Blue Mesh Solutions), along with key subcontractors (Ericsson and Siemens), the project will test the potential of 5G across two use cases: enabling remote-controlled cranes via the transmission of CCTV and; deploying Internet of Things sensors and Artificial Intelligence to optimise the predictive maintenance cycle of the port. The British Government is looking to create a number of Freeports across the UK. The Port of Felixstowe, together with the Harwich International Port, aims to create a major Freeport centred on the two East Coast ports. In this direction, the 5G trial will help deliver on the Government's objective for Freeports to work as hotbeds for innovation and as hubs for global trade due to IoT connectivity sensors, high-speed communication and low latency standards.

2.2 Lessons learnt on current market scenarios and future perspectives

This section provides a quantitative and qualitative assessment of the most relevant characteristics of the projects mentioned in section 2.1. The methodology used to analyse the projects adopting 5G technologies and identify current patterns and future opportunities, adopts the classification shown in Figure 6, inspired by the taxonomy proposed in the studies [25] [26].

Description		
Technologies	**Network Slicing**	**Objectives**
Artificial Intelligence	*MEC*	*Reduce environmental impact*
Blockchain	*URLLC*	*Autonomous vessels/self-driving vehicles*
Cloud	*mMTC*	*Remote control of cranes*
IoT	*eMBB*	*Safety (port and personnel)*
5G		*Logistics automation*
Augmented Reality/Virtual Reality		*Efficiency and productivity in port operations*
Robotics		*Maritime communications*
		5G capacity on demand in rural /underserved areas
		Smart mobility
		Truck platooning
		Accelerate innovation in port
		ICT tool to support operations
		Smart cargo handling
Project initiator	**Stakeholder**	**Sector**
Public	*Local Administration*	*Smart Port*
Private	*Logistics and Transportation company*	*Other sectors*
Mixed	*Citizens/Customers*	*Smart mobility*
	Port Authority	*Smart transport and logistic*
	ICT & Telco Company	
	Other company	
	University & Research Institution	
Business model		
Management	**Infrastructure financing**	**Financial resources**
Public	*Public*	*Public*
Private	*Private*	*Private*
Mixed	*Mixed*	*Mixed*
Purpose		
End-User	**Product**	**Geographical Target**
Local Administration	*Running solution*	*Local*
Logistics and Transportation company	*Ongoing development*	*Europe*
Citizens/Customers	*Specified product/service*	*International*
Port Authority/Operators		
Company		
University & Research Institution		
City		

Figure 6. Classification of 5G projects.

We consider three levels of detail: Description, Business Model, and Purpose. Each axis is structured at the second level in several categories limiting the possible values while preserving the statistical significance. For each category at the second level, more precise information is provided by subcategories at the third level. Due to the large number of factors that play important roles in defining a smart city, we decided to consider only the axes at the root level as mutually exclusive and jointly exhaustive. For the sake of brevity, we describe in the following the first two levels of axes.

- **Description**. It provides an overview of the project and its context, with particular regard to the objectives faced (Objectives), the industry (Sector), the technologies adopted (Technologies), the services related to 5G that are provided (Network slicing services), the nature of the project initiator (Project initiator), and the key actors involved (Stakeholders).
- **Business model**. It addresses the aspects related to the project management and, the business and governance models. In particular, it investigates the nature of the project manager (Management) and the providers of infrastructures, equipment and financial resources (Infrastructure financing and Financial Resources).
- **Purpose**. It refers to the final goal of the project. It identifies the user that will adopt, and benefit from the solution developed by the project (End user), the type of product in relation to the development state (Product) and the geographical target (Geographical target).

Concerning the first category “Description”, Figure 7 shows the technologies adopted in the analysed sample of project. Notice that the sum of the percentages is higher than 100% due to the multiple technologies adopted in each initiative. Given the focus on projects based on 5G-based technology, the greatest part of the projects relies on the use of 5G network (100%) followed by Artificial Intelligence and Machine Learning-based functions in different functionalities of the network (78%) and IoT sensors (e.g., air pollution detector) connected to the 5G network to obtain real-time data (67%). Indeed, 5G is tested to speed up data exchanges between actors involved in operations, with IoT,

augmented reality/virtual reality (25%), including the design of elastic virtual network functions, to allow graceful resource scaling for cloud resources (44%) [13]. For example, several projects adopt augmented reality/virtual reality technologies to support day-to-day operations of drivers, optimise the intra-terminal operations, and to enable fast delivery of documentation and pictures or video material.

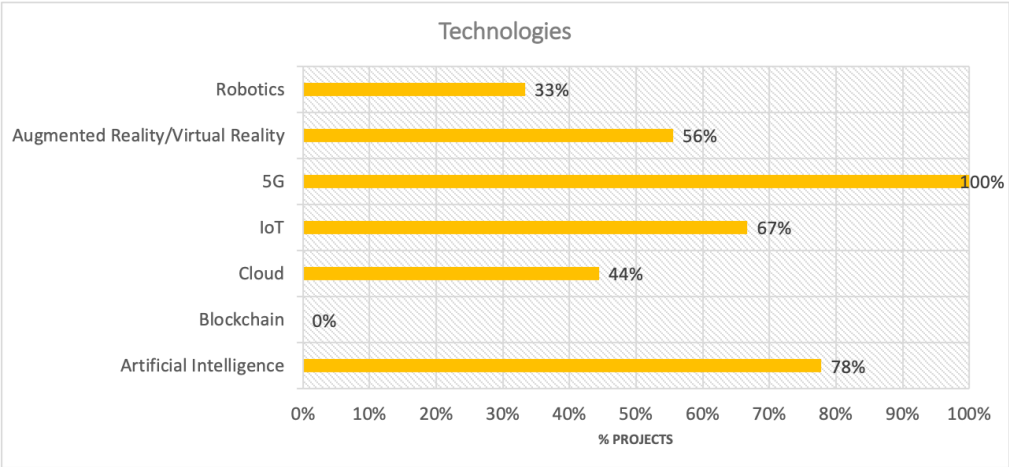


Figure 7. Technologies.

As Popovski et al. (2018) point out [27], the main objective of 5G wireless technology is to support three generic services with vastly heterogeneous requirements that according to the ITU-R are: eMBB, mMTC and URLLC. Basically, eMBB supports stable connections with very high peak data rates, as well as moderate rates for cell-edge users; mMTC supports a massive number of IoT devices; URLLC supports low-latency transmissions of small payloads with very high reliability from a limited set of terminals, which are active according to patterns typically specified by outside events, such as alarms.

In the analysed projects, E2E network slicing services enable flexible slicing of 5G network resources into multiple virtual networks to meet specific customers' requirements. Indeed, E2E network slicing is usually associated with especially different service requirements in various scenarios (Figure 8), such as URLLC (67%), and mMTC (56%), and MEC (56%), eMBB (44%).

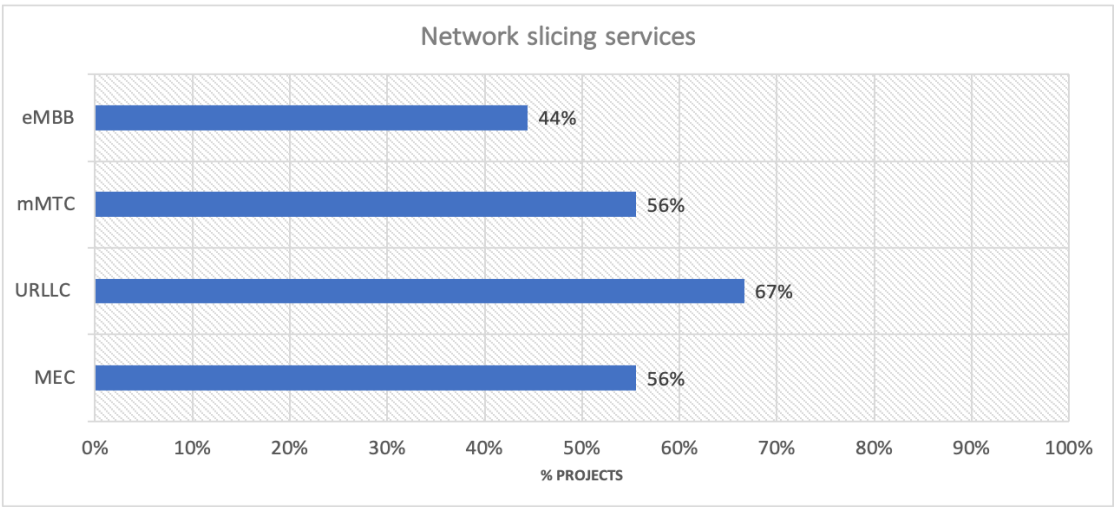


Figure 8. Network slicing services.

Figure 9 shows the objectives and goal addressed by the 5G projects. The 44% of projects focuses on improve the level of automation and digitalise the processes, as well as use 5G technologies to support autonomous vehicles (33%). This is usually associated to the need of increased efficiency and

productivity and guarantees the safety, improves working conditions of operators, 44% and 56% respectively, and the remote control of vehicles and cranes (33%). These outcomes are justified by the specificity of the projects investigated. In fact, due to the focus on logistics and port operations, the greatest part of the initiatives is in the field of smart port, and smart logistics and transportation (78% and 22% respectively). Some of the projects also focus on other fields as media and entertainment or automotive and mobility. The results highlight also the increasing interest on reducing the environmental and societal footprint of operations and improve the sustainability. Indeed, 33% of the projects aim at reducing emissions and the environmental impact.

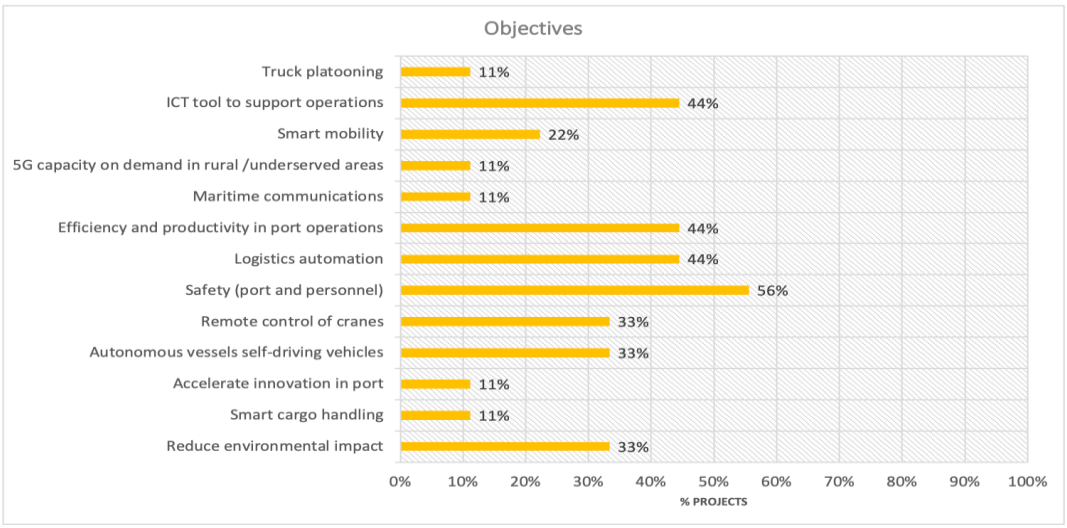


Figure 9. Objectives.

The majority of projects are funded in the frameworks of Horizon 2020 programme and 5G-PPP initiatives. In fact, in 67% of projects the nature of the project initiator is mixed, while for the remaining part (33%) the lead is taken by public entities in order to create private 5G networks in the related port. Thus, the stakeholders (Figure 10) are usually grouped in consortiums composed by ICT & Telco companies (100%) e.g., ICT service providers, Telco companies and Mobile operator companies; Universities and research institutions (78%), Port authority (56%), and Logistics, shipping and transportation companies (44%).

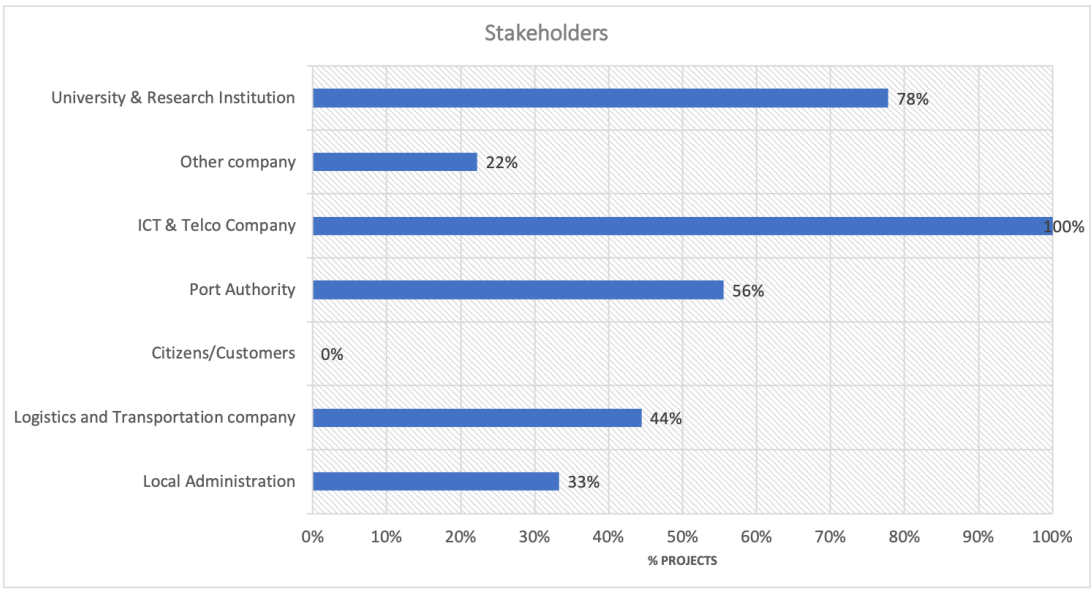


Figure 10. Stakeholders.

Considering the business model axis, the mixed sector assumes a more central role, especially in the management of the projects and the infrastructure financing (100%). For the implementation of these initiatives, it is rare to encounter a project that does not involve the collaboration of two or more entities from different sectors. In contrast, the financial resources come mostly from the public sector (100%).

Finally, focusing on the outcome in terms of products, services and innovations, 56% are ongoing projects, thus under development with non-specified products. The 33% of projects have running solutions in the original or testbed ports. While, only one project (Port of Livorno) has as output a specified product (i.e., the PORTMOD platform). Thus, it emerges the need to evaluate the business model to guarantee the scalability of the initiative.

As mentioned before, the great part of projects are focused on the optimization of logistics and transportation processes and port operations. Thus, the most important end-users (Figure 11) are logistics and transportation operators (67%) and port authority and port operators (67%). Few projects consider the City as end-user, while an important gap is the need to address the connection between port terminals and cities.

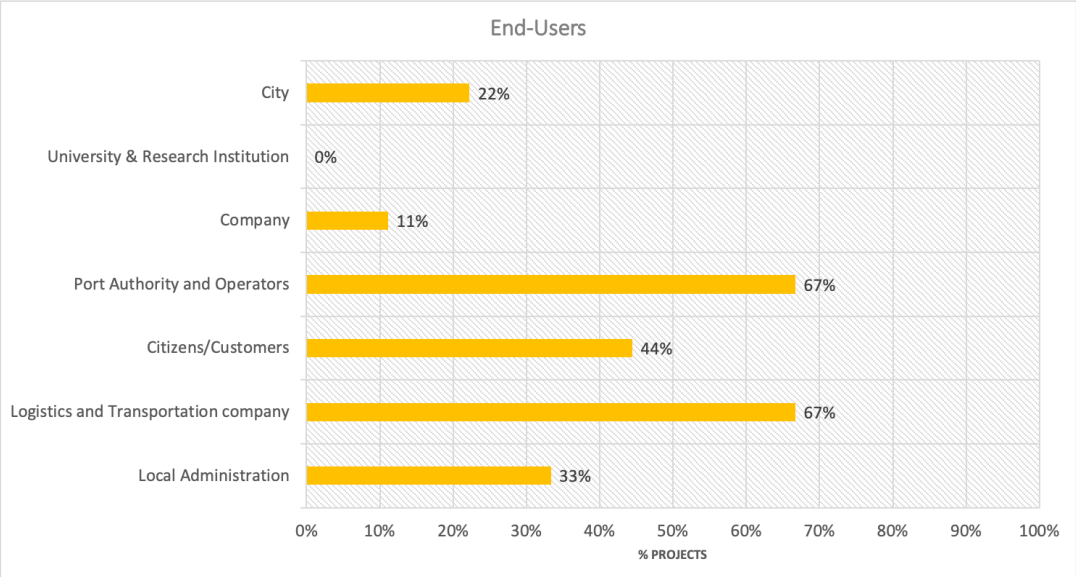


Figure 11. End-users.

Regarding the geographical target, as shown in Figure 12, 56% of projects are implemented in different European sites, 33% on a local level (e.g., single port), while the remaining part focuses on the international level. For example, the 5G-MOBIX implements the validation and testing in a diverse set of 5G corridors rolled out in Europe, as well as Asia (China and South Korea) to furtherly enhance alignment of views on 5G.

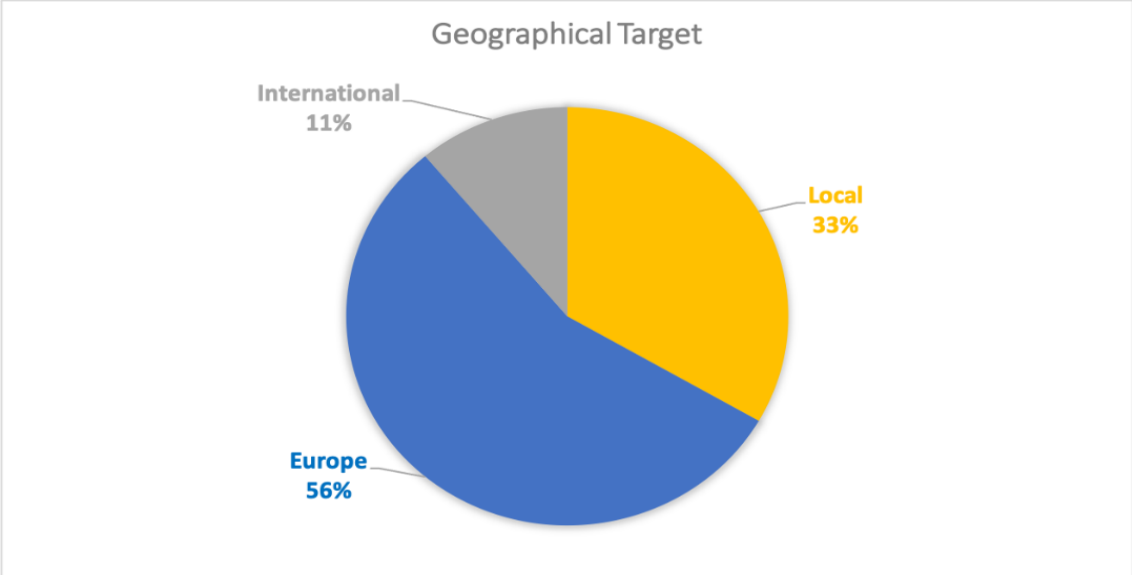


Figure 12. Geographical target.

To conclude, given the huge impact of shipping and maritime transport in the global trade, operational efficiency becomes crucial for ports. However, remote control of cranes and the improvement of security and safety (Figure 9) are only initial attempts at 5G applications in the port industry. Indeed, 5G and other emerging technologies will promote the full digitalization and automation of terminals, creating new applications and use cases in the future.

An example is the application of Blockchain for 5G that is less frequently used, according to the results emerged in our sample of projects (Figure 7), and this outcome will be confirmed by the survey. However, as [28] points out, Blockchain is a disruptive technology that can offer innovative solutions to effectively solve the challenges in 5G network (e.g., decentralization, transparency, network privacy, and security vulnerabilities), bringing benefits to the future society. More in detail, leveraging Blockchain and other technologies in a whole system can develop more effective solutions enabling and empowering a plethora of 5G services vital to solve complex port scenarios like spectrum management, data sharing, network visualization, and privacy.

Finally, as emerged from analysing the business model category, few projects have specified output products that become factual solutions at the end of the pilot phase. This highlights the need for port authorities and stakeholders to rethink their value-chain in the ports of the future. It means that the focus on efficiency connected to the physical flows and operations will be supported by the design and development of new data-driven business models engaging all the different stakeholders.

The analysis of the state-of-the-art highlights that 5G networks are usually supported by a massive adoption of Artificial Intelligence and Machine Learning technologies, sensors spread into the port to monitor different parameters (e.g., air quality conditions) and augmented reality/virtual reality tools. Moreover, in the analysed projects, E2E network slicing services enable flexible slicing of 5G network resources into multiple virtual networks to meet specific customers' requirements. These technologies and services are adopted with the aims of improving the level of automation and digitalisation in the port, optimising the efficiency and operational performances in the port as well as guaranteeing better port conditions, both from and environmental and safety perspectives. While the initiative of these projects is taken by both private and public bodies, engaging e.g., academics, mobile and telco operators and port authorities, the funding is mainly public. Looking at the state-of-the-art, two main gaps can be identified. First, few projects have running solutions or a specified product fully operational after the pilot phase. Thus, a greater attention to the design of the business model and its scalability is needed. Second, port-terminal logistics needs to be better aligned with an urban freight transport and city logistics perspective.

3 STAKEHOLDERS REQUIREMENTS

5G-LOGINNOV aims at considering the perspectives and requirements of the different stakeholders involved in the project, from the beginning phases. It will help to design the business model properly, boosting the acceptance of the proposed solutions in the market. This chapter provides an overview of the 5G-LOGINNOV approach to address the stakeholders' gaps analysis of the project Living Labs.

This chapter highlights the 5G-LOGINNOV methodology to assess stakeholders' requirement (section 3.1), the survey results (section 3.2) and main conclusions from this type of analysis (section 3.3)

3.1 Methodology to conduct the survey

Task 4.1 has developed a survey addressed to Living Lab actors, with the aim of assessing the level of knowledge and adoption of innovative technologies (i.e., 5G, Internet of Things and Digital Twin, Cloud, Blockchain and Artificial Intelligence) related to Industry 4.0 and Logistics 4.0 in the project consortium.

This survey is a very important part of WP4 in order to define the starting point for the development of new products and services based on the innovative technologies. It is intended to be filled by the companies involved in each Living Lab, and by other companies that collaborate in the activities of the Living Labs.

The survey has the following structure [29]:

- Details about the respondent and its organisation.
- Assessment of the respondent's awareness and knowledge on Industry and Logistics 4.0 paradigms.
- Assessment of the respondent's awareness and knowledge on 5G, Internet of Things and Digital Twin, Cloud, Blockchain and Artificial Intelligence technologies.
- Assessment of the Critical Success Factors.
- Use case impact assessment.
- Contacts and further participation.

Thanks to the results of the survey, stakeholders' requirements and interest for the solutions, based on the abovementioned technologies, will be determined.

Through the contact persons previously identified for each Living Lab, the survey has been administered in CAWI (Computer Aided Web Interview) to a range of stakeholders involved in the different use-cases.

On January 27th, 2021, 44 responses have been received:

- 15 from Athens Living Lab;
- 16 from Hamburg Living Lab;
- 13 from Koper Living Lab.

The information collected through the survey is meant for internal (project consortium) and research use only and will not be used for any other purpose and shared with third parties.

The results of the survey, presented in the present deliverable and in other future events organised by the consortium, will be anonymous and will present the overall situation about all the different investigated aspects.

3.2 Survey results

3.2.1 Details about the respondent and its organisation

Considering the **industry domain of the respondents**, Figure 13 highlights the strong focus on Transportation and Logistics sector, followed by IT and Telco. It is therefore possible to count, in the following sections of the survey, on a specific knowledge of the logistics sector, mixed with information coming from service providers (in particular in IT and TELCO sectors). Even if the manufacturing sector is not present, 15.2% of the total surveys come from companies working in the automotive field.

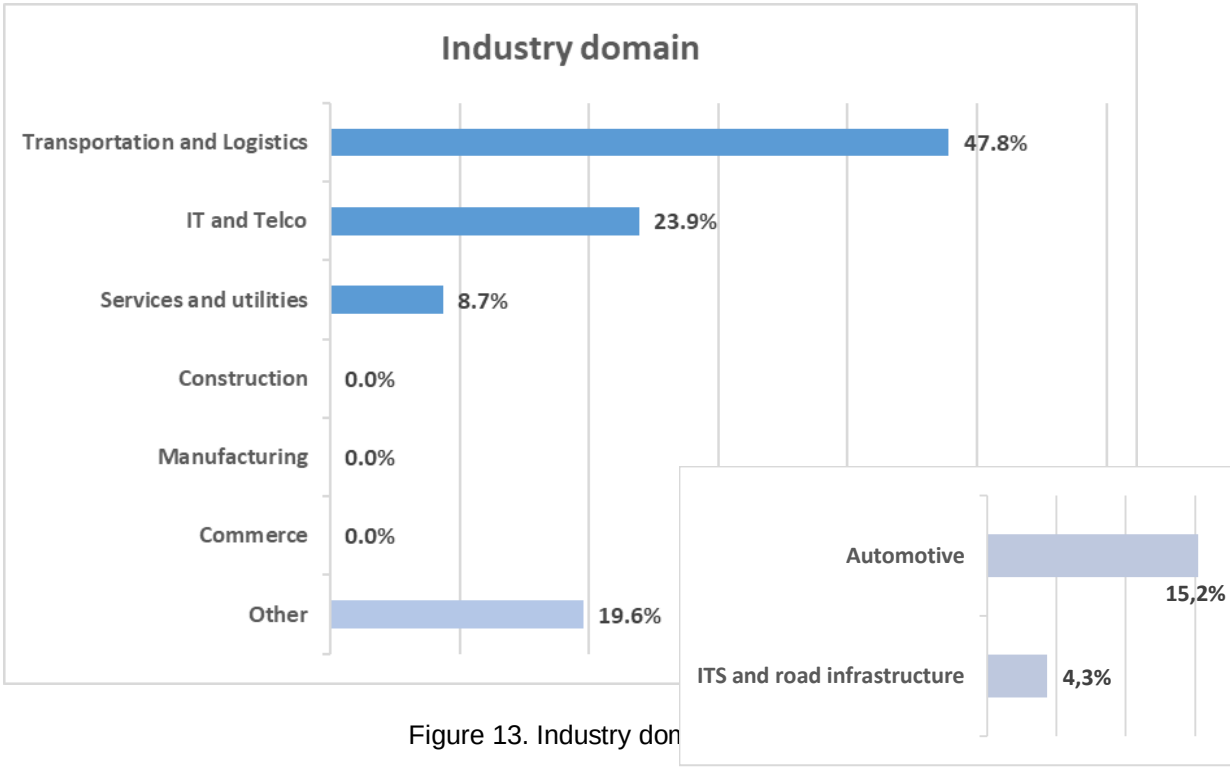


Figure 13. Industry dom

Moreover, the professional level of the respondent is high (managers, senior managers, chief executives) in 61.4% of the overall sample, thus highlighting a strong engagement of the companies in this phase of the project.

Focusing on the **level in the logistics chain** in which the company is involved, Figure 14 shows that the respondents are largely composed by technology providers (38.6%) and IT and TELCO service providers (15.9%). Considering Warehouse management, 2 PL (Second-Party Logistics, enterprises that own assets to transport products from one location to another), 3 PL (Third-Party Logistics, companies in charge of logistics functions in outsourcing), and Receiver, 27.3% of the companies are involved in the more operational activities of the logistics chain.

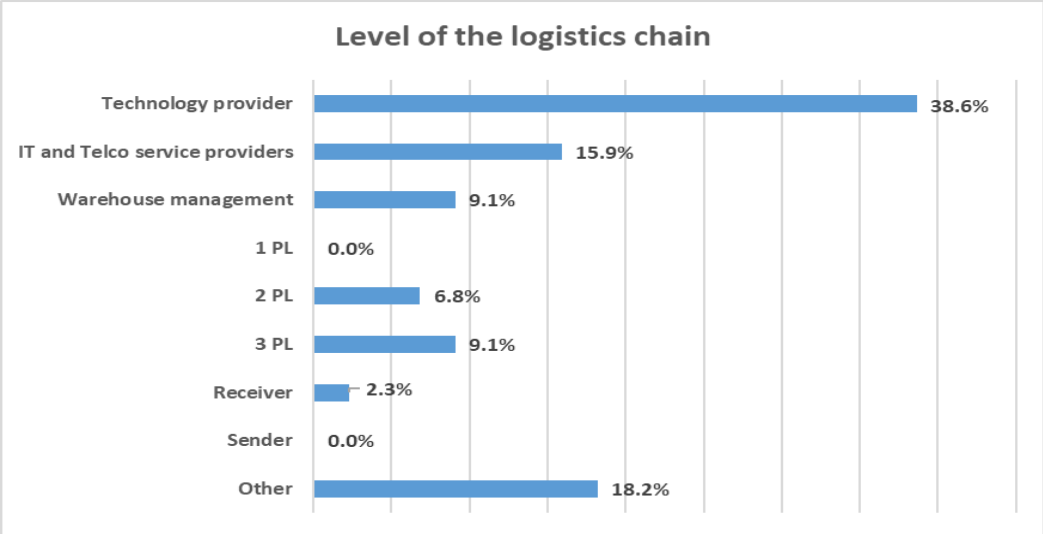


Figure 14. Level of the logistics chain.

Considering the **size of the company**, the sample is quite totally composed by small/medium enterprises and large enterprises (47.7% for each category), largely operating on international markets (77.3% of the respondents). According to these characteristics, the revenue level (Figure 15) is greater than 50 M€ for more than 40% of the respondents.

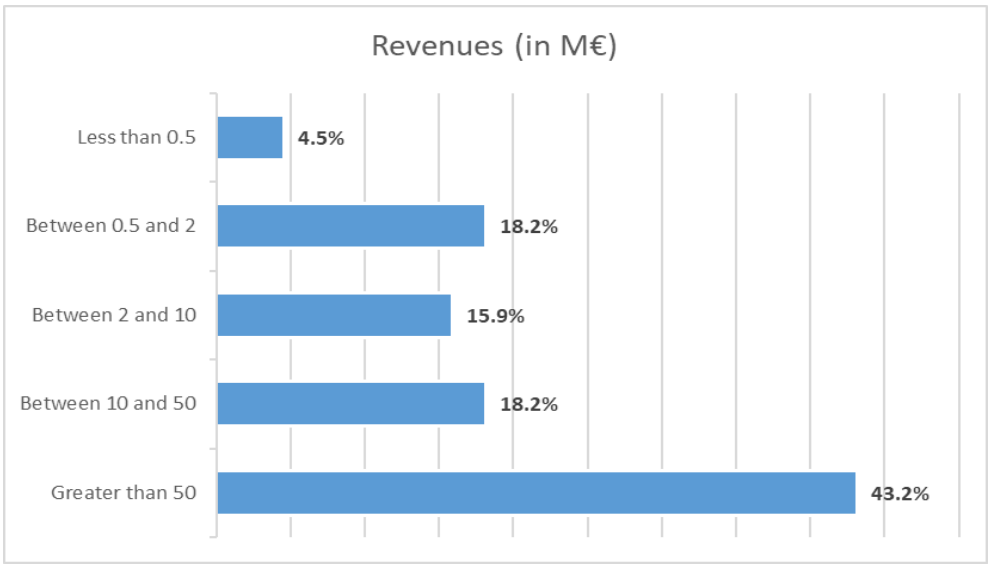


Figure 15. Annual revenues.

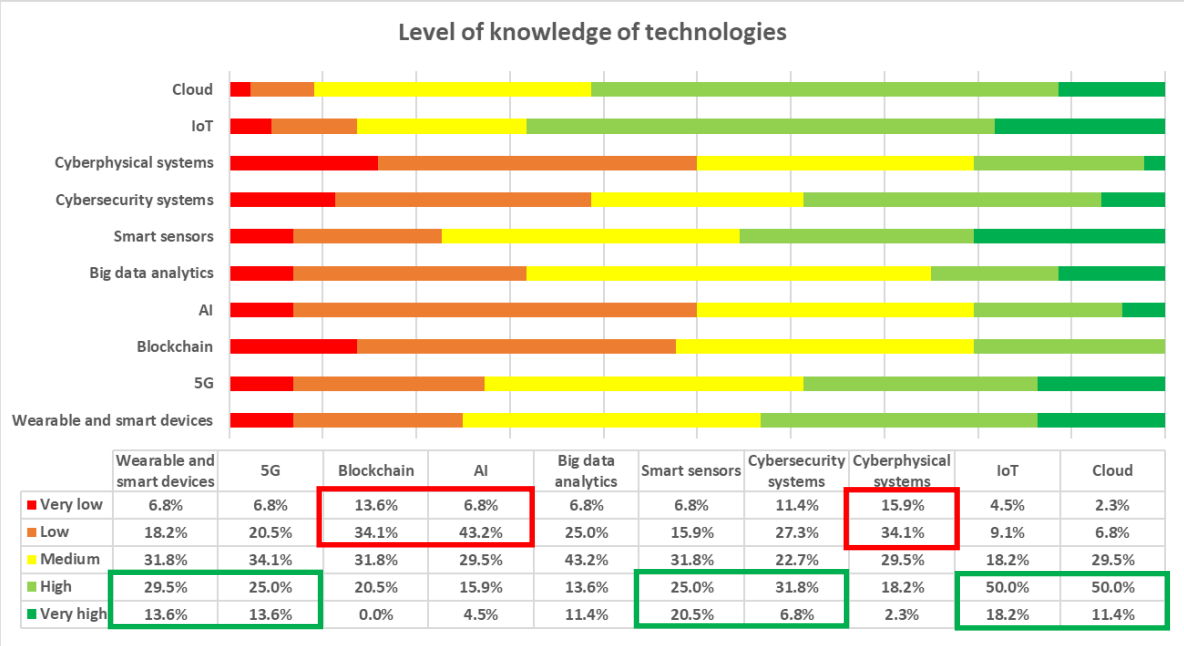
3.2.2 Awareness and knowledge on Industry and Logistics 4.0 paradigms.

This section of the survey aims to assess the level of knowledge on the enabling technologies of Industry 4.0 and Logistics 4.0, and specifically about:

- **Cloud**: cloud computing is a technological capability to use IT infrastructures and services that are not installed on a local computer or server.
- **Internet of Things (IoT)**: network of physical objects embedded with sensors, software and other technologies for the purpose of connecting and exchanging data with other devices and systems.

- **Cyberphysical systems**: technologies that integrate the computation, networking and physical processes.
- **Cybersecurity systems**: technologies that allow companies to protect the corporate networks and devices from the theft or damage due to cyber-attacks.
- **Smart sensors**: IoT components represented by devices that take input from physical environment and use built-in resources to perform predefined functions and data processing.
- **Big data analytics**: technologies that allow the collection and analysis of large amount of data.
- **Artificial Intelligence (AI)**: ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.
- **Blockchain**: distributed ledger database for recording transactions between parties in a verifiable and permanent way.
- **5G**: fifth generation wireless is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. 5G will enable a sharp increase of the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology. Beyond speed improvement, 5G is expected to unleash networks of billions of connected devices, with the right trade-offs between speed, latency, and cost.
- **Wearable and smart devices**: any kind of electronic device designed to be worn (e.g., smart glasses, smart watches).

Starting from an overall high awareness on Industry 4.0 and Logistics 4.0 (79.5% of the respondents know these paradigms); respondents were asked to express their **level of knowledge** about the aforementioned technologies, using a 5-level scale (from *Very low* to *Very high*). The results of this question are shown in Figure 16.

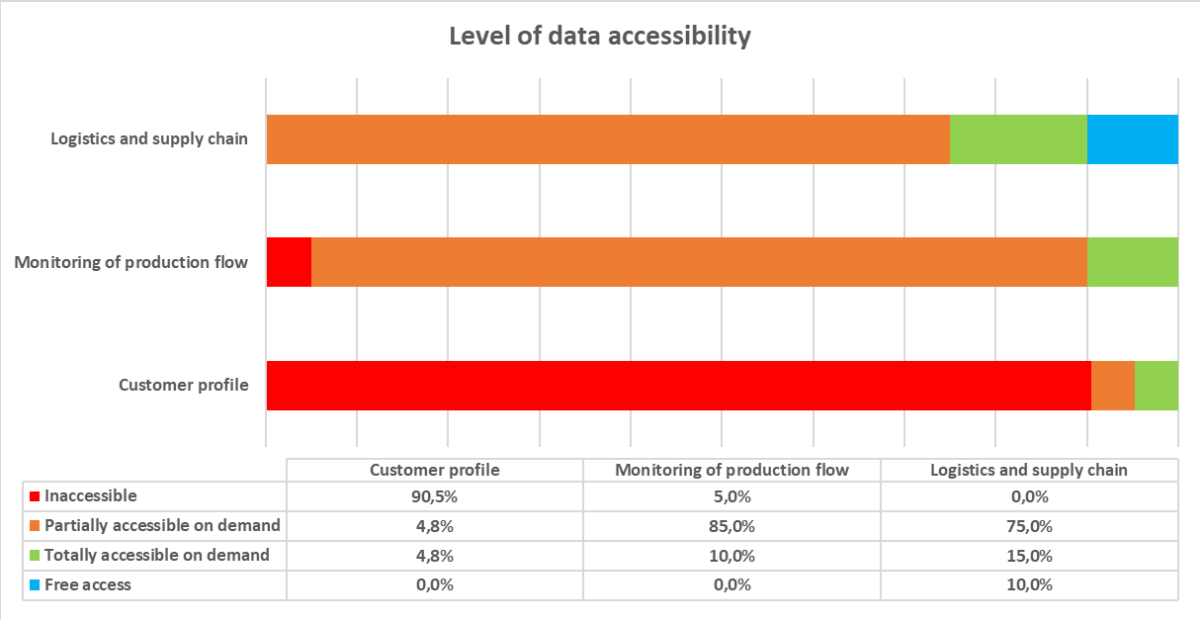


	Wearable and smart devices	5G	Blockchain	AI	Big data analytics	Smart sensors	Cybersecurity systems	Cyberphysical systems	IoT	Cloud
Very low	6.8%	6.8%	13.6%	6.8%	6.8%	6.8%	11.4%	15.9%	4.5%	2.3%
Low	18.2%	20.5%	34.1%	43.2%	25.0%	15.9%	27.3%	34.1%	9.1%	6.8%
Medium	31.8%	34.1%	31.8%	29.5%	43.2%	31.8%	22.7%	29.5%	18.2%	29.5%
High	29.5%	25.0%	20.5%	15.9%	13.6%	25.0%	31.8%	18.2%	50.0%	50.0%
Very high	13.6%	13.6%	0.0%	4.5%	11.4%	20.5%	6.8%	2.3%	18.2%	11.4%

Figure 16. Level of knowledge of technologies.

The most known technologies are Internet of Things (68.2% of the respondents has a high or very high knowledge) and cloud (61.4%). Moreover, 70.5% of the companies involved in the survey state that cloud solutions are currently adopted. Other technologies, such as smart sensors, cybersecurity systems, wearable and smart devices, and 5G have a strong level of knowledge (about 40%), while Blockchain, Artificial Intelligence, and Cyberphysical systems are the less known ones (about 50% of respondents know them at a low or very low level). It is also possible to highlight that no one of the respondents has a very high level of knowledge of Blockchain technology.

Industry 4.0 and Logistics 4.0 paradigms usually refer to external services that use company data and information. About the **willingness of the companies to allow data accessibility to external services**, 59.1% of the respondents assess that data are only partially accessible, while data and information are not at all accessible for 27.3% of the respondents, and only 13.6% state that their data are totally accessible by external services. Asking the **reasons of the inaccessibility**, or partial accessibility, of data and information, 85.7% of the respondents state that data must be accessible only by company's members, while 7.1% do not trust in data managers, and a similar percentage of the sample do not perceive any economic benefit in data sharing. Considering the different aspects in which data accessibility and information sharing can be potentially useful for business, Figure 17 shows the different **levels of accessibility** that the respondents consider appropriate.



	Customer profile	Monitoring of production flow	Logistics and supply chain
Inaccessible	90,5%	5,0%	0,0%
Partially accessible on demand	4,8%	85,0%	75,0%
Totally accessible on demand	4,8%	10,0%	15,0%
Free access	0,0%	0,0%	10,0%

Figure 17. Level of data accessibility.

The most accessible data are the ones related with logistics and supply chain: 10% of respondents consider that these data should not have any restriction, and 90% of respondents consider logistics and supply chain information partially (75%) or totally (15%) accessible on demand. Considering data related with the monitoring of production flow, only 5% of respondents consider them inaccessible, while 85% consider these data partially accessible on demand, and 10% totally accessible on demand. The most inaccessible category of data is the one related with customer profile: in this case, quite all the respondents agree in considering these data totally inaccessible, while only 9.6% consider them totally or partially accessible on demand. The concepts of data and information sharing are strictly connected with the need to ensure the **security of these data**: 70% of the respondents are aware of security requirements concerning data sharing. Concerning the **cybersecurity measures** adopted by the companies, the main ones are:

- Employee training on Cybersecurity (35.6% of the respondents).
- Closed corporate network with anti-intrusion system and firewall (32.2% of the respondents).
- Internal servers with controlled access and backups in safety environments (32.2% of the respondents).

Moreover, it is interesting to highlight that 73.9% of the companies involved in the survey state that all the three aforementioned measures are implemented, while 17.4% of the companies adopt two of the aforementioned measures. The most adopted measure is the employee training on cybersecurity, which is always adopted in integration with at least another measure.

After investigating the level of knowledge of the enabling technologies related with Industry 4.0 and Logistics 4.0, the assessment focuses on the actual level of implementation of these technologies within the companies. In Figure 18 it is possible to see which are the **most important activities** in the business of the companies involved in the survey.

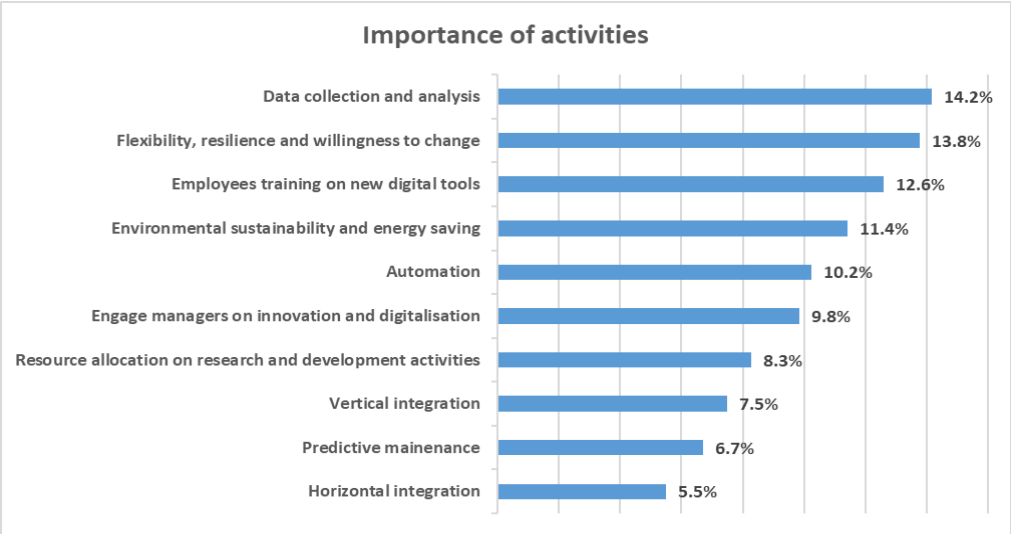
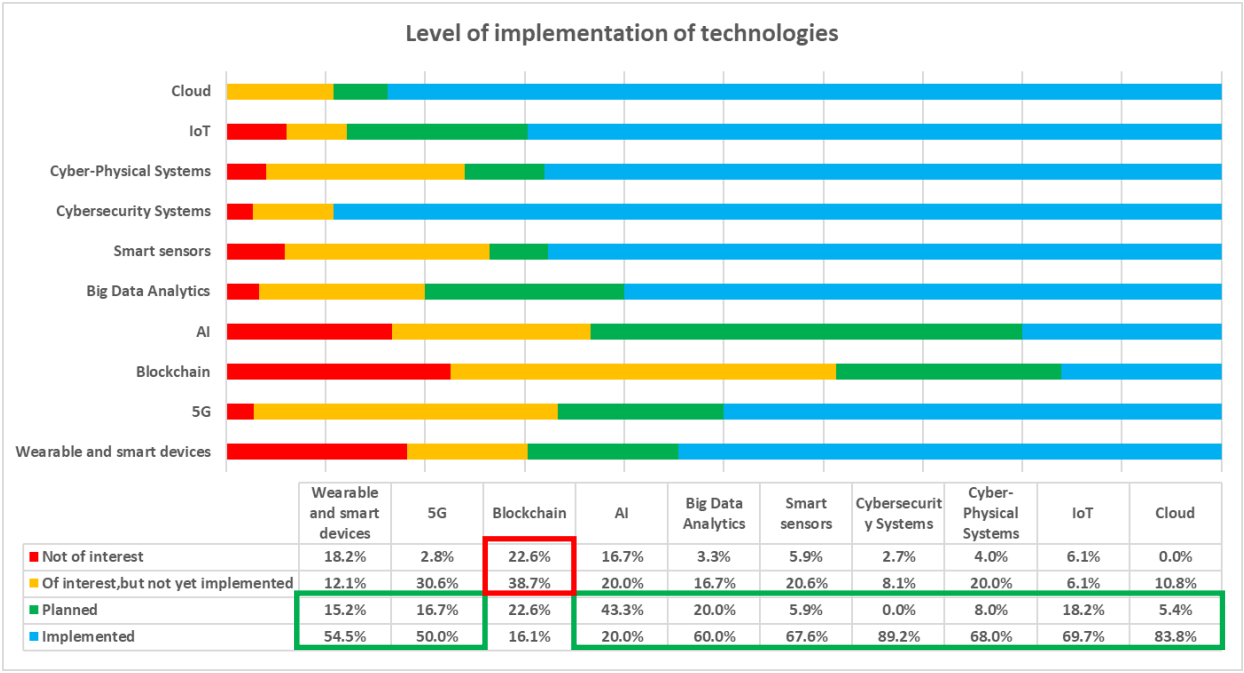


Figure 18. Importance of activities.

Data collection and analysis is the most important activity (14.2% of the respondents), also because collecting and analysing data is crucial to ensure the effectiveness of other activities, such as flexibility and resilience (13.8%), automation (10.2%), resource allocation (8.3%), and predictive maintenance (6.7%). Considering the activities involving human resources, 12.6% of the respondents recognise the necessity to train the employees on new digital tools, and 9.8% consider important the engagement of managers on innovation and digitalisation. Vertical and horizontal integration are not considered important activities, in accordance with the low tendency towards data sharing highlighted in Figure 17.

Figure 19 shows the actual **level of implementation** of the technologies previously investigated in Figure 16.



	Wearable and smart devices	5G	Blockchain	AI	Big Data Analytics	Smart sensors	Cybersecurity Systems	Cyber-Physical Systems	IoT	Cloud
Not of interest	18.2%	2.8%	22.6%	16.7%	3.3%	5.9%	2.7%	4.0%	6.1%	0.0%
Of interest,but not yet implemented	12.1%	30.6%	38.7%	20.0%	16.7%	20.6%	8.1%	20.0%	6.1%	10.8%
Planned	15.2%	16.7%	22.6%	43.3%	20.0%	5.9%	0.0%	8.0%	18.2%	5.4%
Implemented	54.5%	50.0%	16.1%	20.0%	60.0%	67.6%	89.2%	68.0%	69.7%	83.8%

Figure 19. Level of implementation.

The companies involved in the survey have implemented quite all the Industry 4.0 and Logistics 4.0 enabling technologies, or at least there are plans to implement these technologies in the short term. It is moreover interesting to highlight that almost 90% of the companies have already implemented cybersecurity systems, even if some of them are not interested in the implementation of these systems. The less implemented technology is the Blockchain (implemented by 16.1% of the respondents, and planned by 22.6%), even if the technology is considered of interest by 38.7% of the companies involved in the survey.

Figure 20 highlights the **expected benefits** of the implementation of the technologies previous investigated.

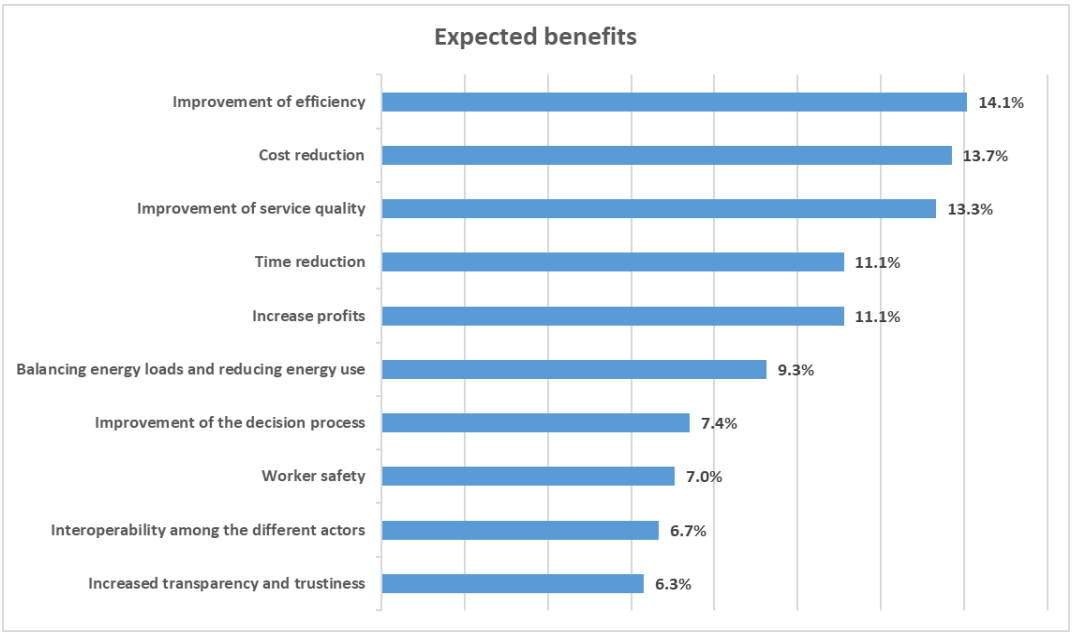


Figure 20. Expected benefits.

Analysing the expected benefits, it is possible to highlight a strong correlation between many of them. In particular, the improvement of efficiency (the most expected one, for 14.1% of the respondents) can drive the companies to an improvement of service quality (13.3%), thus reducing costs (13.7%) and increasing profits (11.1%). Other expected benefits, such as time reduction and the reduction of energy use, even if considered less important, are strictly related with the improvement of efficiency. Interoperability among different actors (6.7%) and increased transparency and trustiness (6.3%) are the less expected benefits, thus confirming the low tendency towards data sharing highlighted in Figure 17.

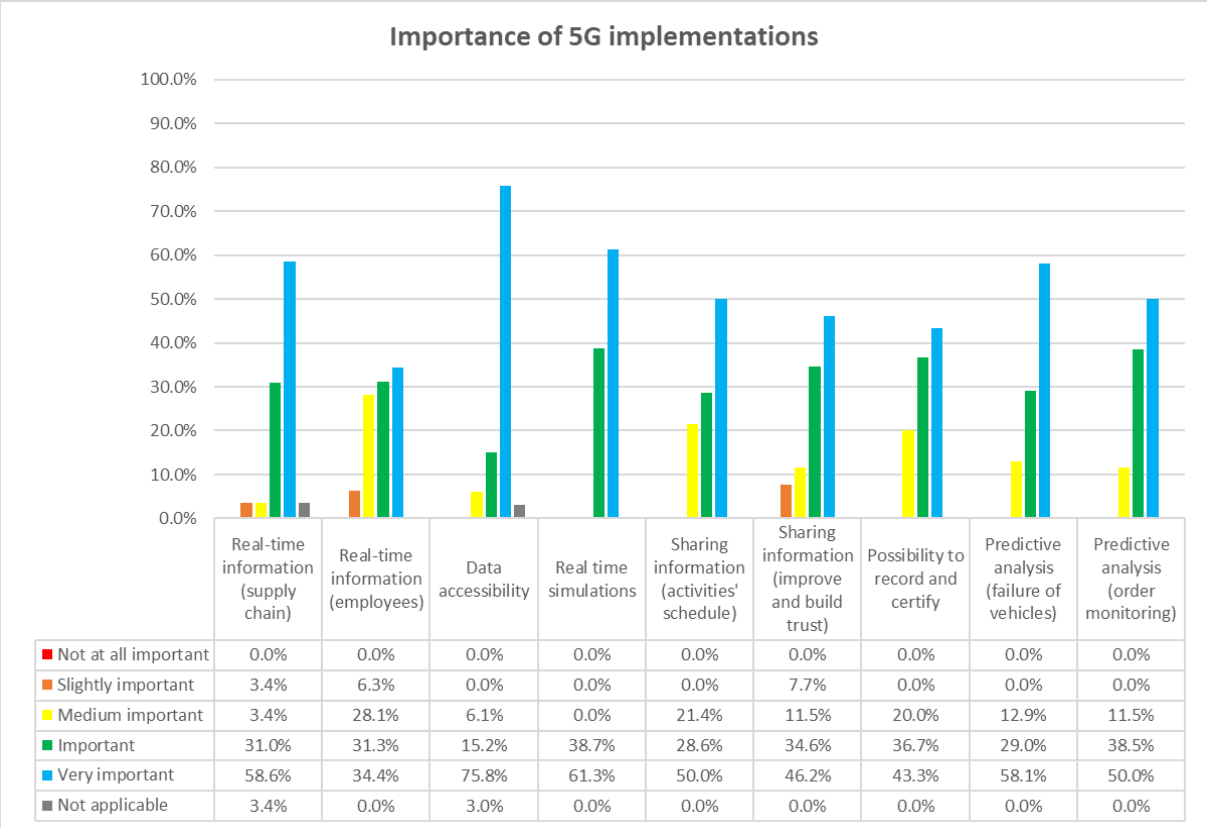
3.2.3 Awareness and knowledge on 5G, Internet of Things and Digital Twin, Cloud, Blockchain and Artificial Intelligence implementations

This section has the aim to investigate the most important implementations of the different technologies by the respondents. In particular, the following implementations have been investigated:

- Real-time information on the status of the whole supply chain.
- Real-time information on the activities carried out by the employees.
- Data stored in clouds and accessible from any computer/device connected to the network.
- Possibility to exploit the real-time data to perform simulations on the processes, making the processes and resources employed more efficient.
- Sharing information with the different actors in the supply chain to better plan and schedule activities.
- Sharing information with the different actors in the supply chain to improve and build trust.
- Possibility to record and certify in an automatic/semi-automatic way all the processes or activities.
- Predictive analysis, on the data collected, aimed at indicating the future date of failure of vehicles.
- Predictive analysis, on the data collected, aimed at reporting the impossibility of delivering an order in time.

For each of these statements, respondents were asked to assess the importance of the specific technology, using a 5-level scale (from *Not at all important* to *Very important*).

The **5G** technology is known by quite all the respondents (92.9%); the results of the importance of the applications based on this technology are highlighted in Figure 21.



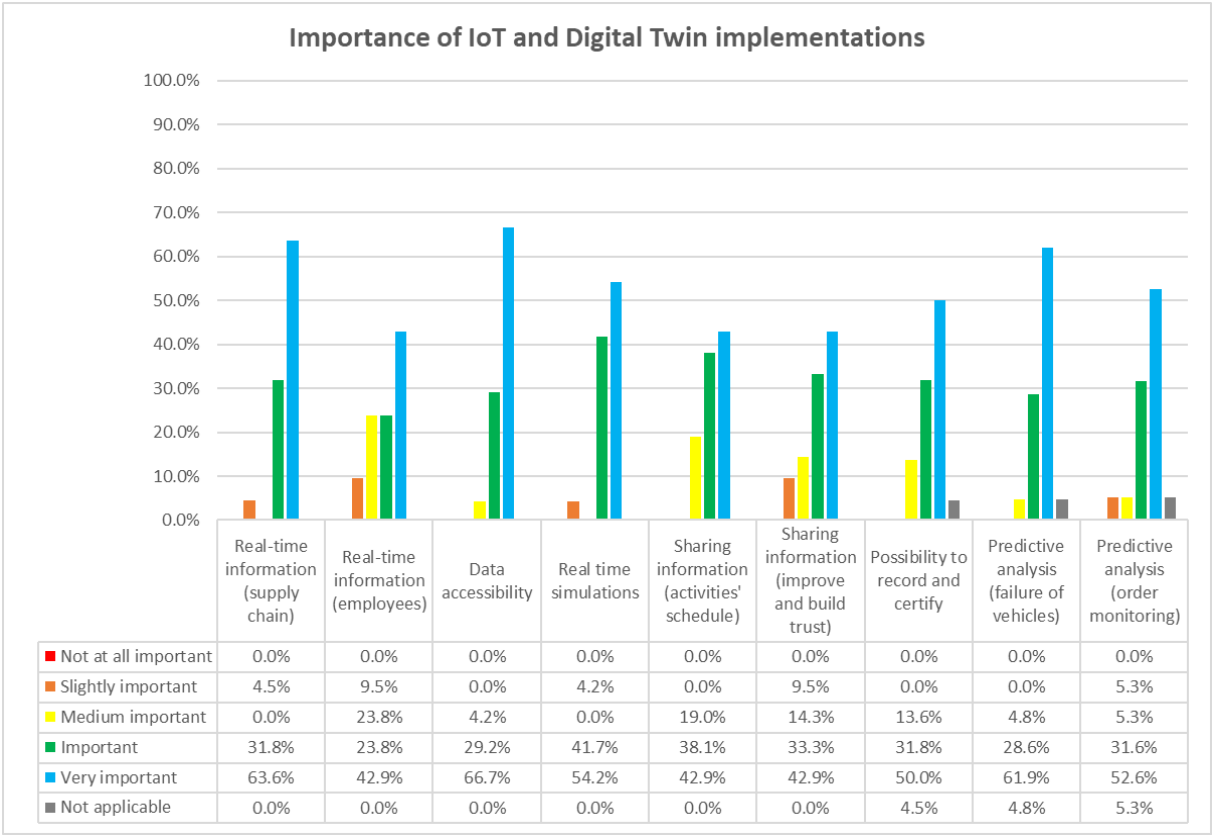
	Real-time information (supply chain)	Real-time information (employees)	Data accessibility	Real time simulations	Sharing information (activities' schedule)	Sharing information (improve and build trust)	Possibility to record and certify	Predictive analysis (failure of vehicles)	Predictive analysis (order monitoring)
Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slightly important	3.4%	6.3%	0.0%	0.0%	0.0%	7.7%	0.0%	0.0%	0.0%
Medium important	3.4%	28.1%	6.1%	0.0%	21.4%	11.5%	20.0%	12.9%	11.5%
Important	31.0%	31.3%	15.2%	38.7%	28.6%	34.6%	36.7%	29.0%	38.5%
Very important	58.6%	34.4%	75.8%	61.3%	50.0%	46.2%	43.3%	58.1%	50.0%
Not applicable	3.4%	0.0%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 21. Importance of 5G implementations.

5G technology is considered very important for all the implementations, even if some respondents stated that this technology is not applicable for real-time information on the supply chain and for data accessibility. Considering the results of this graph, 5G technology is considered the backbone for all other Industry and Logistics 4.0 enabling technologies.

Considering the **actual implementation** of this technology in the companies involved in the survey, 50% of the respondents have implemented or plan to implement the technology within the short term, while 27.8% are interested but prefer to see the results of use cases.

The **Internet of Things (IoT) and Digital Twin** technologies are known by 73.8% of the respondents; the results of the importance of the applications based on these technologies are highlighted in Figure 22.

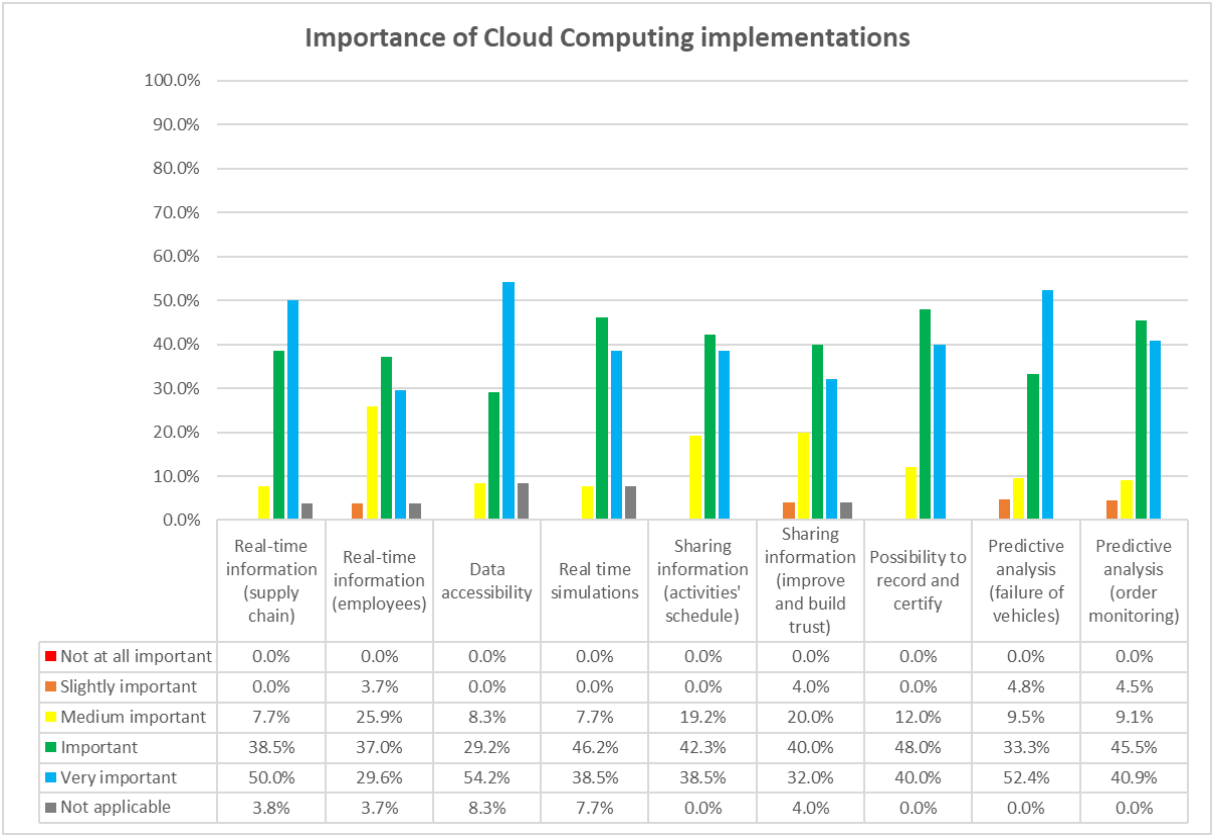


	Real-time information (supply chain)	Real-time information (employees)	Data accessibility	Real time simulations	Sharing information (activities' schedule)	Sharing information (improve and build trust)	Possibility to record and certify	Predictive analysis (failure of vehicles)	Predictive analysis (order monitoring)
Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slightly important	4.5%	9.5%	0.0%	4.2%	0.0%	9.5%	0.0%	0.0%	5.3%
Medium important	0.0%	23.8%	4.2%	0.0%	19.0%	14.3%	13.6%	4.8%	5.3%
Important	31.8%	23.8%	29.2%	41.7%	38.1%	33.3%	31.8%	28.6%	31.6%
Very important	63.6%	42.9%	66.7%	54.2%	42.9%	42.9%	50.0%	61.9%	52.6%
Not applicable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	4.8%	5.3%

Figure 22. Importance of IoT and Digital Twin implementations.

All the respondents consider very important IoT and Digital Twin technologies for all the investigated implementations, even if about 5% of them consider these technologies not applicable for predictive analysis (both for the failure of the vehicles and for the order monitoring). Considering the **actual implementation** of this technology in the companies involved in the survey, 51.5% of the respondents have implemented or plan to implement the technology within the short term, while 15.2% are interested but prefer to see the results of use cases.

The **Cloud Computing** technology is known by 85% of the respondents; the results of the importance of the applications based on this technology are highlighted in Figure 23.



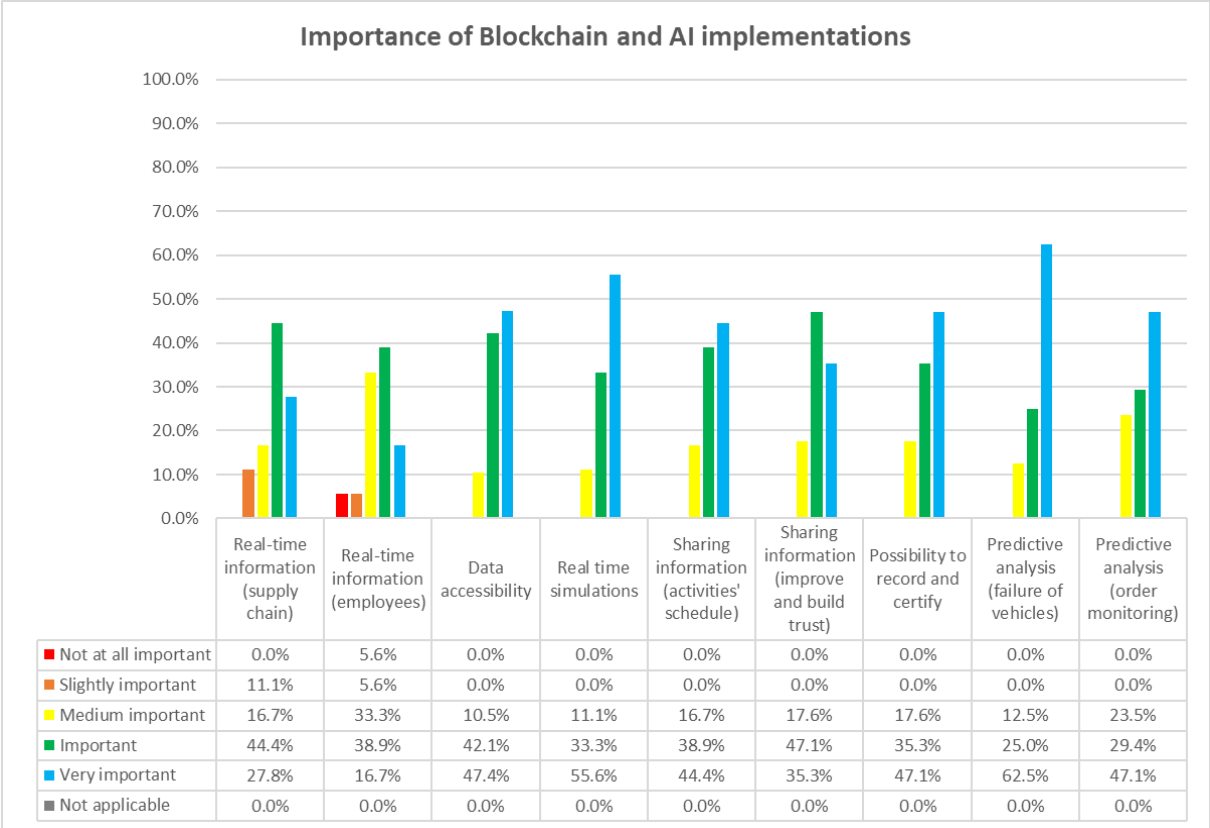
	Real-time information (supply chain)	Real-time information (employees)	Data accessibility	Real time simulations	Sharing information (activities' schedule)	Sharing information (improve and build trust)	Possibility to record and certify	Predictive analysis (failure of vehicles)	Predictive analysis (order monitoring)
Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slightly important	0.0%	3.7%	0.0%	0.0%	0.0%	4.0%	0.0%	4.8%	4.5%
Medium important	7.7%	25.9%	8.3%	7.7%	19.2%	20.0%	12.0%	9.5%	9.1%
Important	38.5%	37.0%	29.2%	46.2%	42.3%	40.0%	48.0%	33.3%	45.5%
Very important	50.0%	29.6%	54.2%	38.5%	38.5%	32.0%	40.0%	52.4%	40.9%
Not applicable	3.8%	3.7%	8.3%	7.7%	0.0%	4.0%	0.0%	0.0%	0.0%

Figure 23. Importance of Cloud Computing implementations.

The possibility to collect and analyse large amounts of data, enabled by cloud computing technologies, is considered very important in order to obtain real-time information on the supply chain, ensure data accessibility, and make predictive analysis on the failure of vehicles. Other implementations, such as real-time information on employees, information sharing, record and certify information, and predictive analysis on order flows, are mainly considered important.

Considering the **actual implementation** of this technology in the companies involved in the survey, 50% of the respondents have implemented or plan to implement the technology within the short term, while 26.7% are interested but prefer to see the results of use cases.

Blockchain and Artificial Intelligence (AI) technologies are known by 72.5% of the respondents; the results of the importance of the applications based on this technology are highlighted in Figure 24.



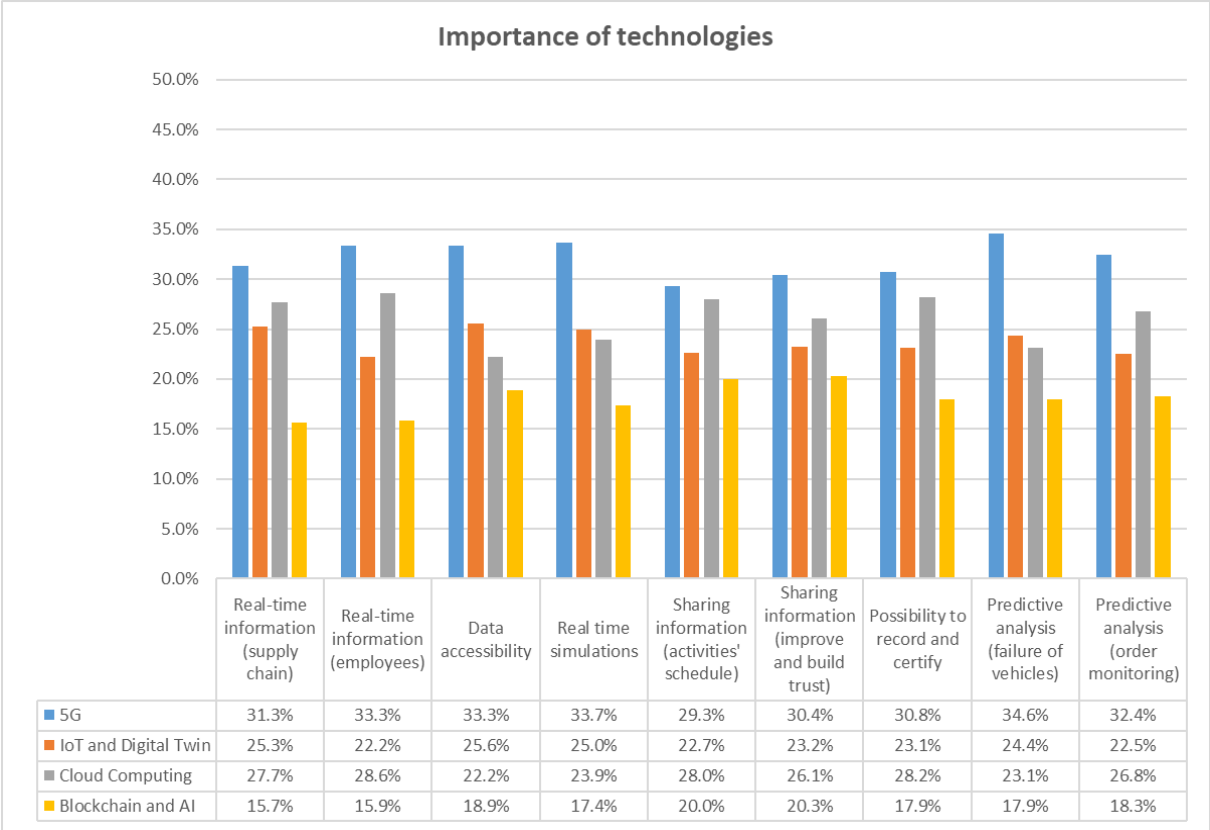
	Real-time information (supply chain)	Real-time information (employees)	Data accessibility	Real time simulations	Sharing information (activities' schedule)	Sharing information (improve and build trust)	Possibility to record and certify	Predictive analysis (failure of vehicles)	Predictive analysis (order monitoring)
Not at all important	0.0%	5.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slightly important	11.1%	5.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium important	16.7%	33.3%	10.5%	11.1%	16.7%	17.6%	17.6%	12.5%	23.5%
Important	44.4%	38.9%	42.1%	33.3%	38.9%	47.1%	35.3%	25.0%	29.4%
Very important	27.8%	16.7%	47.4%	55.6%	44.4%	35.3%	47.1%	62.5%	47.1%
Not applicable	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 24. Importance of Blockchain and AI implementations.

Blockchain and AI technologies are considered very important for applications related with real-time simulations and predictive analysis (both on failure of vehicles and order monitoring). They are considered important for real-time information on supply chain and on employees, and for the information sharing. Even if, as resulted from the previous analysis, Blockchain is the less known technology, none of the respondents considers it not applicable for the investigated applications.

Considering the **actual implementation** of this technology in the companies involved in the survey, 25% of the respondents have implemented or plan to implement the technology within the short term, while 28.6% are interested but prefer to see the results of use cases. This is a further confirmation on the low level of knowledge of this technology in the logistics sector.

In Figure 25, the same data of the previous graphs are analysed in an aggregated way to show in a single sight which are the **most suitable technologies for each one of the different implementations**. For each implementation, we considered only the responses that judge important or very important the specific technology.



	Real-time information (supply chain)	Real-time information (employees)	Data accessibility	Real time simulations	Sharing information (activities' schedule)	Sharing information (improve and build trust)	Possibility to record and certify	Predictive analysis (failure of vehicles)	Predictive analysis (order monitoring)
5G	31.3%	33.3%	33.3%	33.7%	29.3%	30.4%	30.8%	34.6%	32.4%
IoT and Digital Twin	25.3%	22.2%	25.6%	25.0%	22.7%	23.2%	23.1%	24.4%	22.5%
Cloud Computing	27.7%	28.6%	22.2%	23.9%	28.0%	26.1%	28.2%	23.1%	26.8%
Blockchain and AI	15.7%	15.9%	18.9%	17.4%	20.0%	20.3%	17.9%	17.9%	18.3%

Figure 25. Importance of technologies for different implementations.

Results show that 5G is considered the backbone for the application of all other technologies, and it is the most important technology for all the implementations.

IoT and Digital Twin are also considered important technologies for all the implementations, and in particular for real-time information on the supply chain, data accessibility, real-time simulations (one of the main objectives of Digital Twin), and predictive analysis on the failure of vehicles.

Cloud Computing is considered an important technology for implementations related with real-time information (on the supply chain and on employees), information sharing to optimise the schedule of activities, and the possibility to record and certify data and information.

Finally, Blockchain and AI are confirmed as the less important technologies for all the analysed implementations.

3.3 Main survey conclusions

The results of the survey administered to a sample of companies involved in Living Labs activities show a generally high level of knowledge of the Industry 4.0 and Logistics 4.0 enabling technologies, and in large part of the companies these technologies are already implemented, or at least they will be implemented in the short term.

The main expected benefits of the companies are related with an improvement of efficiency and quality of the service provided, thus optimizing the operations, and reducing times and costs. Moreover, the most important activity related with the companies' business is data collection and analysis, in order to monitor the production flows and the supply chain, make simulations on potential new scenarios, and perform predictive analysis.

While 5G technology is considered the backbone for the adoption of all the other technologies and the implementations of new services, Blockchain and artificial intelligence result as the less known and implemented technologies. In particular, the main reason of the low implementation level of Blockchain lies in the low willingness of the companies to share data with external organisations, even if all the companies are aware about the importance of data security and have already implemented measures to ensure it.

Data collection and analysis, as well as the improvement of flexibility, are the most important activities for the panel of respondents. Moreover, the main expected benefits of the implementation of new technologies are the improvement of efficiency and service quality that can lead to an optimization of time and cost. Considering these results, the most important implementations of the technologies are the real-time information (on supply chain processes and employees), the information sharing and the predictive analysis on the orders. For these implementations, 5G and Cloud Computing are considered the most important technologies, but it is also important to develop Blockchain and AI solutions to improve the information exchange between the different actors involved in the supply chain.

Given that horizontal and vertical integration are both considered among the less important activities for the companies' businesses, and the interoperability among the different actors of the supply chain is one of the less expected benefits, the proposition of new products and services must provide also a clear vision of new business models that can be deployed. Specifically, there is the need to focus on the effectiveness of collaborative business models to foster transparency and trustiness, thus reducing the barriers and fostering the information exchange between different actors.

Therefore, the development of new products and services must take into account the different accessibility levels that companies want to apply to different categories of data and ensure the companies that data sharing solutions are compliant with these levels of confidentiality. Moreover, large part of the companies involved in the survey states that they could be interested in implementing Blockchain solutions only after seeing the results of similar use-cases, so the proposals of new products and services should be made giving a clear view on the potential benefits of data sharing between the actors involved in the supply chain. In this perspective, the activities performed in the Living Labs give the possibility to test on a reduced scale the effectiveness of new products and services, in order to collect results and to scale these solutions in a wider market.

4 STRATEGIES TO INVOLVE NEW ACTORS AND BOOST MARKET OPPORTUNITIES

In this chapter, the document highlights how findings from chapter 2 and 3 shall be applied in other 5G-LOGINNOV project activities that will address market uptake of new solution and involve new actors, including indication on how these suggestions shall be addressed in the Living Labs contexts. Chapter 4.1 will explain how 5G-LOGINNOV activities will include the results from the market state-of-the-art and survey analysis in their plans; chapter 4.2 will provide suggestions to Living Lab leaders in approaching and engaging the new actors.

4.1 Plans for 5G-LOGINNOV activities

The results of D4.1 will be used in other tasks of the project in order to define the potential market opportunities for new actors (SMEs and start-ups), and to monitor the development phase of new products and services. The present deliverable will provide input for Task 4.2 “Emergence of New Actors”, specifically for the design of the Open Call and to foster the integration of new actors in the project consortium and in the market. It will be relevant as it represents the baseline source of information to build new business models in Task 4.3 “Boosting economic opportunities”. The outcomes of D4.1 will feed the definition and development of the exploitation strategies in Task 5.3 “Exploitation” and will contribute to Task 5.4 “Standardisation and Spectrum” to foster the interoperability between existing stakeholders and new actors (SMEs and start-ups).

The outcomes of this deliverable will be an input for the design of the specifications for the 5G-LOGINNOV Open Call that will be released under the Task 4.2 “Emergence of new actors” in the first half of 2021. The Open Call will award five new actors in the project Living Labs, by identifying and awarding five start-ups that will join the project and bringing important innovations and new ideas to cope with the Living Labs objectives. According to the state-of-the-art analysis from past projects, we can conclude that 5G networks are usually supported by a massive adoption of Artificial Intelligence and Machine Learning technologies, sensors spread into the port to monitor different parameters (e.g., air quality conditions) and augmented reality/virtual reality tools. Moreover, in the analysed projects, E2E network slicing services enable flexible slicing of 5G network resources into multiple virtual networks to meet specific customers’ requirements. The 5G-LOGINNOV Open Call for start-ups shall consider this as an important lesson learnt and clearly describe the current technology set-up of Living Labs, so that applicants can have a better understanding of the current gaps that they are willing to cover and can better explain, in their application forms, the added value they could introduce. The applicants shall also be informed that they are going to join a group of pre-involved industrial and policy actors, so they may be ready to intervene in the Living Labs instances with a “flexible innovation” attitude, knowing that during the project duration the technological infrastructure and the governing structure of the 5G-LOGINNOV ports may be subject to changes. Furthermore, considering the requirements of the current stakeholder of the Living Labs logistics chain to implement the planned use cases, as described in 5G-LOGINNOV D1.1 “5G-enabled logistics use cases”, will improve the effectiveness of the Open Call, thus improving the potential market adoption of innovative solutions proposed by the participants.

The overarching goal of the 5G-LOGINNOV project is to capture the possibilities offered by the 5G to enable the implementation of new technologies, to support the related new market growth and to create economic opportunities for new and innovative market actors. Task 4.3 “Boosting economic opportunities” will deal with this goal by identifying sustainable business models based on the use of 5G core innovation technologies to pave the way for the next generation of logistics and port operation, with the perspective to involve new actors, such as SMEs and start-ups as well as existing actors investing in new application domains. The analysis of recent 5G projects (mainly financed by public funds) identifies a clear lack of planning in terms of economic sustainability of the solutions (few projects have running solutions of a specified product fully operational after the pilot phase) and in

terms of collaboration with non-port stakeholders (port-terminal logistics needs to be better aligned with an urban freight transport and city logistics perspective). Thus, the definition of business models in 5G-LOGINNOV shall take into account that: 1) the financing and revenue models for the new solutions shall consider not only 100% public, but also public-private forms of funding, so that the investment risk is shared, but the commitment of the involved parties is more clear; 2) the port area has to be considered as part of the wider urban environment: the inclusion of non-port actors and other non-industry actors representing different urban categories may bring an added value in terms of innovative and inclusive design thinking when the business models are discussed. This process may enhance not only a better integration with the other urban infrastructure (and consequent economic savings) but also enable the identification of new business ideas that may exploit the potentialities of the 5G-LOGINNOV implementations.

While the Task 4.3 business modelling activities will approach a wide audience, the Task 5,3 “Exploitation” will focus on the commercialisation strategies for the 5G-LOGINNOV partners. The Key Exploitable Results must be defined as those products, services and methodologies raised by the project that address the actors’ needs and requirements as defined in Chapter 2 and 3. This will enable the definition of proper exploitation strategies for the proposed solutions, thus overcoming potential barriers in the market adoption. Similarly, Task 5.4 “Standardisation and Spectrum” shall identify requirements and strategies by assessing the technologies assessed in the stakeholders’ knowledge assessment survey, explained in Chapter 3.

Finally, since the activities of T4.1 will continue until the end of the project, all the processes deployed to develop and test new 5G-based solutions will be continuously monitored in order to define proper action plans for the market adoption, as well as a set of key exploitable results. In this perspective, different dissemination events and brainstorming sessions will be organised, with the involvement of the main stakeholders and the selected new actors of the different Living Labs. This process is also necessary to forecast the relevant future scenarios that could impact the logistics sector in the next years.

4.2 Business and engagement strategies to be adopted in 5G-LOGINNOV

The analysis of the survey results clearly identifies the interest of the Living Labs involved stakeholders in the development of technology-based solutions to improve the efficiency of the logistics processes, through the optimisation of resource usage and time consumption, with the final objective to improve the service level and reduce the costs. The most important activities highlighted by the respondents rely on data collection and analysis, with the aim to improve the monitoring process of the logistics chain, with positive impacts on flexibility and resilience to changes. As highlighted by the state-of-the-art analysis, these objectives need an improvement in the collaboration and data exchange between the different actors. The general high level of knowledge and application of the enabling technologies is a good starting point for the development of new solutions, but the results of the survey identify a potential barrier in the low trustiness of the respondents in data sharing technologies, even if all of them already implemented cybersecurity measures to ensure data protection.

For these reasons, the proposition of new 5G enabled products and services must focus on the definition of collaborative environments within the Living Labs, with the aim of improving the effectiveness of the processes through an optimisation of the overall logistics chain, at the same time ensuring a high level of data protection. The new actors that will be involved in Living Labs through the Open Call shall collaborate to address the needs for data sharing. The already involved actors, on the other side, shall define a strategy to include new actors not only in organisational and operational terms, but also in terms of data sharing infrastructure to enhance a smooth data sharing process. The new actors and the old actors may be trained in order to improve the knowledge on the respective tools for data exchange and data collection at the very beginning of Living Labs iterations. Thus, the

set-up of the data collection coordination in Task 2.1 “Development and deployment coordination” and Task “Tools for data collection and evaluation” shall be ready to uptake the novelties that the new actors involved in Living Labs will bring, allowing for scalable strategies that could be used also in non 5G-LOGINNOV frameworks. A similar approach has to be kept in mind in planning the evaluation activities.

5 CONCLUSIONS AND FINAL REMARKS

In the present deliverable, a preliminary state-of-the-art analysis has been conducted to investigate the current patterns, characteristics, as well as gaps in projects based on the adoption of 5G technologies to improve logistics and transportation operations in ports. The overall aim was to understand how market actors of the logistics sectors behave in terms of uptake of innovative technologies, with emphasis of 5G and its potentialities. First, a market analysis of relevant projects and initiatives has been performed (Chapter 2); then, an assessment with 5G-LOGINNOV Living Labs stakeholders has been conducted (Chapter 3). Finally, the learnings from these analyses have been capitalised in order to provide suggestions to boost market possibilities in the 5G-LOGINNOV context (chapter 4).

The market analysis in Chapter 2 highlights that 5G networks are usually supported by a massive adoption of Artificial Intelligence and Machine Learning technologies, sensors spread into the port to monitor different parameters (e.g., air quality conditions) and augmented reality/virtual reality tools. Moreover, in the analysed projects, E2E network slicing services enable flexible slicing of 5G network resources into multiple virtual networks to meet specific customers' requirements. While the initiative of these projects is taken by both private and public bodies, the funding is mainly public. Two main gaps have been identified: first, few projects have running solutions or a specified product fully operational after the pilot phase. Thus, a greater attention to the design of the business model and its scalability is needed. Second, port-terminal logistics needs to be better aligned with an urban freight transport and city logistics perspective.

The analysis of the results of the 5G-LOGINNOV stakeholders' assessment survey (provided in Chapter 3) mainly highlights a high interest of the stakeholders to improve the effectiveness of the logistics processes, with direct connections with continuous monitoring and optimisation of the resource usage, to improve service quality and reduce costs. These objectives can be reached through continuous data collection and analysis, but an important aspect to be considered is the need to share these data between different actors of the supply chain, in the perspective that the improvement of the effectiveness of the overall process will bring benefits to all the actors involved. All the stakeholders involved in the survey declare a very high level of knowledge and implementation of the enabling technologies, but the low trustiness in data sharing technologies can act as a barrier to the development of collaborative business models for the implementation of innovative services. For these reasons, it is very important to create collaborative environments in the Living Labs to test the innovative solutions on a limited scale before replicating and scaling them on wider markets.

Chapter 4 highlights how the results of the state-of-the-art analysis will be used in other tasks of the project to ensure the continuous involvement of the stakeholders and new actors in the development of 5G-based innovative products and services for the logistics chain. Keeping into account the stakeholders' needs and requirements from the first phases of the project will help the design of the Open Call, identifying the most relevant aspects of the proposals with the aim to select the ones with high potential of market adoption. Moreover, all the proposals coming from new actors must be supported by collaborative and sustainable business models, in order to highlight the potential benefits of the proposed products and services. The involvement of existing and new actors in the development process of the innovative solutions is also helpful to define the most suitable exploitation strategies, overcoming potential barriers in market adoption.

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