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(Article begins on next page)

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Innovative Business Models in Ports' Logistics

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***Abstract*—Since the global request for freight transportation is increasing as a consequence of the increasing requirements of the modern economy, logistics processes need to be optimized through the application of innovative technologies, to ensure a high level of quality, flexibility, and effectiveness in logistics operations. The adoption of innovative technologies allows the creation and development of new products and services, able to optimize the existing logistics processes and create value. In particular, one of the most promising technology for logistics applications is the 5G communication network that allows, together with companion technologies such as the Internet of Things, Artificial Intelligence, and the Cloud, the collection, integration, and sharing of a large amount of data from different sources. However, to ensure the market adoption of innovative products and services, the different actors and stakeholders of the logistics chain must be involved from the early stages of the development. This allows them to keep into account their actual needs in the development process of the business models and for the future exploitation of the solutions. This paper analyzes the process of development of collaborative business models in the context of 5G-LOGINNOV, a project aimed at the development of 5G-based solutions to optimize the logistics operations in ports and retro-ports.**

***Index Terms*—5G networks, Business Models, Port innovation, Supply chain management, Logistics 4.0**

I. Introduction

The continuously growing global demand for freight transportation is the consequence of the increasing requirements of the modern economy. This implies that data collection from a multitude of different sources along the supply chain, as well as the need for more effective and reliable connectivity solutions to collect and securely share data are becoming more important. For these reasons, 5G networks are the backbone of data collection and sharing infrastructures, but they need to be integrated with companion technologies (e.g. Internet of Things, Cloud computing and storage, Blockchain, and Artificial Intelligence) to increase the potential applications of the information gathered and to extract valuable outcomes. Besides the application of innovative technologies in the existing processes, the digital transition of ports' activities towards the Logistics 4.0 paradigm needs the development of collaborative business models, to highlight the added value given by the information sharing between different actors. Moreover, the business models are the main gateway between the development and testing activities in the context of the innovation project and they allow the market adoption of the tested solutions beyond the duration of the project. It is therefore important, to ensure the market acceptance of the innovative business models, to engage all the existing actors and potential new entrants in their development, starting the process with the analysis of their daily activities and their potential needs.

This paper aims to analyze the different business models under development in the context of 5G-LOGINNOV project [1]. The objective is to evaluate which are the most important needs of the stakeholders in the port environment, as well as the most promising applications of 5G networks and companion technologies in ports' operations to address these needs.

The paper is structured as follows. Section II presents the main most recent literature contributions on business models for logistics and supply chain to understand how business models can create value. The 5G-LOGINNOV project is briefly described in Section III. While Section IV presents the GUEST methodology and how it has been adapted to be implemented in the context of 5G-LOGINNOV project. The preliminary results from which we started the development of the business models are described in Section V. Furthermore, the different types of business models that have been identified are described in Section VI. Finally, Section VII presents the main outcomes of the preliminary analysis.

II. Literature review

The creation of business models is a complex activity that requires close collaboration between many people - diversified by age, experience, and role, who can combine their different points of view to define business models that are well structured and concretely implementable [2]. Although there are abundant templates and processes for developing business models (among the others: [3]–[6]), nowadays most of the business models are represented using the CANVAS [2]. This approach allows to highly standardise the components of the business model, to have all the information in a single diagram, and describe how an organization creates, delivers, and captures value. Even if the CANVAS is the most used template, this representation can be difficult to understand, especially for the stakeholders who need to capture the possible future impacts of the business models [5]. In other words, CANVAS is a static representation.

In the report produced in the context of the SocialRES project, [7] which analyses nine cases of social innovations implemented thanks to crowdfunding, platforms cooperatives, and aggregators, the authors identify, analyse and describe different business model archetypes. A special focus is dedicated to understanding how social and environmental perspectives have an impact on them. According to this report, the most used tool for business models - the CANVAS model - mainly takes into account economic attributes but does not assess the environmental and societal perspectives. Therefore, this purely economic perspective is not able to bring ideal solutions if we consider that in our society, the planet, the people, the products, and the community have a very important value and role [8]. The creation of the business models should result from a process of discussion with all the involved stakeholders who can verify the value of the designed models.

Regarding the involvement of stakeholders, [9] argues that good collaboration between stakeholders is a very important resource for the creation of value. The stakeholders have a complete vision not only of the product and the sales but also of the customers and the market. Similarly, [10] claims that, in addition to the importance of the stakeholders, the relevance of data sharing and mutual exchange of information between the actors involved must be considered. The studies reported in [11] show that the business models have three dimensions: 1) "Who" that constitutes the value of networking; 2) "Where" that describes the sources of value; 3) "Why" that represents the reason partners collaborate. These three elements have given the business models an identity that takes into account the contents, the actors, and the context.

The numerous analyses, together with the methodologies of creation and evaluation of the business models, are an indication of their importance in any reality. In the last few years, the authors have agreed on the fundamental importance of business models to create value (among the others: [12]–[17]). The succession of studies on business models has led [18] to entrust them with an even broader role. Meaning that business models are created, developed, and managed precisely to produce value. Furthermore, they must now be seen as a tool that organizes and facilitates the relationship between stakeholders and, therefore, the creation and exchange of value. The business models are now seen as creators and incubators of value through the sharing of data and information between the different actors. Also, [11] has examined the relationship between the business models and the creation of value in the frugal innovations environment. In particular, the authors claim that the business models have a double role. The first role is the value capturing from the revenue generation of the innovating organization. The second is value creation, which means that the business models create the value coming from the impact that the innovation has on the local economy and environment.

In this new context, the GUEST Methodology is proposed as an inclusive and contaminating solution.

III. 5G-LOGINNOV

In the context of port logistics, the 5G-LOGINNOV project [1] aims to optimize freight and traffic operations in ports and logistics hubs, implementing and testing innovative concepts, applications, and devices supported by 5G technologies, Internet of Things (IoT), data analytics, next-generation traffic management, Cooperative, Connected and Automated Mobility (CCAM) and the 5G logistics corridors. Moreover, one of the objectives of the project is to select innovative startups and SMEs, to be engaged in the development of 5G-based solutions in the framework of activities carried out at the three Living Labs of the project (in Athens, Hamburg, and Koper). Besides the engagement of these new actors within the activities of the different Living Labs, the objective is to create the opportunity for future collaborations between innovative startups and SMEs and the existing actors and stakeholders of the port, with the development of innovative and collaborative business models, based on information collection and sharing. In particular, one of the project's KPIs is to develop a set of eight business models for 5G core innovation technologies in port operations, structured in four pillars: Maintenance, Operation efficiency, Environment-oriented traffic management and 5G-logistics corridors.

IV. Methodology

A. GUEST Methodology

The GUEST methodology [19]–[21] is a business development methodology aimed to foster the potential for the adoption of innovative products or services in different markets or sectors. The GUEST methodology has already been used with success in several European projects, in more than 50 innovation and industrial projects, and more than 40 SMEs and small innovation groups. In its general version, the GUEST methodology helps to control the process that starts from an idea and arrives at its implementation, through an analysis of the involved actors and stakeholders to keep into account their vision, ambitions, concerns, difficulties, and opportunities from the first stages of the development, investigating their real needs and expected benefits.

B. 5G-LOGINNOV and the GUEST methodology

The GUEST methodology has been applied in 5G-LOGINNOV project to assess the current ports' logistics environment, from which to start with the development of innovative business models. In particular, the methodology has been used to analyse the current ports' logistics sector and the market potential of innovative products and services [20], [22]–[25]. In the application in the 5G-LOGINNOV project, the methodology aims to control the process, from the original idea to its implementation, and to provide a conceptual and practical tool to stakeholders and actors involved in the process, enabling them to communicate their vision, difficulties, and opportunities. In the context of the 5G-LOGINNOV project, a previous application of the GUEST methodology provided some preliminary results, summarized in section V,

from which to start the development of the innovative business models to ensure the market penetration of the project's results.

V. Preliminary results

The first phase of the assessment of the current scenario has been done through the application of taxonomy to recent or ongoing projects dealing with 5G applications in ports' areas, to understand the main existing gaps. The analysis highlighted that 5G networks are usually supported by 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:

1) Few projects have running solutions or a specified product fully operational after the pilot phase. Thus, greater attention to the design of the business model and its scalability is needed;
2) Port-terminal logistics need to be better aligned with urban freight transport and city logistics perspective.

The analysis of the current scenario continued with a survey addressed to 5G-LOGINNOV Living Lab actors, to assess their level of knowledge and adoption of innovative technologies related to Industry 4.0 and Logistics 4.0. The analysis mainly highlighted a high interest 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. It appears that 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 who participated in the survey declared a very high level of knowledge and implementation of the enabling technologies, but the low trust 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 to test innovative solutions on a limited scale before replicating and scaling them on wider markets.

The technology gaps in the 5G-LOGINNOV Living Labs areas have been also assessed, with the perspective of clarifying the most effective strategies to engage new actors in the 5G-LOGINNOV implementations. As a result, we concluded that at Piraeus Container Terminal, the main gaps are linked to innovative Augmented Reality (AR) applications enabled by 5G, including (but not limited to) the generic scope of the following use cases:

- AR-assisted guidance to speed up repairs in port assets (e.g., trucks, lifts, cranes, etc.).
- Increase quality in manual production tasks and lower the chance of errors in warehouse operations.
- Reduce training time at port operations and related assets, with on-the-job real-time tuition.
- Reduce drivers' distraction and detect drowsiness, thus increasing workers' safety in the ports' areas.

From the overall design of the Hamburg LL, the 5G infrastructure enables the collection of extended Floating Car Data and expands this data to Floating Truck and Emission Data (FTED). Therefore, a gap has been identified linked to the need to fully exploit available data from CAN-Bus and other sensor data which can be transferred from the vehicle to the Multi-access edge computing (MEC). This led to the following possible topic of interest:

- Traffic Management, Connected Automated Driving, and other applications that can make use of the given 5G-LOGINNOV infrastructure (e.g., MEC, Telematics Device, etc.).
- Contributions that can elaborate an uptake of the Green Light Optimal Speed Advisory for Automated Truck Platoon for Hamburg LL to an original equipment manufacturer (OEM)-centric integration of vehicle data sources and their data fusion.
- Solutions allowing navigation systems to make use of "Green Navigation".
- Solutions allowing to support Eco-Drive training out of the generated data and the data fusion out of 5G (MEC, etc.).

In Koper, gaps were identified linked to security and environmental aspects of port operation related to UAVs (Unmanned Aerial Vehicles, e.g., drones) and Artificial Intelligence (AI)-assisted video analytics deployed in the cloud. Special attention should be given to the following supportive services and use cases:

- Providing autonomous operation of UAVs (e.g., drones without human pilots) in harsh industrial and port environments.
- AI- and Machine Learning (ML)-based applications for cloud environments targeting support services for the port security operation.
- AI- and ML-based applications for cloud environments targeting port safety and environment monitoring on the land and sea.

Based on the state-of-the-art market analysis and the survey results, the main recommendation to boost market possibilities in the project have been highlighted. In general, the definition of business models shall take into account that:

1) The financing and revenue models for the new solutions shall consider not only public, but also public-private forms of funding so that the investment risk is shared, but the commitment of the involved parties remains 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 enabled technologies' implementations. Moreover, the proposition of new 5G enabled products and services must focus on the definition of collaborative environments, to improve 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 scenario analysis will continue with the assessment of products and services enabled by 5G that are expected to bring advantages to ports' operations from the economic and operational terms. The goal is to define their expected impact and added value on operations and local business models and, at the end of the project, assess if expectations have been met.

The outcomes of the current scenario analysis are the starting point for the development of the collaborative business models to foster the market adoption and of the innovative, 5G-based products and services in the Living Labs (LLs) environment beyond the duration of the project. In fact, through the assessment of the current scenario, actors and stakeholders involved in the activities of the LLs have been profiled to define their operational needs, as well as the pains and the gains affecting their activities.

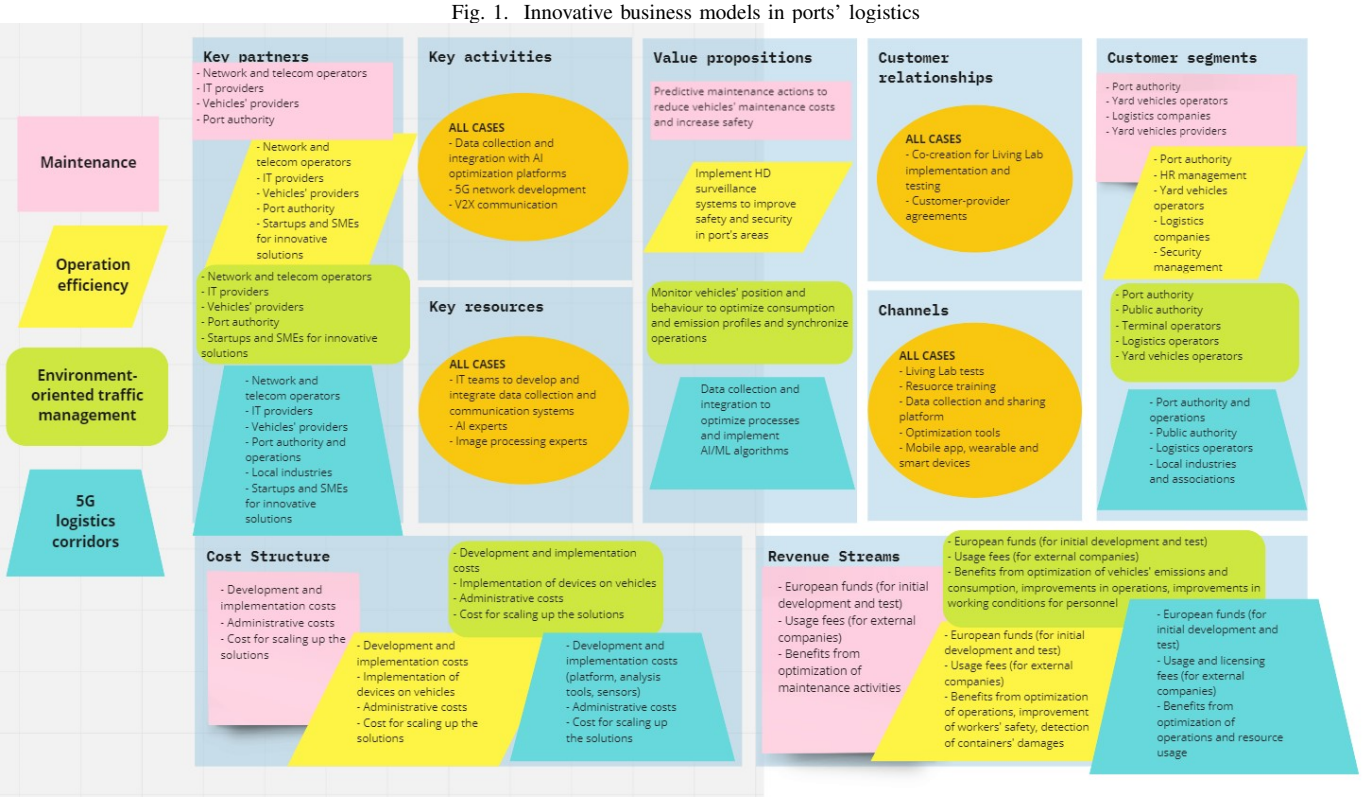
First, a set of four preliminary high-level Business Models have been developed, according to different macro use-case categories (Maintenance, Operational efficiency, Environment-oriented traffic management, 5G logistics corridors). Then, these business models have been further detailed to keep into account the objectives of the specific use cases of the project. To develop the high-level Business Models related to each macro use case category, their objectives have been defined. For maintenance, the main objective is to collect and analyse data coming from sensors and exchanged through 5G networks to increase the lifecycle of the machinery, reduce their breakdowns and optimize the operational costs related to maintenance (i.e., predictive maintenance and optimisation of spare parts procurement and inventory). For operational efficiency, the objectives of the business models rely on the optimisation of the operations within port activities by collecting and using data to decrease traffic jams and queues (thus reducing also consumption and pollution), avoid errors in container identification, ensure the correct assignment of container jobs, and increase the quality of working conditions of the yard operators. Considering the environment-oriented traffic management, the business model focuses on the creation of a network, enabled by 5G communication and information sharing, between the different logistics actors of the port and surrounding area. The main objective is to reduce the environmental impact of ports' activities by optimising the operations. The business models related to 5G logistics corridors are aimed to standardise the 5G enabled port operations systems to foster the cooperation between the logistics actors, thus defining a roadmap toward the pan-European deployment of 5G. The analysis of the project's use cases allows the creation of a matrix in which each use case is associated with one or more objectives of the project. As a result, ten business models - strictly connected to the objectives of the use cases of the project – have been created.

VI. Business Models

This section aims to present a comparative analysis of the main characteristics of the business models related to the four different objectives (Maintenance, Operation efficiency, Environment-oriented traffic management, and 5G-logistics corridors), reported in Figure 1.

1) Considering the value propositions of the different business models, a common objective is to collect and share data coming from different sources to implement actions related to the four pillars. In all the cases (implementation of predictive maintenance, development of high definition video surveillance systems, real-time monitoring of vehicles' positions and behaviors, and in general information exchange between actors and stakeholders), the 5G infrastructure is the backbone that enables high speed and high volume data exchange with low latency. Moreover, since every business model type implies information sharing between different partners, further development must keep into account GDPR and data confidentiality issues, to foster the market acceptance of the proposed solutions.
2) Considering the customer segments addressed by the different business models, port authorities are the most commonly impacted ones, with benefits related to optimization of operations and processes, as well as the improvement of the safety and security conditions inside the port areas. For the same reason, yard personnel and yard truck operators are impacted by the improvements in their working conditions.
3) The customer relationships highlighted in the business model canvases are, at this stage of the development process, the same for all the different pillars: during the project duration involved actors and stakeholders will collaborate to develop and test the solutions in the different Living Labs, while beyond the duration of the project other agreements (i.e., one or more actors will act as the providers of the innovative products and services) will be adopted to ensure the market adoption of the tested solutions.
4) Also for the channels to communicate the solutions, during the project the test activities in the Living Labs will act as a communication platform. Moreover, other communication channels (e.g., communication through mobile apps and wearable devices) will be implemented to communicate the solutions to the customer segments.
5) Also the key activities needed for the development of the different business models presents many common points. In particular, 5G networks and data collection infrastructures are the starting points for the development of all the

Fig. 1. Innovative business models in ports' logistics



considered business models. Depending on the objective of the different business models, other activities are related to the development of optimization algorithms and AI platforms (for maintenance and environment-oriented traffic management), image processing systems (for the operation efficiency pillar), and V2X communication protocols (for 5G logistics corridors).

6) As all the solutions are based on the implementation of innovative technologies, the key resources needed for the development of the proposed solutions come from the ICT sector. Moreover, to ensure the integration of the innovative products and services with the existing tools and processes, there is a need to involve in the development activities of the ICT functions of the actors and stakeholders involved in the Living Labs.
7) As a direct consequence of the key activities and key resources, the key partners highlighted in the business models are mainly IT providers and telecommunication operators. Furthermore, there is the need to involve technology providers (e.g., for the IoT sensors and surveillance systems), as well as the providers of yard vehicles that must be integrated with these systems.
8) The cost structure is directly linked to the key activities and resources, and it is composed mainly of the development and implementation costs of the IT components of the innovative services and products. Other cost sources are related to administrative costs to manage the development and implementation activities and to maintain the solution beyond the duration of the project. Moreover, scale-up costs must be considered to adapt the solution for a wider application in the market.
9) The main source of revenues during the development and test phases of the project is related to the European funds to the Living Lab partners. Beyond the end of the project, other sources of revenue must be considered to ensure the economic sustainability of the solutions in the market. If the solutions developed in the project can be adopted also by companies and operators external to the port environment, a payment system based on usage and licensing fee can be developed. Moreover, the most significant sources of revenue for the companies adopting the innovative solutions are related to cost savings due to the optimization of operations and processes, as well as the improvements in the safety and working conditions for the personnel involved in the port's activities (e.g., the social cost for potential injuries).

VII. Conclusions

The importance of data collection and sharing between actors and stakeholders involved in the ports' logistics is continuously increasing. Data collection and sharing are among the main drivers of ports' processes optimization. In this context, 5G networks and companion technologies (such as the Internet of Things, AI, and Cloud Computing) enable real-time monitoring and optimization systems and extract valuable information from the data collected. EU-funded projects, such as 5G-LOGINNOV, positively affect the development

of innovative 5G-based products and services in the ports' logistics domain, allowing companies from different sectors to collaborate and create new solutions. To fully exploit the potential of the application of innovative technologies in ports' logistics, the development of collaborative business models fosters the market adoption of the innovative products and services beyond the duration of the project. The potential business models developed in 5G-LOGINNOV, highlight the importance of the data collected from different sources to implement IT tools for the logistics processes and optimization of the ports. In particular, the use cases defined in the project focus on the monitoring of the position and behavior of trucks and yard vehicles to synchronize the operations and implement predictive maintenance actions, as well as on the implementation of video surveillance systems to monitor the port's areas and to detect potentially dangerous situations, thus addressing also the social aspect related to the improvement of safety and working conditions for port's personnel. The potential benefits derived thanks to the application of these solutions directly impact the port authority in terms of process optimization. Furthermore, other actors and stakeholders (such as logistics operators and security management) will be positively affected by the synchronization and optimization of the port's operations. The market adoption of these solutions beyond the project duration can be obtained thanks to the analysis of the sources of costs and potential revenues that allow the economic sustainability of the solutions under development. Given that costs are strictly related to the development and testing activities (within the project consortium) and scale-up costs in case of market exploitation of the solutions, the potential sources of revenues (after the EU funding phase) come from cost savings related to the optimization of the processes. Moreover, it is possible to foresee the application of licensing and usage fees for external actors interested in adopting the solutions.

Considering further steps of development for 5G-LOGINNOV project, the GUEST methodology for business modelling will continue with the direct engagement of Living Labs actors to collect their comments and suggestions in order to define how the value propositions can be declined in the activities of the Living Labs, and how they can be deployed according to the objectives of the different use cases.

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