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The European 5G-LOGINNOV project: Analysis and development of new business models related to 5G and companion technologies

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To my parents, who are a constant source of inspiration and encouragement.

To my brother, who shares with me every moment.

To all the people, who believed, believe and will believe in me.

Abstract

Nowadays, there is a progressive improvement and development of new technologies characterized by a daily occurrence changes and evolutions. The working environment and the everyday life are influenced by these new technologies making tasks better and faster. From a firm's point of view, the technological progress is an important tool for competitive advantage and innovation is the key word. Among innovations, what have a greater impact are those called disruptive innovations. Focusing on technological innovation, it is important to underline how the birth and spread of 5G and companion technologies is making the emergence of a new era where people and things can be constantly connected. These types of innovation, however, because of their disruptive nature, can often be slow or meet many barriers to their widespread. The manufacturing, energy, transport and financial services are the ones that use 5G business process transformation. In this field, numerous initiatives and projects were being undertaken in order to develop the technologies, the structures and the business models needed to make the best use of the new technologies' capabilities. Among these there are European projects which are part of the Horizon 2020 program.

In this thesis, the focus is on the European 5G-LOGINNOV (5G LOGistics value chain INNOVation) project and on the 5G technologies related to the logistics and transport industry especially in the port ecosystem. In fact, international trade is increasingly growing and new customers' need have been identified. With this project, it is possible to deliver solutions, architectures, technologies and standard in order to create the next generation European communication infrastructure. These technologies will be developed, implemented and tested in three Living Labs located in three different European ports: Athens Port (Greece), Hamburg Port (Germany) and Luka Koper Port (Slovenia). This way, it is possible to involve innovative SMEs and start-ups. The 5G-LOGINNOV' s baseline is centered on three main logistics European projects: AEOLIX, SELIX and FENIX; and, focusing about the ports of the future, it is possible to consider one of the most recent European project: COREALIS.

In this thesis, will be analyzed and developed new business models related to 5G-LOGINNOV technologies, in particular, the focus will be on two main 5G core innovation technologies for port operations: maintenance and operation efficiency. In doing so, the GUEST methodology will be used. The GUEST methodology has been developed by researchers of the Politecnico di Torino. By applying the first steps of the method, it is possible to analyze all the actors involved in the project and which stakeholders, resources and customers are implicated in order to develop a value proposition that fulfill all the firm's objectives, bearing in mind the probable costs and revenues.

Contents

CHAPTER 1

The innovation

In an increasingly frenetic world, changes and evolutions are a daily occurrence. Lately, there has been a progressive improvement and development of new technologies that influence not only the working environment, but also the everyday life meeting people needs, making tasks faster and better. Technological progress is also important for firms in today's fast changing industries, especially for competitive advantage. In this context, innovation is highly relevant.

The aim of this chapter, besides the definition of the word innovation, is both presenting different types and dynamics of innovation.

1.1 Definition of innovation

It's very difficult to define clearly and comprehensively what exactly is innovation; however, it is widespread that innovation indicate the creation of something that did not exist before. In addition to understanding the technological aspect, innovation implies the understanding of economic, social and organizational elements associated with it.

First of all, it becomes important underline the differences between fundamental terms that can be misunderstood:

- *Discovery:* it is a new knowledge that can be related to a prior knowledge and it is the outcome of science. Discovery is find out something new.
- *Invention:* it is correlated to a solution of a problem, and is carried out by using technology, defined as technological knowledge, as well as science, define as scientific knowledge.
- *Innovation:* it is the step after to invention when is finally marketed and gives a utility; the aim is the economic exploitation. The innovation is achieved if it is followed by diffusion, which is the adoption of technology by the market.

To move from design to innovation it is crucial to look at management and economy; in this regard Joseph Schumpeter was the first to talk about innovation as an endogenous phenomenon to the economy, determined by economy but which, in turn, also impacts to the economy [Cantamessa, Montagna 2016]. It is a dynamic path of evolution in the economic system through two mechanisms: creative destruction and creative accumulation. Creative destruction is tied up to the introduction of new solutions to the market and is believed to be what drives economic progress creating economic discontinuities. Creative accumulation, on the other side, is based on innovation along established technology [Pasca di Magliano 2016].

1.2 The process of innovation

One of the first model developed, from a theoretical point of view, to understand and correlated technology and science to economy, was the linear model of innovation. The model is represented by several phases, starting from the upstream part, innovation begins with basic research, then appends applied research and development, finally production and diffusion. In the following *Figure 1* is representing the linear model of innovation.

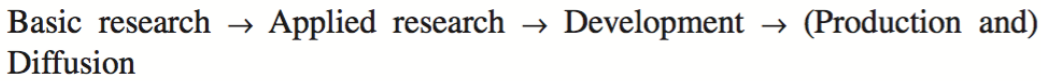

Figure 1: The linear model of innovation [Godin 2006]

The linear model of innovation developed through time in three different steps that are linked, in fact, to three different scientific communities which got into the field of scientific studies. The first step connected basic research to applied research, while the former was not directed to a specific application, but only to knowledge, the latter leaded to invention of a new technology and used basic resources as a source. The second step starring researchers from business school, which were interested in studying the development of new technologies and the industrial management, underling the relevance for the industry. The product development is a process that can last months or even years before the innovation is delivered on the market. Finally, in the third step were economists that pointed out

commercial attractiveness and industrial viability, therefor, they brought to the foreground the impact of these researches on society and economy.

Despite numerous critics, the linear model of innovation functioned as a social fact having become standardized thanks to the Organization of Economics Operations and Development (OEOD)[1]. Obviously now innovation can't be defined as a pure linear process due to the iterative nature of the relationships involved, but the linear model of innovation previously submitted can easily explain the innovation process [Godin 2006].

It is often debated when a new technology can be considered mature enough to be ready for its users and to be exploited at its best. Technological maturity is crucial for understanding the impact of a new technology, especially for a firm's core competences, so we can define it a critical factor of success or failure. In this regard, in 1970s a new metric was developed by NASA to analyze the maturity of a new technology, it is called the Technology Readiness levels (TRLs) [Tomaschek et al. 2015]. This metric is characterized by a 9-point scale which closely follow the linear model of innovation, from the state of basic research to a fully functioning technology. As time passes, the Technology Readiness levels spread across industries and became also an instrument to evaluate projects at European level, from discovery to widespread innovation.

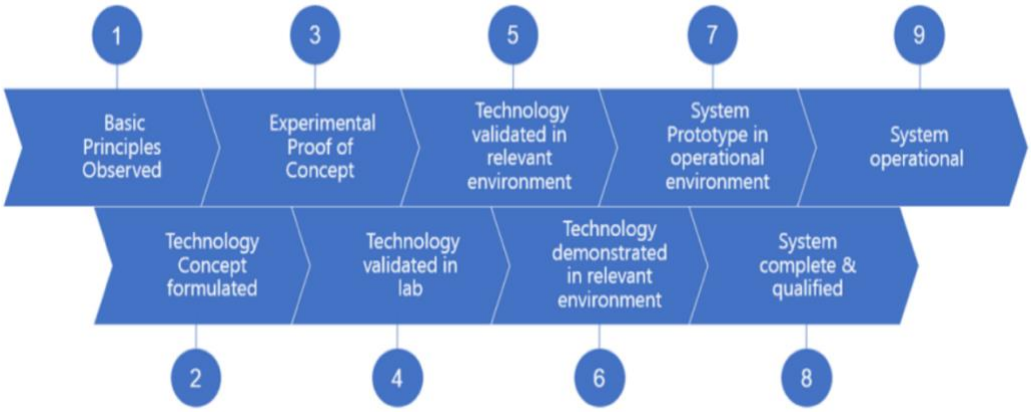

Figure 2: Technology Readiness levels for innovation chain H2020 [Horizon 2020]

[1] *Intergovernmental organization founded in 1961 to stimulate economic progress*

For instance, in *Figure 2,* is represented the TRL scale presented by the European Community for its program Horizon 2020 [Horizon 2020]. Organizations may have changed the original NASA's 9-point scale in relation to their specific needs, but the purpose of each level stays the same.

1.2.1 Economic actors

Looking at *Figure 1* and at the several steps, it is easy to realize that the innovation process is long and very challenging because involved a high risk. In this context is not easy find someone who is available to invest in the entire process from the upstream to downstream. Instead, it is quite possible that there are several actors implicated throughout the innovation process. In the light of the high risks, especially during the early stages, at the beginning of the process the role of academia and the public funding of research are relevant because they want to bring the knowledge in the public domain. The role of industry, instead, is increased at the downstream of the model where it is possible to obtain economic returns. In the last phase, governments usually do not act, since risks are lower and the return on investments is short, they allow the market to work properly and operate freely otherwise there is a risk of deflecting the competitive mechanisms.

Because of the failure rate and the high risk early in the process, the development is selective and competitive, in fact, only the most promising activities, the best, are placed on the market with high returns. It is possible considerate this process as the Darwinian process of natural selection in which nearly 75% of innovations die. Private entities cannot contribute at the beginning of the line; they cannot afford it (economically) because of the uncertainty related to innovation. Precisely for this reason exist specific entities interested not only in profit, which invest in innovation, in basic research and applied research.

The governments not only provide financial support in the first phases of the linear model of innovation, but can also act differently. One of the most important roles that governments hold is the function of regulator at large, this institutional figure determines laws, rules, etc., that have a significant impact on the economic and institutional environment especially for the firms that invest in innovation. Lastly, we must consider that, besides the

role of the regulator at large, governments define standards to increase social welfare. The product has a value thanks to the conformity to the standard which represents the features that products must have according to governments [Cantamessa, Montagna 2016].

1.3 Types of innovation

Innovation can involve different actors and can be occurred at different levels. One of the first distinctions we could do is between product innovation and process innovation. While the former is correlated to the development and the sale of an innovative product by a firm, the latter represents the set of new methods or tools that contribute to improving the company and how operates. Subsequently, we consider the organizational innovation that modifies methods or business processes. Finally, more recently we speak about business models innovation, which implies a new way to create and development and organize a business model and anything related to it.

Beyond existing types of innovation, identifying determinants of innovation is crucial.

1.3.1 Technological paradigm

Talking about technological innovation it is possible to underline two different and opposite determinants of innovation:

- Technology-push,
- Demand-pull.

Technology-push represents innovations introduced by a technological evolution employed in a given industry that define induce needs, they are brought on the market but are developed independently of specific market needs. One example of technology-push are all technologies, high-tech, that meeting a latent demand. Demand-pull represents innovations due to specific market needs, termed primary needs. Generally, these innovations are enabled to support things that otherwise would not find alternatives, for example vaccines. Firms monitor the demand trying to “pull” development and improve products to better respond to needs and society requires. Innovations are always established by both determinants of innovation, as a

matter of fact, there is no point in dividing by classifying technology-push and demand-pull. Thereby it is possible to describe a concept termed technological paradigm defined as a co-evolution of market needs and technological performance over time.

Since it is not easy to understand which of the two determinants, technology-push and demand-pull, comes first, technological trajectories are used. The evolution of trajectories of the innovation process is not linear, but follows a sequence of S-curves, each of these is considered a technological paradigm.

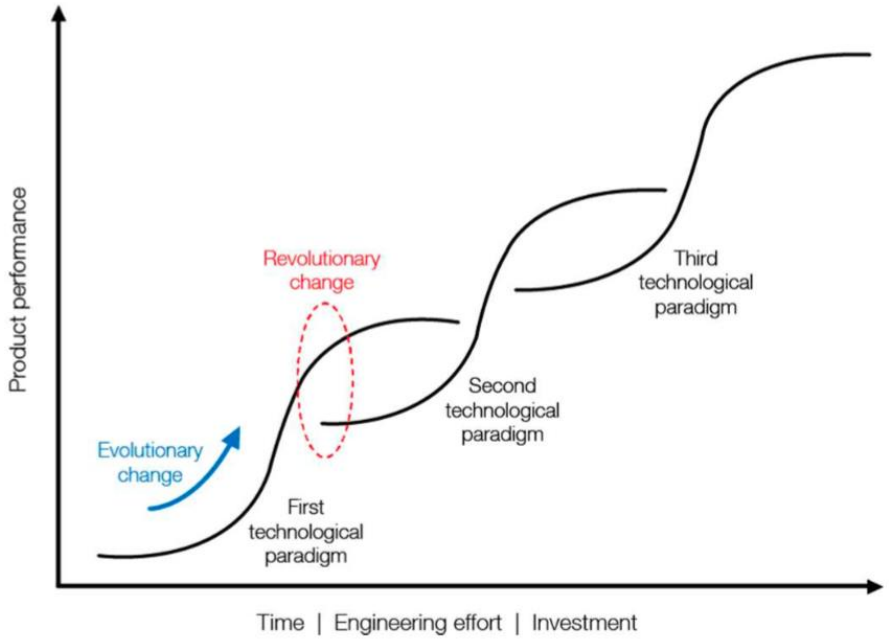

Figure 3: S-curves of technological paradigm [Cols 2016]

The S-curves in *Figure 3* show that when a technology emerge product performance is very low, but with large investments, when the technology reaches its maturity performance starts growing; eventually there is a point of inversion where the S-curve decrease and there is a clear evidence of decreased product performance. During this whole process, there is continuous improvement until product performance reaches its limit, defined as technological limit, due to the intrinsic limit of the technology. Once the limit is reached if higher performance is needed firms have to

accept new technology. Generally, there are several different possible solutions to choose from, but at the end only one can emerge. Therefor evolutionary change is experienced along the given S-curve and are incremental innovations given by demand-side, demand-pull. Revolutionary change occurs when technological limit is reached and when a jump from the given S-curve to the new technological paradigm is required. In this context, we talk about radical innovation and technology-push [Cols 2016].

By observing Figure 3 it is necessary to specify that performance indicator on the Y axis is related to market needs.

In each point of the S-curve there is equilibrium between supply-side and demand-side, according to Cantamenssa and Montagna [2016] a technological paradigm is defined as: “a mixture of supply-side and demand-side elements that blend together in a coherent whole and give birth to a technological trajectory that is at the same time viable for companies, and appreciated by the market”. When even a single technological paradigm relation is broken, it occurs the jump to one curve to the new one. Along the curve, during the evolutionary change, the role of marketing is desperately needed since costumer needs are already known; in the technology-push phase, conversely, needs are not specified, so only the Research and Development is capable to understand and forecast the needs that are going to be developed by the new curve.

1.3.2 Types of technological change

Focusing on technological innovation, the development of new product, it is possible to classify this type of innovation considering two dimensions. The first points out innovation’s impact on the components of the technology, while the second points out innovation’s impact on the connection between components. It is a model proposed by Henderson and Clark [1990] to classify the type of product innovation in term of its impact on the capabilities of the firm and to put it in a better position to understand in which circumstances and what position innovate. In total, there are four types of innovation as stated by Henderson and Clark. Looking at *Figure 4* the first innovation presented is the modular innovation, in this case technology changes some functional elements, but the linking in the

architecture does not change, it is requiring new competencies. On the opposite side, when technologies do not change, but the relationships between components does, there is the architectural innovation. This latter modifies competencies and it is difficult to manage. There are two more types of innovations that are extreme points: incremental innovation and radical innovation. The former type is related to a previous knowledge and to existing component so it is not difficult to manage, the aim is defining and extending an establish product. The latter, otherwise, determines a new technology with new relationships between components and is the most difficult type to pursue.

Relationships between components Reference technologies	Do not change	Change
Change	Modular innovation (e.g. high capacity batteries in cell phones)	Radical innovation (e.g. PCs vs typewriters)
Do not change	Incremental innovation (e.g. faster spinning hard drives)	Architectural innovation (e.g. rear-wheel vs front-wheel drive cars)

Figure 4: Hendenson and Clark model [Cantamessa, Montagna 2016]

Organizations reflect product architectures, which are the set of component and their relationship, if it changes architecture it changes competencies too. This way, a link of the technological paradigm is broken, thus achieving the radical innovation. In order to break the links, radical innovation should first be architectural one.

Radical innovations can be disruptive innovations which in their turn are definitely competence destroying affecting all the industry, if firms don't adapt to changes they are off the market. This condition takes place when there is a new technology that fits better customer needs, but competencies and assets are completely different compare to the old technological paradigm. Incumbents don't notice or are incapable to join the new paradigm due to both objective and subjective factor. Another reason

because disruptive innovations take place is ascribed to focusing on the target market, this condition is termed the Christensen effect. Incumbents are aware of the emerging of a new technology but its performance is too low so they continue to serve their market instead of observing different and new customer needs, moreover the S-curve of the new paradigm are not going to meet the old one for a long time. They unknowing that a completely new group of customers at the bottom of the market with different needs is completely served by the new technology even if the performance is inferior, *Figure 5*. Thanks to its customers, the new technology succeeds to make revenues, investing in the same technology and meeting the old technology much earlier than expected.

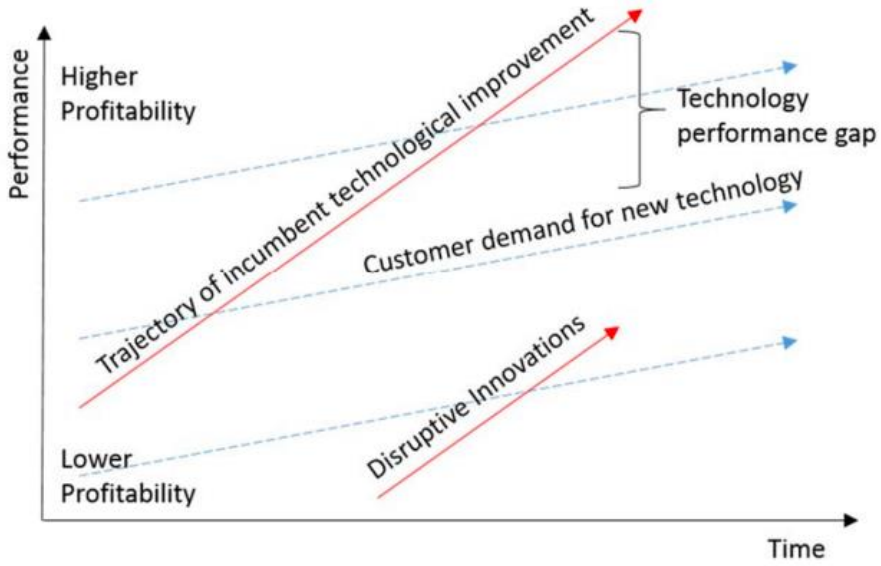

Figure 5: Christensen effect [Christensen et al. 2016]

Disruptive innovations occur when the new market is larger than the existing one and incumbents don't even make their update in time giving space to new entrants. For incumbents is risky embrace radical and competence destroying innovation because of its existing business. To response better to decision making and strategic leadership in developing different types of innovation, such as incremental and radical innovation, they use organizational ambidexterity [Christensen et al. 2016].

1.4 Business model innovation

A business model is characterized by strategic choices; it delineates how direct the organization in order to deliver value to customers and invest money in a sustainable way managing the resources. A second aspect that characterized it, is earning a profit accompanied by a competitive advantage, stating how and where the firm operates. The notion of business model is generally related to the emerging of Internet companies at the beginning of the twenty first century because of the new services and different products, compared to the traditional ones, that companies provide on the market. These new companies are an example of the necessity to have business model being constantly tested and modified [Cantamessa, Montagna 2016]. Subsequently, business models and business model innovation became useful for other firms in different industry either, especially relating to disruptive changes. In fact, they are a way in which a firm can bring a technological innovation to the market and analyze its performance.

Business model can be an innovation, improving and modifying the internal operations of the firm, but in this case the core of the product or services provided does not change. As mentioned, business model innovation may occur due to the technology-push; to maintain leadership in the market or became the first mover the disruptive innovation may require changes in the business model or the necessity to recreate it. On the other hand, even in the demand-pull approach it is possible to modify the business model to satisfy different customer needs [Trimi, Berbegal-Mirabent 2012].

Identifying an appropriate business model is not easy, there are different elements that make up it starting from the design step following by trial-error dynamics to set the right structure.

Beyond established companies and incumbent business, there are other actors in the market whom can exploit business model methods and its innovations to create and organize a new business such as start-ups and entrepreneurs.

A start-up is related to the creation of a new business venture; it is a company, sometimes temporary organization, in search of scalable and

repeatable business model. The first thing necessary for this process is to identify an opportunity or a new idea, then establish and selective the necessary resources to exploit it. Obviously social networks and intellectual capital are some determinants of a competitive advantage, but in certain case an entrepreneur needs to be able to anticipate market opportunities [Trimi, Berbegal-Mirabent 2012].

Entrepreneur spirit is attributed also to the small and medium-sized enterprises (SMEs) that, thanks to their successful activities, enhance innovation contributing to the development of the society. Small firms are heterogeneous, but the specific nature of innovation and the sector belonging are the determinants of innovation in SMEs. These enterprises can diversify their activities and create new products responding flexibly to changes and openings of the market [Blach et al. 2020].

It is very difficult and risky create a business framework with high level of uncertainty related to market, product and customers, especially referring to technological opportunities because they have a short life cycle and are volatile. Clearly an entrepreneur should take some risks in organize and decision making. According to Trimi e Berbegal-Mirabent [2012] technology-based start-ups can be assumed as: “new ventures where know-how and advanced technological discoveries are capitalised and exploited through new products and services”. Having short-term planning, start-ups and entrepreneurs should move faster than competitors.

In this regard, it became necessary ensure flexibility in order to satisfy customers in the best way and in the shortest time; in this setting the Open Business Model, the Business Model Canvas and the Lean process are introduced.

1.4.1 Open Business Model

Innovation is very important to create competitive advantage and value, following the changes of customer demands firms should consider a new approach to pursue sustainability and efficiency. Open Business Model originates from the concept of Open Innovation, proposed by Chesbrough, therefore it is quite important define it.

Generally, established firms tend to develop activities inside firm's boundaries defining them as know-how and trying to take advantage, but few products developed by internal R&D manage to have market return. This process is termed Closed Innovation. Then it is necessary increase productivity on this expenditure allowing innovation to be more open [Cantamessa, Montagna 2016].

In order to exploit ideas and opportunities a company should not be isolated, but expanded its boundaries searching for new ideas, competences, technologies, routines and processes from external sources; these may lead to others innovations on alternative pathways. Moreover, firms can no survive anymore only on their own R&D due to global competition and rising in costs. This way, it is possible to underline that Open Innovation requires firms opening themselves to the market and external knowledge. In *Figure 6* it is proposed a comparison between the Open Innovation model and the traditional Closed Innovation model.

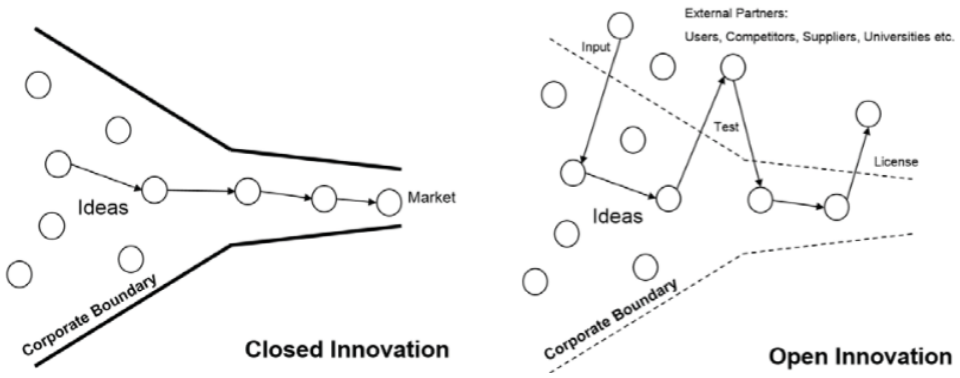

Figure 6: Closed Innovation and Open Innovation [Egger et al. 2016]

In the business model context, Open Innovation allows to acquire new ideas to better improve the business's performance and push eventually additional business model innovations in complementary markets. By adopting Open Innovation, sharing and licensing new technologies are required, meaning that Open Business Model's design should guarantee these possibilities [Trimi, Berbegal-Mirabent 2012].

1.4.2 The Business Model Canvas

The Business Model Canvas is an informal tool, proposed by Österwalder and Pigneur, that emerged to help firms making decision at the right time for business model development, especially in response to underdeveloped and volatile technologies. The Business Model Canvas's scheme enables understanding the objects, principles and relationships that make up the business by reference to four main areas: the product, the costumer, the infrastructure and the financial aspect. This tool contains all the necessary information to relocate an existing business or develop new ideas, and it is essential to the learning cycle especially for start-ups. The Business Model Canvas can be used as graphical tool to visualize all the links between elements that constitute it and easily understand how these work as a whole; it is even possible to evaluate possible trade-offs. It is very important focusing on all the elements that constitute the model avoiding concentrating only on a specific part of the business, this template allows it. Using Canvas model, it is easier sharing and communicating with all the stakeholders involved, which are the main element to maintain and improve activities, but also the best way to identify risks. Moreover, this way it is easier encourages the thinking methodology always based on customer needs [Trimi, Berbegal-Mirabent 2012].

The Business Model Canvas is one of the main aspects that characterize the methodology used in this thesis to evaluate and provide firms with an innovative framework for business management. For this reason, the template is going to be pictured in details later during the description of the methodology used.

1.4.3 The Lean philosophy

In the second half of the 1980s the word “lean” was used to identify a manufacturing method derive from the Toyota Production System, recognized as the Lean Manufacturing [Bortolini et al. 2018]. This philosophy originated to satisfy customers looking for a higher value and a more diverse offer, there are five principles that characterized this approach [Ghezzi, Cavallo 2018]:

1. Create value for the customer offering new services or functions and decreasing costs,
2. Identify the value stream with transparent costs,
3. Create flow avoiding and preventing any stoppage in the value stream,
4. Produce only what is pulled by the customer with responsiveness,
5. Pursue perfection eliminating waste.

The lean philosophy uses different methods and tools in order to fulfil its principles, one of the most important tools is the Kanban system created to manage the flow of manufacturing information and operations. Over the years the lean approach was subsequently extended in other field of application besides manufacturing.

One of the ability to adapt to changes is the agility defined as “the ability to accommodate and adapt to changes in a dynamic environment” [Ghezzi, Cavallo 2018]. The Agile method emerged in the 2000s and it is exactly based on this concept of agility; according to Ghezzi and Cavallo [2018] “Being agile means applying previous knowledge while learning from current experience in order to deliver high-quality products, under budget constraints and in short time frames.” This method was elaborated especially for software development as opposed to the traditional development Waterfall method in which a phase can start only if the previous one is completed. In fact, Agile is focused on the customer and the delivery, so it requires frequent interactions with testing, short plan execution cycles and feedback in order to ensure early and frequent delivery with continuous improvement and adaptive planning [Ghezzi, Cavallo 2018].

The Lean and Agile methods seem to be very similar, but they focus on different aspects. The former methodology consists in reduce waste and improve production rate with continuous improvement, while the latter uses iterative and incremental developments to response flexibly and rapidly to changes and improve products [Trimi, Berbegal-Mirabent 2012].

Some characteristics of the Lean method and the Agile method have been put together and have inspired the Lean Start-up concept, a term introduced by Ries. In particular, there are three main features from which the Lean Start-up took inspiration [Bortolini et. al 2018]:

- Seeking to reduce waste, costs and time to market and customer feedback time to evolve and improve,
- Work with continuous evolution and improvement of functions and involve all employees, this concept is known as Kaizen that states for change for better,
- Implementing a Build-Measured-Learn process (BML), an improvement process like the cycles Plan-Do-Check-Act by Deming and the Observe-Orient-Decide-Act by Boyd.

The Lean Start-up follows numerous steps, *Figure 7*. The first step is focus on ideation which is the creative process to build the business vision. This phase occurs outside the Lean Start-up methodology, in fact, Lean Start-up has merit to the subsequent activities [Bocken, Snihur 2019]. Then a business model is presented with its uncertainties and its hypothesis which are tested by different types of experiments; one of these is the Minimal Viable Product (MVP) which also allows to get customer feedback. After obtaining the results, the entrepreneur analyzes and compares them to previous hypothesis. Finally, the most important step is the learning one from which can be taken four actions: pivoting, iterating, escalating and giving up. The last stage, learning, is very important for a start-up, especially in the early stage. The most radical change is given by pivoting that provides for variations to some business elements to retest them. While iterating consists in promoting changes, escalating allows to invest in the business because considered sustainable in order to achieve economies of scale.

The last possible change is giving up which means that the business vision at the upstream is not able to generate a business model [Bortolini et. al 2018].

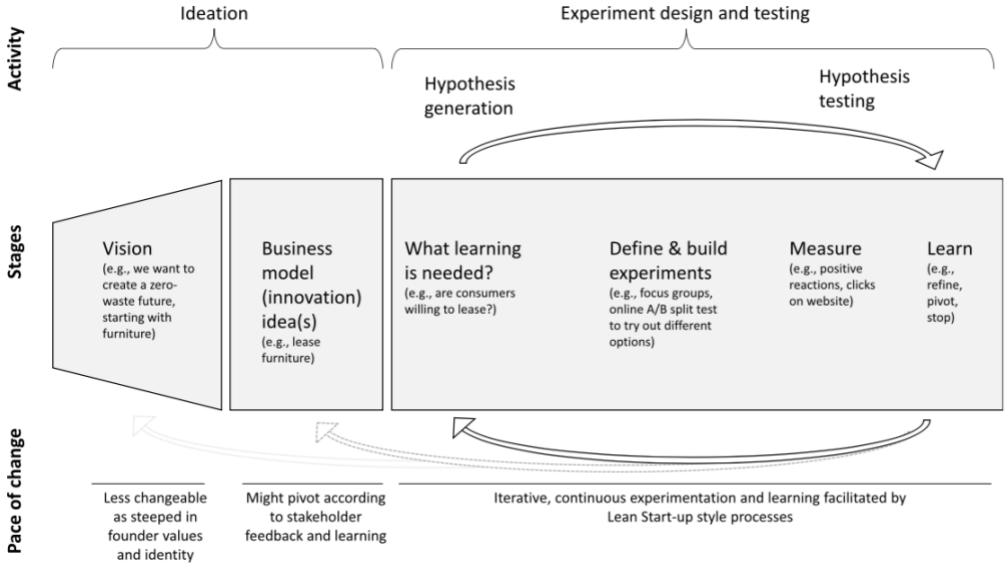

Figure 7: Lean Start-up process [Bocken, Snihur 2019]

So basically, the aim is to speed up processes and create value for customers reducing expenditures avoiding unnecessary investments. Experimentation reduces uncertainty and helps engage social partners and customers, which may support the creation of the right business model [Bocken, Snihur 2019].

1.4.4 Customer Development Model

Traditionally, products are developed in a linear progression as presented talking about the linear model of innovation, which goes from an idea or basic research to the product development. Obviously, this approach finds it difficult to adjust to introducing a new product in a new market. Often developing a product, firms, especially start-ups, invest to create a technology to introduce to the market without searching for customer feedback when it clearly market orientation and identification of customers are a determinant for the firm's success. Following the linear progression, the final product may not be accepted by customers and generating unrealistic expectations as important tools, such as marketing and sale analysis, are not used.

The customer development model is similar to the product development, but is focused on the customers. Also in this model, there are several stages: customer discovery, customer validation, customer creation, and company building. In *Figure 8* every stage is represented as a loop to underlying the iterative purpose. Customer development model and product development model are complementary and therefore are used together; they make it possible study market and improve product.

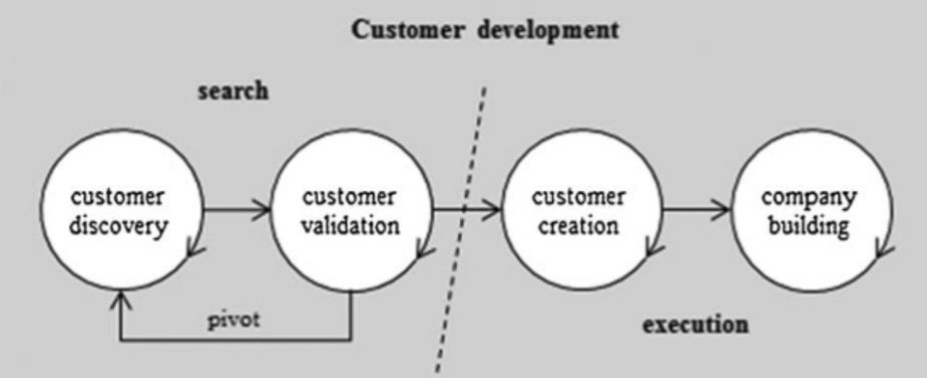

Figure 8: The customer development model [Trimi, Berbegal-Mirabent 2012]

Customer discovery and customer validation are the first important step to identify if the firm has a product that customers want. The former is used to understand customer's needs or problems, while the latter is used to create a sales schedule. Customer creation and company building represent the executive aspect. The customer creation stage is used to forecast demand based on the early sales, while company building describes the evolution of the start-up from the beginning of the process to the lessons learned to exploit market success [Trimi, Berbegal-Mirabent 2012].

CHAPTER 2

The 5G technologies and the logistics industry

The fifth-generation wireless network, 5G, is the last generation wireless network that has enabled to connect not only people, but also processes and objects. In fact, in the last few years there has been an innumerable increase of technologies, devices and methods which, thanks to 5G's capacities, such as the speed of communication and increased transmissible data capacity, make different industries more efficient. Among these one of the most affected by the evolution of the 5G technologies is the logistics and transport industry. In any case, it is necessary to consider that the digital transformation is not simple and sometimes there may be barriers that prevent the adoption of a new technology.

2.1 The mobile wireless network

Wireless communication is defined as "the transfer of information over a distance without the use of wires" [Attaran, Attaran 2020]. The mobile industries have profoundly changed society and the way of communication. In only thirty years there have been a lot of revolution and evolution technological changes. The first-generation wireless network, 1G, was introduced in 1980; it was designed for voice only and based on analog protocols while the successive second-generation standard, 2G, was based on digital ones. One of the most important services that 2G made possible is SMS, changing the way people communicated. A revolutionary technological change was the third-generation, 3G, that provided higher data speeds and transfer capability in alignment with the growing customers' demand to exchange data and have access to the Internet and its services. The next generation, 4G, was only an improvement of the previous one with more services and bandwidth making them available for the masses. The most advanced version of 4G was the Long-Term

Evolution (LTE). The latest generation wireless network is the 5G and it is recently on the market. It is based on digital protocols; wireless signals use higher radio wave frequency than 4G LTE with a great number of small cells. Approximately every ten year, it is introduced a new mobile generation [Attaran, Attaran 2020].

Based on the definitions presented in the first chapter talking about innovations, 5G technologies are considered disruptive innovation and it is for this reason that they appear to have a strong impact not only for companies, but also causing profound changes in society.

2.1.1 The 5G capabilities

5G is not only an improvement of 4G, but offers different innovations in various services and customers can use them differently according to application's needs. This last generation wireless network is enable to connect not only people, but also processes and objects.

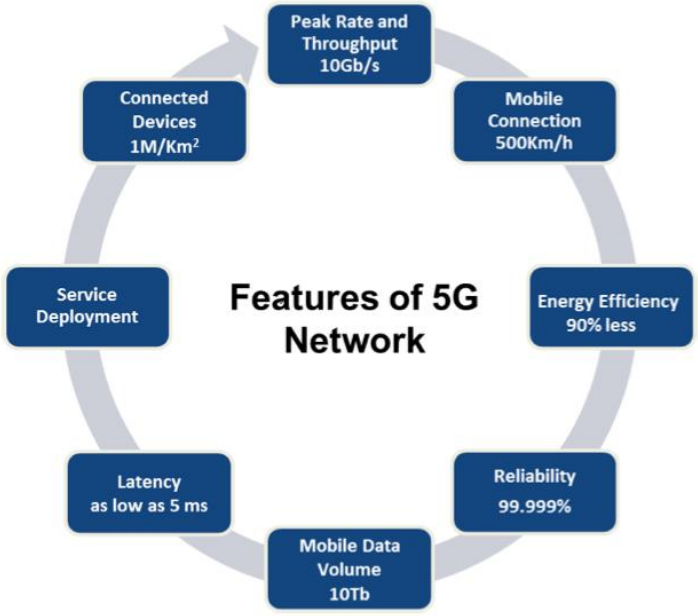

Figure 9: Features of 5G network [Attaran, Attaran 2020]

The 5G system provide, first of all, ultra-reliable and low latency communication (URLCC) with almost instant deliver of data to or from sensors in order to have real-time capture and capacity to carry much more data, enhanced mobile broadband (eMBB), wider bandwidths especially for

streaming data such as high-definition videos, and much faster speeds for consumers combining more spectrums. Reliability, data availability on fast-moving and improve energy efficiency are other 5G capabilities [Gilmore 2020]. The support of machine-to-machine (M2M) communication is improved due to lower battery consumption and latency, and the 5G communication networks can provide an indefinite amount of connections [Attaran, Attaran 2020].

The 5G is a new and young technology and as such it needs to be implemented also through use cases. The 3rd Generation Partnership Project and the International Telecommunication Union worked together to create the right environment and conditions to develop the early technology. Moreover, 5G leads to changes not only in data encoding, but also in the infrastructure used [Attaran, Attaran 2020]. In *Figure 9* are represented the main features of 5G networks.

The first 5G networks use existing 4G LTE infrastructure and provide extra fast data, but already from the beginning of 2020 the 5G uses an entirely new architecture which supports more flexible network slicing and subcarrier encoding improving performance for users [Attaran, Attaran 2020].

2.1.2 The 5G impacts

In the last decades, the world has become more and more connected and digital technologies have assumed a main role. Therefore, there are many changes not only for how technology is perceived, but also for how it is used.

Now a day a digital workplace has become essential, especially to stay competitive in a globalized economy. The aim of having a digital workplace is to increase productivity, increase efficiency, reduce costs and enhance real-time communication. 5G technology could radically transform and empower the digital workplace and how people work. In addition to the main capabilities, 5G also brings improvements in augmented reality and virtual reality, giving the opportunity to create ultra-smart buildings. Moreover, 5G capabilities provide real-time access to data storage and processing power via Cloud [Attaran, Attaran 2020]. All this could be very

useful for example for remote workers and a situation like the one created because of Covid-19 may have contributed to the use and development of such technology. 5G technology will definitely have an enormous impact for the future.

Digital-driven transformations have risen in all industries. Thank to digitalization and the 5G system, industries can exploit the networks and platforms for the purpose of creating automation of processes of Industry 4.0 and supporting the rollout of Internet of Thing (IoT) and the adoption of critical communications services. Therefore, industries want to use digitalization as a way of increasing productivity resulting in decreasing costs, increasing revenue by collecting customer intelligence to better serve them and decreasing risk. The most critical factors for using 5G technology are: first-mover advantage, faster time-to-market for products and services, higher bandwidth [Attaran, Attaran 2020].

Various traditionally vertically structured industries are going to be transformed by 5G technologies [Ahokangas et. al 2020].

Among the industries across the globe, manufacturing, energy, transport and financial services are the ones that use 5G business process transformation [Attaran, Attaran 2020].

2.1.3 Barriers to 5G adoption

Technology is an important instrument that is used to create value for different actors and in various industries across the globe. Considering organizations and their management, it is possible underline the importance of information and how in the past this information management systems were passive and static. Only by combining existing tools, business need, business strategy and goal the technology is able to express its entire value and enhance quality and productivity improvements. Technology itself is not the solution, but it is fundamental how it is used. The digital transformation is not simple and there are often challenges that could limit the adoption of a new technology from businesses. According to Attaran [2020] the most critical digital transformation challenges are:

- The lack of digital literacy and expertise in the organization,
- Consider the digital transformation as a cost instead of a long-term investment,
- The lack of an empowered culture focused on agility,
- The lack of budget,
- The lack of right resources,
- Human barriers such as politics interests or fear and skepticism regarding new technologies.

Digital transformation is not a simple integration of the previously technologies, but it is nothing else than a real IT transformation. Consequently, it is required a cultural change in the organizations in order to adapt to continuous innovation and rapidly respond to challenges and opportunities [Attaran, Attaran 2020].

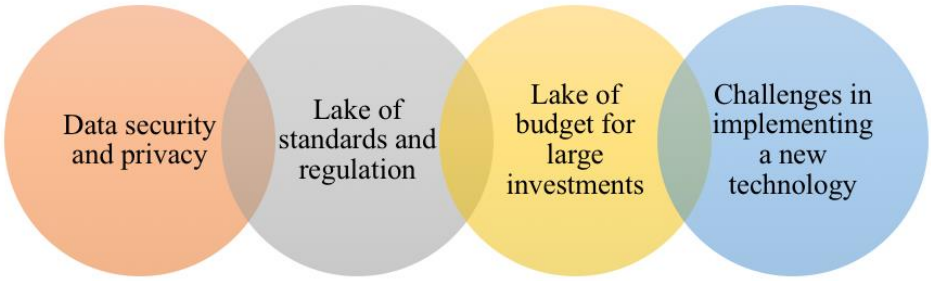

Figure 10: Main barriers to 5G adoption [Attaran, Attaran 2020]

Having said that, there are a lot of barriers even related to 5G adoption, *Figure 10*. For example, one of the most important problems identified is data security and privacy. With an increasing in open innovation and in open-source technologies, innovations and collaborations improve, but on the other hand it is possible to have security vulnerabilities [Attaran, Attaran 2020].

The 5G standardization and regulation is still in progress in relation to 5G technology evolutions because it is in a continuous evolving. In fact, new use cases enhance the definition of standard according to their impact to businesses. Moreover, as mentioned before, 5G network infrastructure is costly and sometimes companies do not have the flexibility to make such as large investments. It is for all these reasons that industries at large are not

completely ready to use the 5G technology, even in more developed markets [Gilmore 2020].

2.2 Transport and logistics industry

One of the most important sectors for a country is the transport and logistics one along other core sectors such as manufacturing and retail. In fact, international trade is increasingly growing, but also customers are requiring for more flexible delivery time and more detailed tracking for a smaller and smaller fee. The industry should adapt to these changes and response to needs. Facing capital and fixed operating cost high, logistics companies may have problems investing in new technologies or solutions that improve efficiency. Moreover, national and local governments have an important role, especially for investments in transport infrastructures, but they also want to enhance safety and promote a greener industry to be environmentally friendly [Gilmore 2020].

To drive improvements in efficiency, it is necessary collect a huge quantity of data, but this is not enough because through analysis and automation, such as artificial intelligence and machine learning, it is possible to derive more value. Connectivity and data management are used to collect data and provide data to users in real-time when they need them.

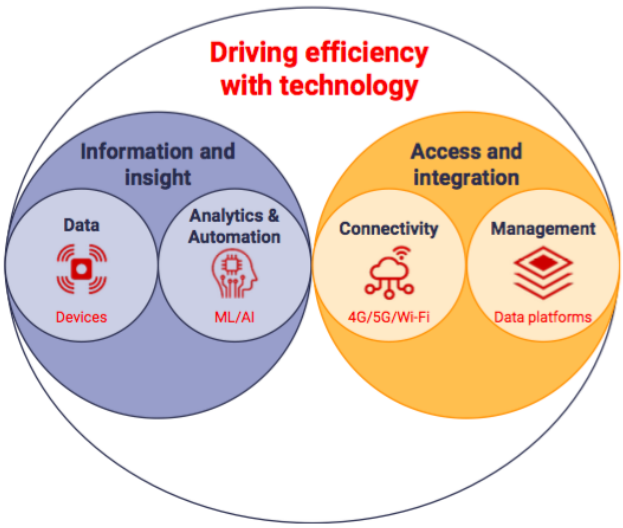

Figure 11: Ways to improve efficiency [Gilmore 2020]

To sum up technology has a key role in digital transformation as shown in *Figure 11*. Nevertheless, there are two main reasons that are holding back this transformation [Gilmore 2020]:

- The degree of automation is limited because many companies still use manual process and the data collected are unstructured,
- There is no sharing of information because the logistics industry is fragmented and there is a high competitiveness.

2.2.1 Logistics 4.0

The evolution of Information and Communication Technologies (ICT) is considered essential in the last years letting companies to seek efficiency and competitiveness. ICT is used especially in logistics and production operations. In this regard, it is possible to talk about Industry 4.0 as the fourth industrial revolution which is concerned with the development and integration of cyber technologies into digital ecosystem encompassing innovative communication technologies. Industry 4.0 is usually related to manufacturing industries and the idea of "smart factory" concerning mobility, flexibility, integration and smart networking along the value chain and eventually business model innovation. The main aspects of this revolution are the Cyber-Physical systems (CPS) and the intelligent network based on it. These systems relate the physical world, made of processes or objects, with the virtual one information processing via interconnected networks using sensors, actuators, distributed controllers and communication devices [Barreto et al. 2017]. Internet of Things, Artificial Intelligence, Machine Learning and Big Data emerged as new technological solutions.

Obviously, the Industry 4.0 has had a huge impact on the logistics system and the supply chain with a new scope, focusing on the highly trackable of products from dispatch to the end of products' life-cycle. In this area too, CPS are essential to transfer the traditional processes of logistics and supply chain into smart ones, such as mentioned before, and are based on the integration of hardware system and cloud computing as centralized data storage. For all these characteristics, it is possible to introduce the term Logistics 4.0 to identify "smart logistics". Logistics 4.0 can be considered

as a strategic technological direction to increase efficiency and flexibility of transporting, warehousing and storage by using new and different technologies to be closer to customer needs. Unlike previously logistics' eras, this logistics revolution focus on the value chains instead of supply chain or transport. Therefore, digital interconnection of all partners and transparency are another fundamental feature. All this leads to the development of new business model where even third party and fourth party logistics service providers are focusing on the entire value chain [Amr et al. 2019].

Logistics 4.0 is a technology driven innovation, as defined in chapter one this is technology-push and hence introduces a radical innovation. It is important because represent the future developments in logistics.

2.2.2 The role of 5G

As mentioned before, the transport and logistics industry is one of those that uses 5G technology the most in order to enhance and improve the Logistics 4.0 objectives. In addition, it should be noted that road transport is the form most used across the world to transport and it is the one considered in this context. Among all the 5G capabilities, there are three which are important and useful to improve this industry: device density and data volume, low latency and network slicing; *Figure 12* [Gilmore 2020].

Figure 12: Main 5G capabilities [Gilmore 2020]

For the first one 5G enables the possibility to increase the number of sensors and more data can be collected and monitored in a single place. 5G also provide a higher definition and quality of data streaming. Low latency is crucial for real-time transmission of data, especially talking about autonomous driving systems. Network slices, finally, are designed to meet different connectivity needs and are networks that run on the same network infrastructure, but are separate and unique for a specific use. That is

because transport and logistics industry need an efficient broad range connectivity [Gilmore 2020].

It is possible to analyse some use cases and applications of 5G in transport and logistics.

2.2.2.1 Real-time routing and optimization

A key aspect of transport and logistics industries is the supply chain and a poor visibility of the end to end supply chain is an issue. Hence, the need to collect as much data as possible using sensors at all levels of the chain. 5G enhances the wealth of data collected and the number of sensors connected. These data can be analyzed by an Artificial Intelligence engine that suggests real-time automated solutions in order to optimize the supply chain. This way, it is possible to continually optimize and forecast cargo routes taking into account numerous factors and enhance route planning decreasing in distance driving. The other fundamental aspect for the supply chain is the ability to have a dynamic scheduling. 5G can give the opportunity of a continuous update in real-time, it is possible to better organize drivers and deliveries depending on the priorities, requirements and needs. Chances to the schedule can increase efficiency and greater customer satisfaction. In fact, waiting time decreases and meanwhile real-time reporting increases both for logistics companies and customers, for the former is useful to gain visibility of the chain and for the latter to get updates of the delivery tracking [Gilmore 2020].

2.2.2.2 Automated last 100 yards delivery

Transport and logistics are experimenting a new type of final stage delivery, using for example drones, in order to decrease costs and meet on-demand delivery more and more requested due to an increasing e-commerce use. The drone is used only in the last 100 yards and drop-off from the truck that carries both packages and drones. 5G enables drones to real-time communication and real-time streaming of video footage. This use case enables to decrease the distance driven with traditional deliveries and decrease dwell time. Automated technologies, such as drone, are relatively new ones and there are not legislations yet regulating the use of them.

Therefore, the adoption of these technologies could be very low [Gilmore 2020].

2.2.2.3 Connected traffic infrastructure

Traffic infrastructure can integrate connected IoT devices in order to collect and analyse data from the environment and the traffic on the roads. This way, it is possible to use the wealth of data and the reliable connection of these devices to create a smart control of traffic lights optimizing traffic but also introduce smart road signs. This way, it is possible to get a decrease in congestion resulting in increased productivity for logistics companies and get a decrease in fuel emissions, but also a reduction of accidents. In addition, 5G capabilities can be used for longer term analysis of road networks, which can be very useful to monitor the status of the entire infrastructure. Connected traffic infrastructure is strongly influenced by the entire stakeholder ecosystem and coordination at different levels is required to enable the system to operate effectively [Gilmore 2020].

2.3 Smart ports

In the logistics field the port assumes a fundamental role for global supply chains, especially for the global economy. In fact, it is necessary to connect not only nations, but also producers and customers in different markets all over the world enabling and developing world trade. Starting from the characteristics of Industry 4.0 and Logistics 4.0 it is possible to transfer them to port environment, introducing the concept of “smart port”. Even in this case is about interconnections and automation; the former is related to all actors involve in the port chain through the transfer a wealth of data and information in real-time, while the latter concern terminal operations, transport and storage. In fact, in the last years the amount of containers increase and, given the continued growth of world trade, they could increase further; automated operations provide quality and timely services, ensuring speed, reliability and traceability and minimizing the waste [Douaioui et al. 2018].

In *Figure 13* is represented the smart port system. For interconnection are required specific technologies such as a smart information system to exchange data, a data center to store and analyse data and information and

finally a cybersecurity to ensure the integrity and confidentiality of information that are stored and transmitted. On the other hand, for automation are required specific equipment such as smart ship and smart container with sensors that collect data and connect them to the port. Only adapting to these changes logistics and port logistics can support and carry forward to completion the fourth industrial revolution. This creates changes in the configuration of the ports and chains. The port is increasingly a nodal point that can contribute to developing a more efficient global supply chain, distribution and production. Cooperation between ports and supply chains is as important as partnerships between other ports to better use of assets increasing efficiency of scale and scope and skills with benefits [Douaioui et al. 2018].

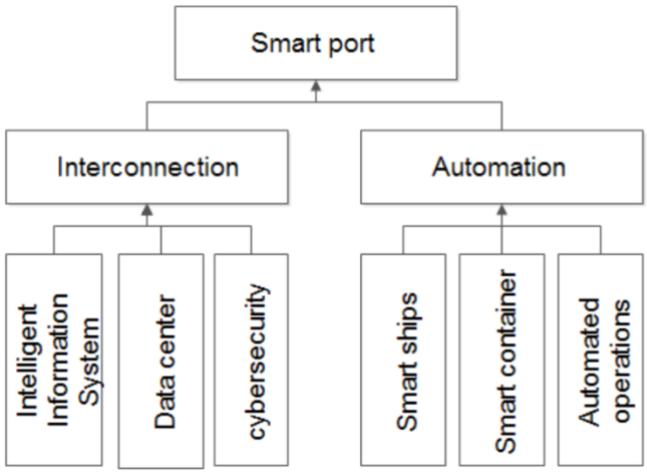

Figure 13: Smart port system [Douaioui et al. 2018]

Innovative digital solutions are necessary in order achieve these objectives, in certain cases is useful to evaluate the development of new innovative business models or create joint ventures to develop new solutions. 5G technologies play an increasingly important role to achieve interconnection and automation objectives.

CHAPTER 3

The 5G-LOGINNOV project

The emergence of 5G technology has affected many sectors, especially increasing efficiency even in logistics and city ports; business innovations, economic development, and environmental benefits are the result of these new technologies. 5G-LOGINNOV is a European funded project[2] started on September 1, 2020 and lasting three years; it is focusing on 5-PPP thematics. The 5-PPP (5G Infrastructure Public Private Partnership) is a joint initiative between the European Commission and European ICT Industry with the aim of delivering solutions, architectures, technologies and standards for the next generation communication infrastructures as a way of acquiring Europe's leadership in established areas or in new markets. Currently the 5-PPP is in its third phase.

3.1 5G-LOGINNOV related past projects

One thing has to be remembered, that the 5G-LOGINNOV project represents the evolution of previous projects taking into account the developments in the recent years. In fact, existing national and European projects are essential to best build the new European 5G-LOGINNOV project. Given the amount of complementary research across Europe that is directly relevant for this project thanks to the corridor optimization for logistics services, there are a lot of initiatives and projects from which it is possible to take inspiration and thereafter use or improve the acquire knowledge.

In this thesis, will be presented some of the 5G-LOGINNOV related projects. 5G-LOGINNOV's baseline is centered on three main logistics projects: AEOLIX, SELIX and FENIX.

[2] The reference https://5g-loginnov.eu/ is used to describe the entire project presented in this chapter.

Taking into account, on the other hand, projects directly related to the port infrastructure, the most recent COREALIS project is considered and described.

3.1.1 AEOLIX

The AEOLIX project is part of the European research and innovation program Horizon 2020, it started on September 1, 2016 and ended on August 31, 2019. The word AEOLIX stands for "Architecture for EurOpean Logistics Information eXchange.

In order to deploy pan-European logistics solutions in a position to significantly increase efficiency and productivity, along a supply chain visibility, an exchange and use of an amount of relevant logistics-related information is needed. Despite the presence of suitable solutions, these are often fragmented and the lack of connectivity of ICT-based information system is critical. This way, different requirements, business models and data models do not optimize the logistics service.

The aim of the AEOLIX project is to establish a cloud-based collaborative logistics system capable of better managing logistics information for real-time exchange of information among logistics actors through a platform. In *Figure 14* is summarized the platform created by AEOLIX for logistics services.

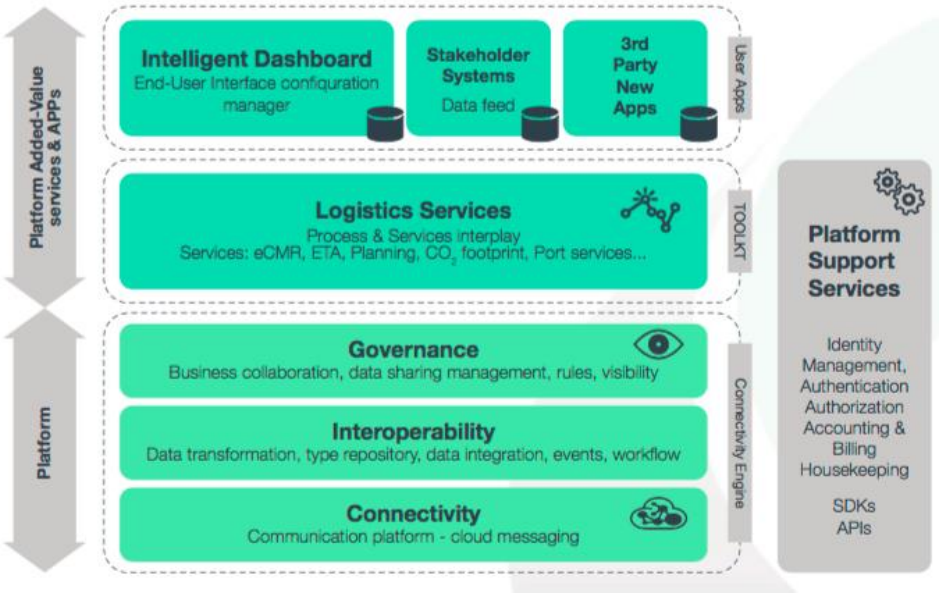

Figure 14: AEOLIX platform view [https://aeolix.eu/vision/]

By easily accessing to the supply chain and creating more visibility, the transport of goods can be even more sustainable and, along to increase efficiency, environmental impact is reduced.

The integration of supply-chain-related transport business processes using software solutions and cloud-base connectivity improves competitiveness and collaboration in the logistics industry [https://cordis.europa.eu/project/id/690797].

For this project were selected twelve Living Labs, where to implement and test the solutions proposed.

3.1.2 SELIX

The SELIX project is part of the European research and innovation program Horizon 2020, it started on September 1, 2016 and ended on August 31, 2019. The word SELIX stands for “Shared European Logistics Intelligent Information Space”.

The aim of the SELIX project is to deliver a “platform for European logistics applications”. In fact, the first step is trying to create a unifying operational and strategic business innovation for European Logistics, especially to promote Green logistics. To reach this it is necessary to establish a consortium of logistics stakeholders and ICT providers in order to create common communication and navigation platforms for European logistics applications. The use of Living Labs became fundamental with the aim of establishing an innovative environment where provide and share data among the consortium.

The result of this project is a cooperation agreement in order to share information and provide tools for data acquisition for logistics applications [https://cordis.europa.eu/project/id/690588/it].

3.1.3 FENIX

The FENIX project is part of the European research and innovation program Horizon 2020, it started on January 1, 2018 and ended on April 30, 2019. The word FENIX stands for “Federated Network of Information eXchange in LogistiX”.

The FENIX project uses H2020 projects' AEOLIX and SELIS as a baseline.

The FENIX concept is built on cloud-based technology that motivates increased collaboration, optimised routing and dynamic re-routing of freight through plug-and-play solutions for supply chain planning and operations. The aim is to develop a set of integrated services that exploit real-time Big Data streams for real time awareness and visibility, delivered from the cloud as a service. These services are based on standards and public-private governance. One of the innovation about the FENIX project is the exploitation of the Internet of Things (IoT), satellite navigation and retrospective historical data, by leveraging automated processes and intelligent algorithms to identify opportunities for more enhanced streamlining of routes, customisation of cargo routing combinations, and optimisation of delivery schedules [ERTICO-ITS Europe 2019].

3.1.4 COREALIS

The COREALIS project is part of the European research and innovation program Horizon 2020, it started on May 1, 2018 and ended on April 30, 2021. The word COREALIS stands for "Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era".

This European project has the aim to propose an innovative framework for cargo ports to handle future capacity, traffic, environmental challenges and to improve efficiency. In doing so, COREALIS uses disruptive technologies that are spreading more and more all over the world and which tend to become the technologies of the future. The Internet of Things, data analytics and 5G networks contribute to developing the next generation traffic management.

Five Living Labs located in five different European ports, Pireaus port, Valencia port, Antwerp port, Livorno port and Haminakotka port, were used to implement and test COREALIS's innovations [https://www.corealis.eu/].

The main objectives of the COREALIS project can be summed up under four points:

- Following principles and models of circular economy for port strategy,
- Reducing the environmental footprint associated with urban environment and intermodal connections (road, truck, inland waterways),
- Enabling the port to become an innovation hub and to take informed strategic decisions,
- Improving operational efficiency, optimizing yard capacity, for example by extending yard equipment lifecycle, improve yard equipment availability and reduce spare parts inventory. Finally, improving streamlining cargo flows.

In *Table 1* are presented the COREALIS technological innovations that had been developed and tested in the Living Labs during the project.

Table 1: COREALIS technologies [COREALIS, port of the future 2019]

RTPORT	5G-enabled smart terminal operations, IoT
PORTMOD	Optimization planning tool for computational thinking (CT) operations
Brokerage Platform	Cloud based marketplace for leasing intra-CT trucks
Truck Appointment System	Reservation system including real-time traffic data
Port of the Future Serious Game	Simulation tool for decision making
Just-In-Time Rail Shuttle Service	Feasibility study for key port-hinterland corridors
Predictor for Asset Management	Machine learning based Just in Time inventory
Cargo Flow Optimiser	Optimization of cargo flows road, truck, ocean, rail, inland- waterway

3.2 Scope of the project

5G-LOGINNOV is a European funded project and has the purpose to design an innovative framework to create new opportunities for logistics value chain innovations by integrating and validating CAD and CAM technologies related to Industry 4.0, logistics and port. In fact, 5G-LOGINNOV stands for "5G LOGistics value chain INNOVation". By using applications, devices and new innovative concepts supported by 5G technologies, this project aspires to create efficiency in freight and traffic operations at ports and logistics and handle the upcoming and future capacity and environmental changes. New types of Internet of Things 5G devices, data analytics, next generation traffic management, emerging 5G networks and new generation of 5G terminals and logistics corridor for future Connected and Automated Mobility are included in the disruptive 5G technologies.

The main innovation that 5G-LOGINNOV brings is building a first-class European industrial supply side for 5G core technologies and new IoT devices, naturally this project will have a strong effect on the logistics industry. It will use "5G technologies to expedite and optimize the Pan-European transport and logistics federative network by establishing the premier European logistics digital nodes as part of the future Physical Internet serving the European logistics community of shippers, logistics service providers, mobility infrastructure providers, cities, and authorities". 5G-LOGINNOV contributes to the emergence of new market players such as SMEs and start-ups making possible open innovation at service level in the logistics and Industry 4.0 sectors. Furthermore, it contributes to the emergence of new global standards.

Based on 5G network functions this project will be able to ensure supply chain tractability and supply chain synchronization in addition to 5G "intelligent" approaches to the management, routing and optimizations in the port area.

5G-LOGINNOV will trail eleven families of use cases using three European Living Labs as facilitator and ambassadors of innovation on ports that test and evaluate 5G-enabled services during the project.

3.2.1 Objectives

5G-LOGINNOV project is structured under seven high level objectives in which ports-city not only make an investment in important technological and societal innovations, but also in novel business models and changes of mind-set. The aim is achieving efficiency and capacity targets, establish a relationship with the cities surrounding ports and lower environmental impact. Obviously, from the point of view of the ports-city automated handling equipment is a fundamental factor in which to invest. The seven objectives are as follows:

- *Objective 1:* develop and deploy next generation ports and logistics hubs system architecture integrated in 5G networks utilizing new types of 5G sensors and devices at three main ports in Europe,
- *Objective 2:* optimize ports and logistics hubs operation and maintenance for reducing their operational costs with innovative concepts and use cases,
- *Objective 3:* reduce significantly operation emissions reaching the goals set by the European Green Deal and the Paris Agreement,
- *Objective 4*: regulate the freight traffic on the future 5G logistics corridor in Europe and integration of connected and automated truck platoons,
- *Objective 5*: Boost innovation at different levels involving new market actors, such as SMEs and start-ups,
- *Objective 6*: support standardization of 5G to ensure interoperability, harmonization and platform openness,
- *Objective 7*: support adoption and take up of 5G enabled next generation ports and logistics hubs system in Europe and beyond.

3.2.2 Methodology

The 5G-LOGINNOV project is characterized by three main phases of development and deployment. Before starting the project, a set of five Personas has already been identified related to 5G-LOGINNOV as a preliminary selection of roles that have a direct impact to or from the city-port, even considering the surrounding urban space. These Personas are: a truck driver, a CT Operations Manager, a port-city resident, a circular economy start-up CTO and a 5G start-up CTO. In fact, 5G-LOGINNOV follows a stakeholder driven approach considering ports' and port-cities' changes brought by ocean carriers, but most of all by the Industry 4.0 and, consequently, Logistics 4.0 based on extended 5G features. All the innovations are proposed taking into consideration and prioritizing the port requirements and needs.

"Living Lab Requirements and Specifications Phase" is the first phase of the project, the aim is to identify all port's stakeholders and classified them in order to comprise the core 5G specifications and requirements through an iterative participatory method. This way, it is possible to support the deployment of innovative use cases involving cutting edge 5G features and technologies and new devices, these will be implemented by each leaving lab. At the end of it all, the 5G architecture requirements for the port and port-city stakeholder is produced. Starting from the five Personas identified, these will be revised and extended and will be created the scenarios describing the living labs infrastructure requirements and specification in the living labs will be created. The evaluation of the impact of the 5G technologies and the new innovative IoT-5G devices on the port will be carried out with KPIs (Key Performance Indicators). In particular:

- KPIs are defined for measuring port operation efficiency increase resulting from 5G enable use cases develop in the living labs and the 5G technology integration,
- Protocols are defined for better assessing CSF (Critical Success Factors),
- Evaluation criteria are defined in such a way as to assess evolved living labs architecture capabilities with 5G technologies and evaluate opportunities for new market actors,

- Requirements and specifications are developed in accordance to 5G-LOGINNOV project.

To meet data handling and cyber-security requirements, the data shared with all the project stakeholders are efficiently handled, especially the data necessary to operate use cases and data collected for the evaluation, defining the data policy. Obviously, a certain level of cyber-security is required. The use of scenarios will be important in order to share not only knowledge about early project results, but also knowledge about the built scenarios across all living labs and different stakeholders to maximize the impact of innovations and their potential. This way, it is possible evaluate a wide-scale deployment of these technologies. At the end of the first phase, different scenarios will be defined and framed to design and develop the 5G-LOGINNOV innovations.

"Technical Development and Deployment Phase" is the second phase, the aim is to involve technical partners that reassess requirements and specifications in a more technical context creating a 5G-requirements-specifications- traceability matrix. This matrix will report the priority level associated with requirements and specifications (must, should, could). This way, the specifications relevant will be identified by ports and living labs end users to integrate them into their legacy ICT infrastructure and 5G infrastructure for enabling end-to-end scenarios testing and deployment. In this case the trial and the evaluation of innovations will be done by:

- The Evaluation of Operation Optimization iteration, that evaluates data and results from each living lab according to test scenarios by providing a feedback and focusing on operation efficiency and costs reduction KPIs,
- The Evaluation of Social and Economic impacts on air pollution, traffic, 5G corridors iteration, that evaluates the externalities of 5G technologies tested with the use cases on the environment, society and economy.

Once the factors that are influenced by the 5G technologies used in the project have been identified, the assessment will be done by analyzing their impacts with qualitative and quantitative tools. In particular the economic

impact of 5G technologies will be taken into account considering the living labs.

“Living Lab full-scale deployment and impact assessment phase” is the third and last phase of the project. In each living lab, a full set of solutions will be ready to be deployed and real-time trials will take place. This way, it is possible to test, demonstrate and evaluate the results in the specific environment that characterizes every port in a different way. In addition, an impact assessment of the solutions obtained is also carried out and this iterative process will be carried on until the end of the 5G-LOGINNOV project. It is important that all the innovations that will be developed are properly integrated to the legacy infrastructure of port-cities and that the impact of project activities to the intra-terminal operations and cargo transfer to other transport nodes will be measured. One further point that is important is to measure the impact of 5G technologies to the social environment and how they promote the climate change adaptations.

As mentioned presenting the objectives of 5G-LOGINNOV project, the aim is to improve logistics operation by exploiting 5G technologies; in this framework, new actors, such as start-up, will have opportunities to create new businesses. In fact, during the three phases of the project new processes and business models will be validated in order to identify sustainable strategies to increase and deploy the solutions developed in the living labs.

To this end, the 5G-LOGINNOV organized an open call for the selection of five innovative start-ups and SMEs aiming to develop 5G-based solutions in the framework of activities carried out at the three Living Labs with the aim of extending those activities through the integration of innovative solutions.

3.3 Living labs

Living labs are defined as “user-centered, open innovation ecosystems based on a systematic user co-creation approach in public–private–people partnerships, integrating research and innovation processes in real-life communities and settings” as reported by Steen and van Bueren [2017]. In fact, the aim is to develop new products, such as an object, a service, an

application, a process or a system, or an innovation to find new solutions to existing or new problems producing and exchanging knowledge increasing sustainability for local solutions. Users, private actors, public actors and research institutes are important contributors to the development and innovation process. Co-creation is a key feature of living labs and it occurs only when all actors participate together. The living labs activities are tested and evaluated in real-time use context [Steen, van Bueren 2017].

In *Figure 15* are presented the steps of working which are used in the living labs.

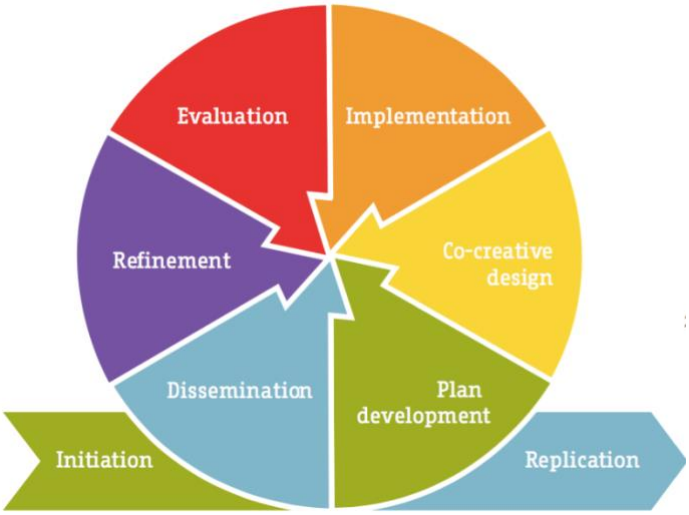

Figure 15: Living lab way of working [Steen, van Bueren 2017]

In the 5G-LOGINNOV project are involved three living labs located in three different European ports: Athens Port (Greece), Hamburg Port (Germany) and Luka Koper Port (Slovenia). All logistics corridors optimization between ports and hinterland are extremely important not only for the cities but also for reducing CO2 and NO_X emissions in accordance with the European Green Deal program.

Every port has its characteristics, infrastructures and partners involved; despite the differences related to the site location and the type of innovations implemented, the three European ports have more or less the same expected benefits.

3.4 Use cases

In order to achieve the seven objectives presented, the 5G-LOGINNOV project requires to implement eleven use cases beyond TRL 7 in the port living labs, where a set of 5G technologies and capabilities is going to be realized and evaluated. These technologies are developed with regard to port and logistics as well as surveillance and security operation support without neglecting remote automation.

Figure 16: 5G-LOGINNOV project concepts [https://5g-loginnov.eu/]

In *Figure 16* are represented the main 5G-LOGINNOV project concepts and in *Table 2* are described the eleven use cases that will be implemented in the three living labs situated near the ports taken into account.

Table 2: 5G-LOGINNOV uses cases [https://5g-loginnov.eu/]

5G-LOGINNOV Management and Network Orchestration platform	A 5G-LOGINNOV architecture will be used for automated deployment and life cycle management of network and services VNF (Virtual Network Functions) components. This architecture will enable high availability and resilience.
5G-LOGINNOV Device Management Platform Ecosystem	The Device Management platform has a variety of different IoT-5G devices that operate 24/7 in a two way communication path and offers methods for device configurations via different paths and tools to diagnose and debug streams of data.
The 5G-LOGINNOV Optimal selection of yard trucks	All ports are characterized by traffic jams and queues in loading places caused by internal yard trucks for the movement of containers. The 5G access point on yard trucks will enable the maximisation of operational efficiency allowing the selection of the optimal truck.
The 5G-LOGINNIOV optimal surveillance cameras and video analytics	Due to frequent accidents, the installation of 4K PTZ surveillance cameras is foreseen to provide a live feed over the 5G network to the current terminal operations monitoring platform. Video analytics will be used to send messages to the security when is determined human presence in areas not allowed.
The 5G-LOGINNOV automation for ports: port control, logistics and remote automation	Port machinery will be equipped with industrial cameras for capturing and transferring of UHD images for identification of markers and detection of structured damage, moreover will be performed port infrastructure monitoring and remote metering.
The 5G-LOGINNOV 5G mission critical communications in ports	A real-time video surveillance will be used by security along with portable video surveillance with night vision capabilities and drone-based surveillance for ad-hoc video support. Finally will be implemented private security operations management and support featuring a services to support security operations.
The 5G-LOGINNOV Predictive Maintenance	This use case provides analysis of data collected through monitoring in order to anticipate eventual breakdowns that lead to higher costs when handled with corrective maintenance or routine maintenance.
5G-LOGINNOV Floating Truck & Emission Data (FTED)	Vehicle type and configuration, current vehicle conditions, route characteristics, transport management system measures and traffic flow are strongly related to the potential of emission reduction and have to be analysed.
5G-LOGINNOV 5G GLOSA & Automated Truck Platooning (GTP)-under 5G-LOGINNOV green innitiative	GLOSA (Green Light Optimized Speed Advisory) is an application that allow communication between vehicles and traffic infrastructure in order to minimize capacity shortage across urban road networks with a positive economic and environmental impact by taken into account real-time data.
5G-LOGINNOV dynamic control loop for environment sensitive traffic management actions (DCET)	The aim is to define the logistics corridors in close cooperation with all stakeholders, exchange V2X information via 5G using precise positioning and showcase how 5G GLOSA can decrease air pollution and be applied in other logistics corridors.

CHAPTER 4

The GUEST methodology

The GUEST methodology has been developed from the analysis of Italian star-ups and SMEs by some researchers from the Politecnico di Torino with the aim to guide different actors involved in the decision-making process and evaluate their outcomes reducing the time to implement[3].

4.1 GUEST definition

The GUEST methodology provides an innovative framework for business management; in particular, it allows to control the process from a new idea to its implementation. Moreover, thanks to its conceptual and practical tool, the GUEST methodology enables the different stakeholders to communicate vision, difficulties and opportunities to each other using the same structure. This way, it is possible increase efficiency and quality of companies.

The term GUEST is the acronym of five words representing the steps of the method: Go, Uniform, Evaluate, Solve and Test.

Despite the methodology standardizes the tools used to develop a new business or launch a start-up, it is necessary to create an overall process monitoring tool. It is in this context that GUEST takes inspiration from the Kanban method of Lean Production presented in Chapter 1.

4.1.1 The Kanban method

The original Kanban method manages the flow of information, especially inside the companies using special instruction cards related to the different activities. This way, it is possible to streamline production planning and reduce waste. Considering process control, Kanban was adapted.

[3] The reference http://www.theguestmethod.com/ is used to describe the GUEST method in the present chapter.

In the Process Kanban, the cards are replaced by standardized port-it with different color (red, yellow, blue, green and orange) that correspond respectively to the GUEST steps dividing the process in five phases. In the first phase, “Becklog queue”, there are overdue activities that must enter the next stage, “To do”, where activities are performed with priority. “WIP” is the third phase and reports activities in progress while the “Done” phase indicates completed activities which need to be approved by the Project Manager. Finally, the last phase, “Sent”, identifies approved activities that can be sent to the client.

In the post-it is reported the activity, the beginning date, the ending date and the resource responsible for the specific activity.

Using the process Kanban, activities can be managed independently and it is possible not only to oversee a single project or an entire business at all time in a standardized manner, but also detect critical internal problems that may be common to several projects. Moreover, every member of the team has the opportunity to contribute with suggestions and the Project Manager can overview the company’s progress.

Alongside the Process Kanban, it is necessary the Project Kanban.

The Project Kanban is required for every single project and has a higher level of detail, even if the basic structure is similar to the Process Kanban previously described. In fact, in every stage of the GUEST methodology both task and sub-tasks are reported. This way, it is possible to monitor a project and shared it with a client in order to better satisfy him.

The aim of using these two tools is to be able to have a complete overview of the business and of each project monitoring:

- The Average time of client acquisition,
- The Average time of the start-up phase of an operating activity,
- The Average time of project management,
- Monitoring of the activity of each resource involved in a project,
- Monitoring and evaluating the performance of each team member,
- Ability to compare the progress of projects in the same scope or with similar characteristics.

4.2 Go phase

The Go phase is the first one of the GUEST methodology and its goal is to create a connection with the company in order to collect useful information to evaluate the potential of the project.

In *Figure 17* is summarized the Go phase process characterized by four steps.

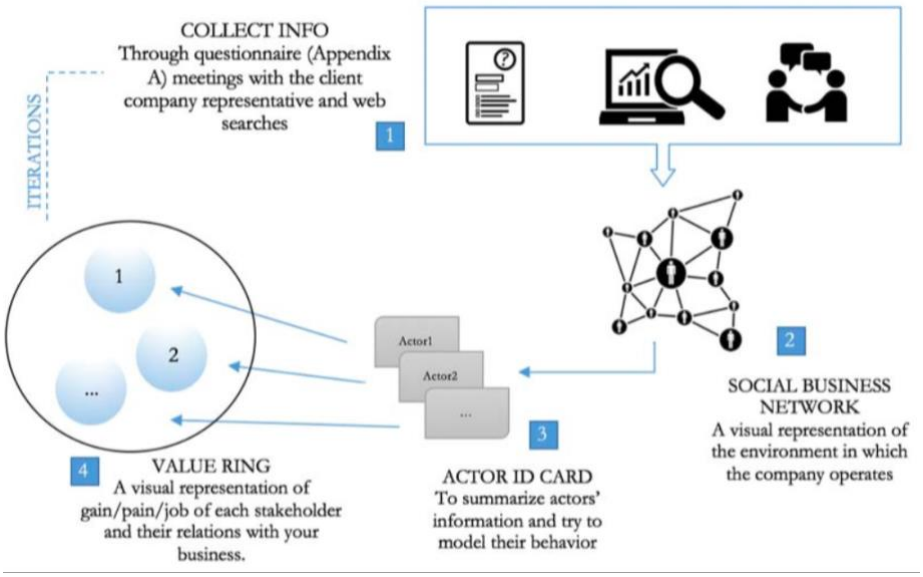

Figure 17: Go phase [http://www.theguestmethod.com/]

The first step is to collect information through meetings and a questionnaire, this last one in particular is articulated in seven sections: general information, activities, commercial information, customers, suppliers, competitors and evaluation of the business.

Then a Social Business Network (SBN) document is created to visually represent the company and its environment underlining the interactions between all elements and the relationship between the different actors of the system, both positive and negative. In the standardized SBN chart, every type of actor is considered as an interdependent unit and is represented by a specific node, each node is connected by one or more arches that differ among themselves according to the type of relationship. Arches can be unidirectional or bidirectional and represent channels for the transfer or the flow of resources. This way, it is possible to take into account the overview

of a business entity and how it operates not only considering the direct relationship. This phase is useful for evaluating and planning operational actions.

The next two steps are fundamental to identify the actors and the stakeholders of a business.

4.2.1 Actor ID Card and Value Ring

The Actor ID Card is a tool that helps to define the different actors of a business in such a way that, once their needs have been identified, it is possible to create a product that meets them. In order to do that, it is needed to know very well the actors and elaborate a strategy starting from this.

This tool is inspired by the Canvas model (Chapter 1), in particular by the Value Proposition that defines the customer, its profile and its needs with the aim of determining the best value proposition. While the Value Proposition of the Canvas is focused on the customer, the Actor ID focuses on all potential actors involved and it is made up of several sections. The definition of the Actor profile concerns the type of actor and its description, meanwhile the Actor Situation concerns the current situation of an actor and is composed by three different parts, *Figure 18*.

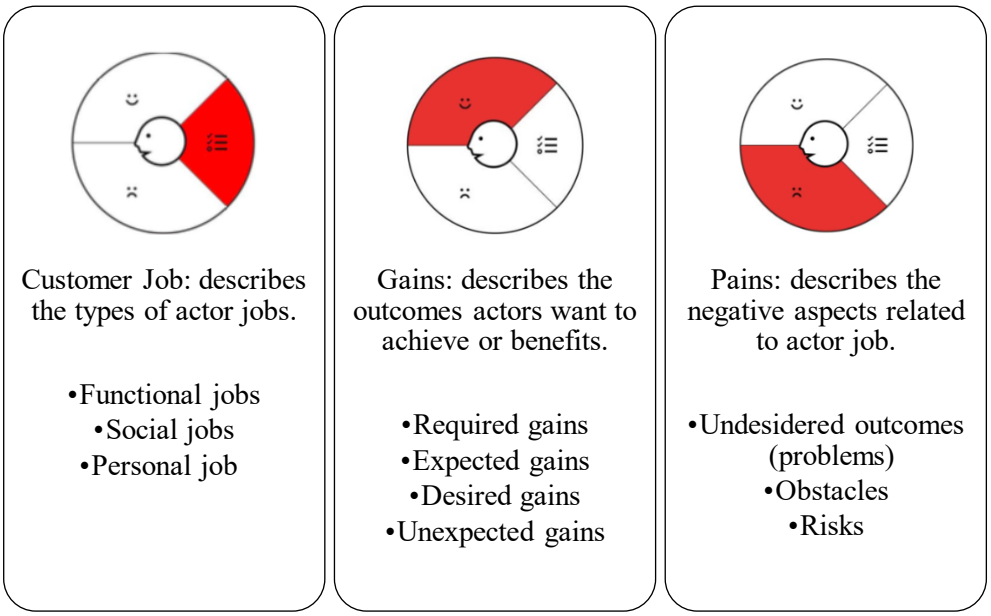

Figure 18: Actor Situation section [http://www.theguestmethod.com/]

The last section, *Figure 19*, is related to the Provider and its actions to minimize pain and enhance gains. Finally, the Value Proposition represents a summary of the suggested proposes.

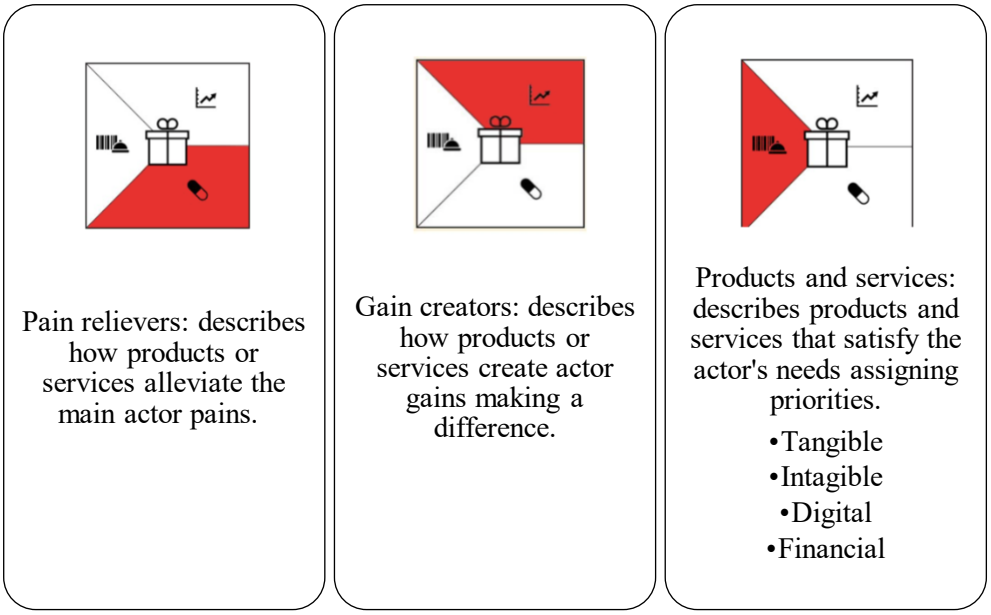

Figure 19: Provider section [http://www.theguestmethod.com/]

The final step of the GO phase is characterized by the creation of the Value Ring, a visual representation that starts from the Actor ID card information and underlines two new variables: stakeholder influence and priorities, *Figure 20*. The first is represented by the angular area, while the latter is represented by the radius. For each actor, a time priority identified as today, tomorrow and next future is given to his job, gain and pain.

This way, it is possible to better understand the main factors that influence the relations between business and actors, and at the same time prioritize the information about the market environment collected through the previous methods. The aim is to understand customers and their needs in order to create a product, or a business, that suits them best.

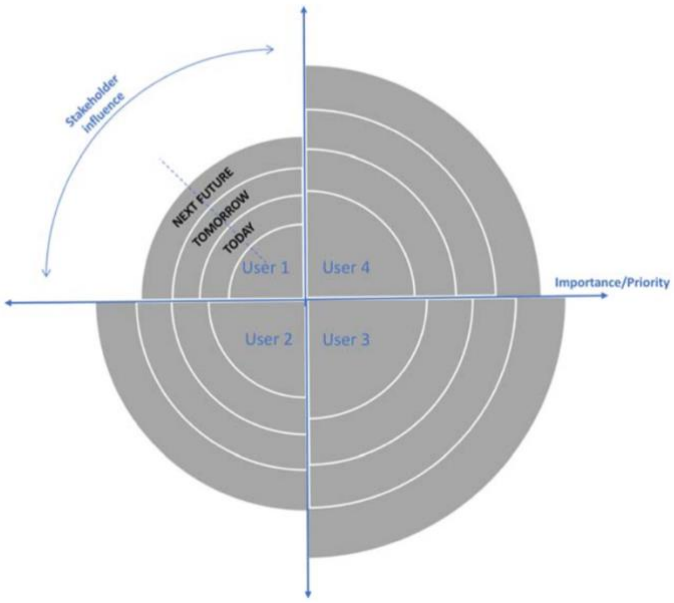

Figure 20: Value Ring [http://www.theguestmethod.com/]

4.3 Uniform phase

The Uniform phase is the second one of the GUEST methodology and its goal is to standardize the information collected in the Go phase understanding the business model and the type of governance.

The tool used in the Uniform phase is the Business Model Canvas.

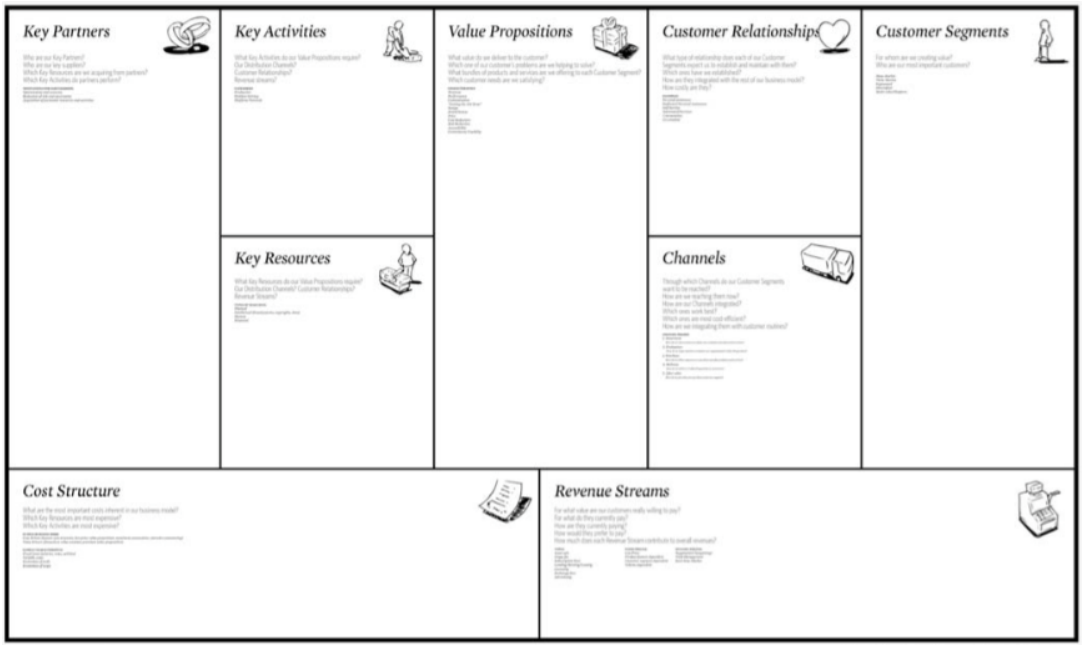

Figure 21: Business Model Canvas [http://www.theguestmethod.com/]

This instrument is useful during the initial stage of a company's creation, but it is also relevant to develop new business ideas, create innovation through innovative start-ups or relocate existing businesses. In this phase the Canvas will be elaborated by using all the information collected.

The Business Model Canvas, *Figure 21*, is characterized by nine building blocks:

- *Customer segments:* define the groups of people or organizations grouped into different segments based on their common needs that the company wants to reach and serve.
- *Value proposition:* represents goods and services which solve customer's problem and create value for a specific customer segment by meeting his needs.
- *Channels:* are points of contact between the company and its customer segments in order to create a satisfying customer experience. Channels can be direct or indirect. The former can require higher costs, but higher margins, while the latter allows an organization to exploit the strengths of their partners even if the profit margins are lower.
- *Customer relationships:* this block describes the relationships between the company and each customer, it is important to understand the type of relationship that is suitable for each customer and the business model. It is reported the ways in which the company acquires customers, retains customers and grows sales.
- *Revenue streams:* represent the flows of revenues received by the company considering the price and the payment method (sale, usage fee, licenses..). In fact, the composition of the revenue streams allows a sustainable business model.
- *Key resources:* in this block are grouped the strategic assets needed to implement the business model and create value for a specific segment. The assets are physical, intellectuals, humans and financial.
- *Key activities:* they are the most important activities and processes that determine a competitive advantage. In fact, the company has to manage them in order to fulfill its business model. Key activities can be productive, as in a manufacturing company, problem solving, as in the service industry, and maintenance or development of platforms and networks.

- *Key partners:* they represent partners and suppliers outside of the company indispensable to implement the business model in order to create success in the market. Strategic alliances and joint ventures allow the company to respond better to different needs. Along with economies of scale, the acquisition and optimization of resources are some of the benefits that these types of relationships can give.
- *Cost structure:* this block is the is the last to be determined. The key resources, the key activities and the key partners will determine a structural cost that the company has to sustain. For certain activities, it is not always easy to keep the costs down. Anyway, along with economies of scale and scope, the business model can have fixed costs and variable costs. Moreover, it is possible to identify a business model driven by cost, focusing on minimizing costs, or a business model driven by value personalizing services.

The nine building blocks that define the Business Model Canvas can be grouped into four main areas: product, customer, infrastructure and finance. The first area represents the value proposition, that is, the products and services delivered by a company to the market. The customer area is characterized by customer segments, channels and customer relationships and is related to customer engagement. Key resources and key partnerships represent the infrastructure management area; it refers to the main functions of logistics and productions considering relationships. Finally, the financial area is characterized by the cost structure and the revenue streams and indicate the sustainability of the company.

The Canvas model has to be read beginning from the center, where there is the value proposition which is the focus of the Business Model Canvas. Then the right side, where there are all the characteristics necessary for the business to work, and finally the left side, where the instruments necessary for achieving the objectives are identified.

4.4 Evaluate phase

The Evaluate phase is the third one of the GUEST methodology and its goal is to start troubleshooting and developing opportunities analyzing the previous results and describing costs and revenues structure along with the identification of challenges and opportunities. Action plans are elaborated.

The operational tools used in this phase are three.

The first one is the SWOT analysis, a strategic planning tool that allows to consider the objective to be achieved, taking into account the internal and external variables simultaneously, and supports the decision-making. The outcome of the analysis is a summary diagram that represents the strengths and the weaknesses of the system (endogenous factors), and the opportunities and the threats (exogenous factors).

The second tool used by the Evaluate phase is the Balanced Scorecard, it is a complete strategic planning and management system model used to measure and evaluate the performance of an organization. It starts from the strategy and goes up to the verification. The four different perspectives that are compared are:

- Economic and financial,
- Customer,
- Internal process,
- Learning and growth.

Obviously, in this model the vision and the strategic intent to pursue the corporate vision are fundamental.

The ICE diagram, Identity-Control-Evaluate, is the third tool used in this GUEST's phase. This is a document depends on the completion of the SWOT analysis and is characterized by with three columns. The first one called Identify represents the identification of opportunities or problems of the company. The Control column, the second one, is to define the actions or solutions needed to take advantage of opportunities or solve problems. Finally, the Evaluate column analyses and monitors the solution defining key point indicators, KPI. The goal of the ICE diagram is to translate problems and opportunities into tangible actions to be implemented and

continuously monitored. This tool takes into consideration both financial and non-financial factors. The perspectives analyzed during the definition of opportunities and problems are the Balanced Scorecard's ones.

4.5 Solve and Test phase

The Solve phase is the fourth one of the GUEST methodology and its goal is to analyze in detail the solutions of the problems previously identified and suggest different operational models.

There are two types of documents that can be used in this phase:

- Executive ICE-Diagram,
- Solution Canvas.

The first one, the Executive ICE-Diagram, is the document that summarizes the operational plan considering both the economic resources and necessary time for their implementation. This document includes the cash flow of the business activities.

By considering the Solution Canvas, it is possible to underline one main difference compared to the Business Model Canvas. The Business Model Canvas used in the Uniform phase represents the company 'as is', while considering the Solution Canvas the focus is focusing on the solutions that have been studied and designed thanks to the implementation of the previous step starting from the Business Model Canvas.

Even the Solution Canvas is divided into nine sections, but they are quite different:

- Decision makers,
- Constraints,
- Decisions,
- Information/resources,
- Users,
- Channels,
- Goals,
- Costs.

The last step of the GUEST methodology is the Test one.

It involves a summary of the action plans undertaken, their implementation and the evaluations of the results. Searching for continuous improvement, the Test phase can be the starting point for the reapplication of the GUEST methodology.

For this reason, the symbol used to represent the GUEST methodology is an infinite, *Figure 22*.

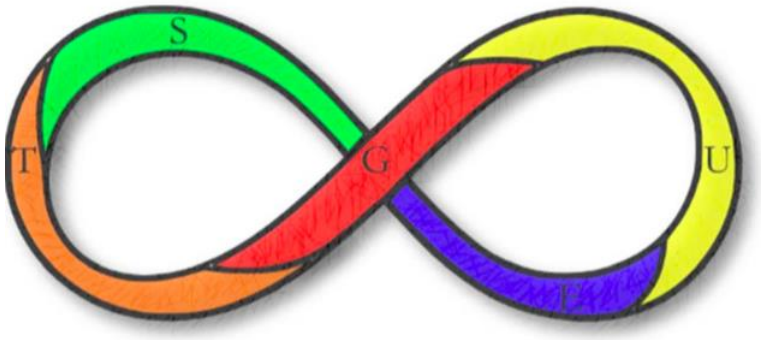

Figure 22: The GUEST symbol

CHAPTER 5

Application of the GUEST method to the 5G-LOGINNOV project

In this chapter the first steps of the GUEST methodology will be applied to the European 5G-LOGINNOV project. After an accurate research, the stakeholders and their characteristics will be identified to find out the actors who may have a greater influence within the project. After having studied in deep the profiles of the actors involved, the value ring will be identified. Subsequently, taking into account the Uniform phase, the aim of the analysis is to elaborate and develop two different business models, each of which focuses on a main 5G core innovation technologies for port operations presented in the European 5G-LOGINNOV project: maintenance and operation efficiency.

5.1 Stakeholder profile

In order to apply the Guest methodology, it was carried out a study to identify the generic stakeholders related to a port referring to the context of the 5GLOGINNOV project. Different types of stakeholders and eventually conflicting interests may come together due to the ecosystem of a digitalized-port which is as a multi-stakeholder environment. It is important to keep in mind that there are two main activities related to the port. The first operation is the physical one, like stevedoring, that take place in the port area, while the other activity is logistics transport to deliver goods. By considering all these aspects, twenty-two stakeholders were identified and the Actor ID card was used to describe the actor, the actor type and the actor situation that includes the description of job, gains and pains.

The twenty-two stakeholders will be analyzed individually, but for convenience, the stakeholders have been grouped in six categories represented in *Figure 23*. This way, it is possible to easily identify the main groups to which they belong.

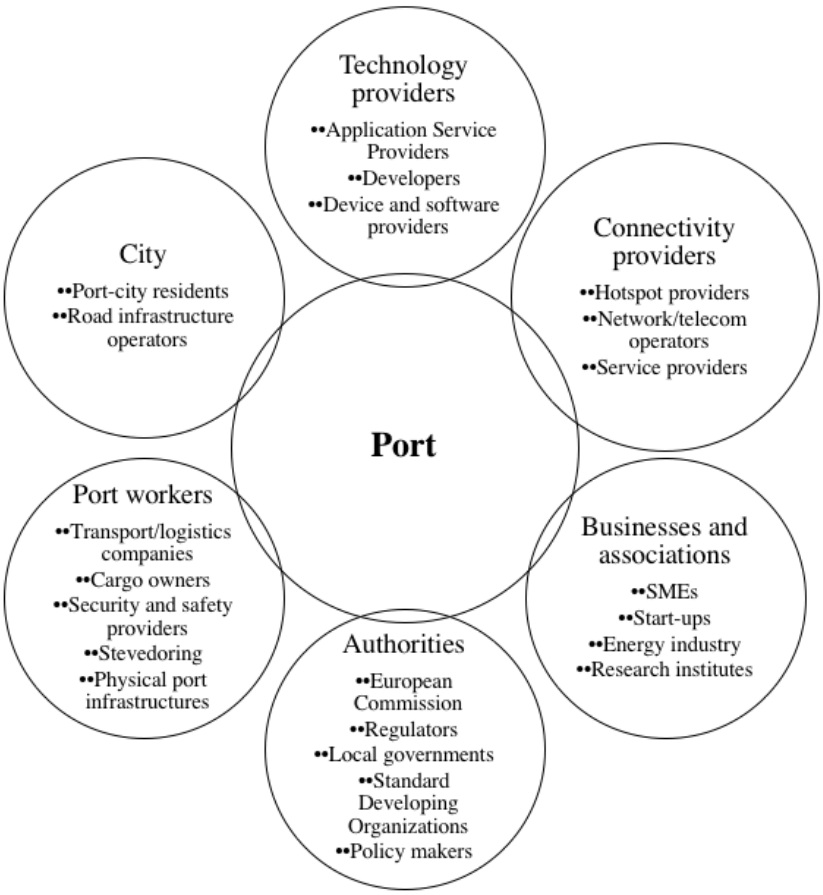

Figure 23: Stakeholders' categories

Sum up, in this ecosystem there are technology provider companies, that supply solutions, and connectivity providers, essential in a digitalized-port. These are 5G-related industries. Another group is determined by businesses and associations that contribute in developing the new technologies and the new business models, then there are the authorities that define boundaries and modes of action. The group "Port workers" identifies all the actors working in the port and related activities inbound and outbound. Finally, port-city residents and road infrastructure operators are grouped together representing the interests of the city.

5.1.1 Application Service Providers

Application service providers (ASPs) Actor ID is presented in *Table 3*. They are businesses providing computer-based service that allows users to connect to cloud-based apps and use them. The purpose of ASP is providing an application software that resides in the vendor's system. Users can access the software through a web browser. To each costumer can be offered a license. This way, the application service provider can fully own software applications and gain from an annual or monthly fee eventually. It is possible for these businesses create an economic advantage being among the first in this framework in offering these services compared to their competitors. Consequently, ASP achieve a certain reputation on the market. On the contrary investments in this industry are large with high costs and low return on investment. Moreover, in an innovation environment, like the 5GLOGINNOV project, is useful sharing knowledge and capabilities to increase the success probability in developing new technologies, so it is quite difficult deciding what to share with other companies and create, for example, a joint venture. Obviously, ASPs must comply with regulatory constraints.

Table 3: Application service providers Actor ID

Actor: Application service providers
Actor Type: Stakeholder/User Actor Description: ASP (Application Service Provider) is a business providing computer-based service that allows users to connect to cloud-based apps and use them Social-Economic stratification: 5G industry, technology provider, business

Actor situation

Job
The purpose of ASP is providing an application software that resides in the vendor's system. Users can access the software through a web browser (for example using HTML). To each costumer can be offered a license.

Gain	**Pain**
- Fully owns software applications - Make all information available to costumers - Provide special purpose client software - Monthly/annual fee - Economic advantage - Reputation	- Investments - Costs - Challenge between collaboration/competition - Regulatory constraints

5.1.2 Developers

Developers are very important professional figure whom develops web application and software, writes and executes the source code as described in *Table 4*. SW/functions developers supply virtual network appliance, gateways, firewalls, proxies and so on. Beside developing several types of software and applications they have ensured the security of them. In this project on the one hand, they bring technology solutions and innovation, and on the other they acquire new capabilities and knowledge to be used in different contexts. Working in a new field, it is possible that developers do not have access to the necessary information to develop appropriate web application or they do not understand how the logistics work so it is difficult comprehends all the needs. In addition, developing a web application or software, it is likely to occur malfunctions or problems in executing the source code.

Table 4: Developers Actor ID

Actor: Developers
Actor Type: Stakeholder/User Actor Description: develop and provide technology solutions Social-Economic stratification: 5G industry, technology provider, computer scientist

Actor situation

Job
A developer is a very important professional figure who develops web application and software, writes and executes the source code. SW/functions developers supply virtual network appliance, gateways, firewalls, proxies and so on.

Gain	**Pain**
- Developing several types of software/applications - Provide solutions - Bring innovation - New knowledge and abilities - Ensure security	- Lack of information - Malfunctions - Understanding logistics - Backward system

5.1.3 Device and software providers

Device and software providers are businesses that develop objects, generally machines, that include a hardware and a software parts. In particular, they can sell them as a package. Moreover, offering the possibility to customize these technologies, they want to obtain an

economic advantage in such a way that they ensure the markets. In *Table 4* device and software providers Actor ID is presented. Reputation is also a key factor. Even for device and software providers, there are large investments. Regulations and, especially, standard constraints are aspect that can impact on the procedures used by these providers that much, often imposing limits. Always talking about innovative project, it is possible that there is a fight between collaboration and competition.

Table 5: Device and software providers Actor ID

Actor: Device and software providers
Actor Type: Stakeholder/User Actor Description: develop and provide technology solutions Social-Economic stratification: 5G industry, technology provider, business

Actor situation

Job
A device and software provider is a business that develops objects, generally machines, that include a hardware and a software parts. In particular, they can sell them as a package.

Gain	**Pain**
- Economic advantage - Reputation - Ensure markets - Customization	- Investments - Challenge between collaboration/competition - Regulatory constraints - Standard constraints

5.1.4 Hotspot providers

Hotspot providers Actor ID is presented in *Table 6*. They arrange Internet access, usable by all people, using Wi-Fi technology via a wireless local area network using a router. They are important in the 5G project because provide all the basic elements to develop this new technology. The primary aim of this business is bringing a wide range of connectivity improving speed, latency, ultra-reliable low-latency communication (uRLLC), and bandwidth to enable an enhanced exchange of information using network data. This way, it is also possible to ensure access to real time data to everyone and update them. Talking about logistics it is very important and useful, providing the geolocation that can be used by trucks. By entering this new business, hotspot providers can stimulate revenue growth. Using the Internet, it may run into numerous issues related to security and legal aspects due to the openness of the system. These connectivity providers should be careful and take into count these aspects.

Table 6: Hotspot providers Actor ID

Actor: Hotspot providers
Actor Type: Stakeholder Actor Description: provide network connection via wireless/wired networks thanks to day-to-day activities Social-Economic stratification: 5G industry, connectivity provider, business

Actor situation

Job
Hotspot providers arrange Internet access, usable by all people, using Wi-Fi technology via a wireless local area network using a router.

Gain	**Pain**
- Wide range of connectivity - Network data - Geolocation - Facilitate communication - Access to real time data - Speed, latency and bandwidth - Stimulate revenue growth by entering new business	- Security issues - Legal issues - Regulatory constraints

5.1.5 Network/telecom operators

Network and telecom operators are companies that provide access to a wireless telecommunication/communication network or the Internet (MVNO, MNO), *Table 7*. Network operators design, build and operate network services that are offered to service provider, but they also in charge of orchestrating resources from virtualized infrastructure provider (VISP). They want to provide an enhanced mobile broadband (eMBB) and coverage to allow communication between all devices even the long-distance ones. The massive machine type communication (mMTC) is going to allow to manage in an economic way the robust connection of billions of devices. In this project, they can supply network slicing, fulfilling different requirements, and a machine-to-machine communication (M2M) which is the direct communication between devices using wired and wireless channel. By doing so, network and telecom operators search to make up the basis for having requirements for instant revenues. Doing so, they should make large investments and risk to provide a technology not mature enough to spread in the market. Even in this case privacy and regulators may have an impact.

Table 7: Network/telecom operator providers Actor ID

Actor: Network/telecom operator providers
Actor Type: Stakeholder Actor Description: provide network connection via wireless/wired networks thanks to day-to-day activities Social-Economic stratification: 5G industry, connectivity provider, business

Actor situation

Job
They are companies that provide access to a wireless telecommunication/communication network or the Internet. Network operators design, build and operate network services that are offered to service provider, but they also in charge of orchestrating resources from virtualized VISP.

Gain	**Pain**
- Network slicing - Machine-to-machine communication/component provider - Private network - Mobile broadband - Coverage - Requirements for instant revenues	- Investments - Maturity and quality issues - Regulatory constraints - Privacy - Costs - Challenge between collaboration/competition

5.1.6 Service providers

Service providers allow its subscribers access not only to the internet but also to other services such as Cloud computing, NSaaS, and storage that can make device and location independence. They can provide sensors and analytics, video analytics and edge analytics. This way, there is a wealth of information and retain digital data available to all the users increasing their flexibility. Obviously, it can happen to enter invalid data, or on the contrary, that there is a lack of substance; downtime may occur. The service provider can help developing the 5G technology by IT consulting and IT system and network integration looking to increase its revenue. Network security can also be furnished by service providers and consists of the processes that prevent unauthorized accesses. It is important to respect privacy and security policies. A service providers Actor ID is presented in *Table 8.*

Table 8: Service providers Actor ID

Actor: Service providers
Actor Type: Stakeholder Actor Description: provide network connection via wireless/wired networks thanks to day-to-day activities Social-Economic stratification: 5G industry, digital service and connectivity provider, business

Actor situation

Job
Service providers allow its subscribers access not only to the internet but also to other services such as Cloud computing and storage. They can provide sensors and analytics, video analytics and edge analytics. Network security can also be furnished by service providers and consists of the processes that prevent unauthorized accesses.

Gain	**Pain**
- Wealth of information available - Retain digital data (video, pictures...) - Device and location independence - IT consulting - IT system and network integration - NSaaS provider - Increase users' flexibility - Increase revenue	- Downtime - Security policies - Privacy issues - Lack of substance - Invalid data - Challenge between collaboration/competition

5.1.7 Innovative SMEs

Innovative Small and Medium Enterprises (SMEs) can easily provide technological solutions; they usually want to develop a new business model or enter a new market segment alongside their core business, but a Small and Medium Enterprise could also use infrastructure and services provided by different projects becoming a user. In *Table 9* is presented their Actor ID. The primary aim of this type of firm is innovation; obviously, this requires investments and cost that should be minimized in order to create an efficient new business model related to the new technology. SME already has an organized structure from which take inspiration, but R&D is always difficult to manage, from resources and knowledge point of view. As mentioned in the first chapter, this is one of the reason Open Innovation is used. However, managing to enter emerging markets such as the 5G market, these firms can have the first mover advantage.

Table 9: SMEs Actor ID

Actor: SMEs
Actor Type: Stakeholder/User Actor Description: Small and Medium Enterprises could use infrastructure and services provided by different projects becoming a user, but SMEs develop also different solutions or product Social-Economic stratification: 5G industry, business

Actor situation

Job
Innovative SMEs can easily provide technological solutions; they usually want to develop a new business model or enter a new market segment alongside their core business.

Gain	**Pain**
- Innovation - Provide technological solutions - New components for the infrastructure - New market/business - First mover advantage	- Investments - Costs - Entry barriers - Unconsolidated R&D

5.1.8 Start-ups

Start-ups are an opportunity to facilitate entrepreneurship and research, especially in innovative fields; circular economy seems to have more and more importance. The start-ups Actor ID is presented in *Table 10*.

Table 10: Start-ups Actor ID

Actor: Start-ups
Actor Type: Stakeholder/User Actor Description: a start-up is a company, sometimes temporary organization, in search of scalable and repeatable business model Social-Economic stratification: 5G industry, business

Actor situation

Job
Start-up is an opportunity to facilitate entrepreneurship and research, especially in new innovative fields; circular economy seems to have more and more importance.

Gain	**Pain**
- Innovation - New market - Scalability - Research	- Investments - Costs - New business model - Immature technology

The hardest thing in this case is creating a sustainable business model that enables technology to better respond to customer need so it is possible that the final product is not mature enough or the market is not ready jet to adopt it. This process is a long-term one and require large investments.

5.1.9 The energy business industry

The energy business industry, as presented in *Table 11*, involves the production of different type of energy and includes regulators, policy makers, Smart Cities and power companies. The purpose of the energy industry, especially in the last few years, is to provide a healthier environment paying attention to air pollution and green energy. In logistics is particularly important to note the pollution caused by trucks so the aim is reducing CO2 emissions, congestion and air pollution to improve the citizen quality of life and to reach the goals set by the European Green Deal. It is very important for the energy industry reputation. For this reason, even the energy industry had interest in joining this project increasing revenues and ensuring the market.

Table 11: Energy industry Actor ID

Actor: Energy industry
Actor Type: Stakeholder Actor Description: the energy business industry involves the production of different type of energy and includes regulators, policy makers, Smart Cities and power companies Social-Economic stratification: vertical industry

Actor situation

Job
The purpose of the energy industry, especially in the last few years, is to provide a healthier environment paying attention to pollution and green energy. In logistics is particularly important to note the pollution caused by trucks so the aim is reducing CO2 emissions, congestion and air pollution to improve the quality of life of citizens and to reach the goals set by the European Green Deal.

Gain	**Pain**
- Innovation - Increase revenues - Ensure markets - Green energy development - UE goals	- Investments - Costs - Reputation - Not widespread technologies

5.1.10 Research institutes

Research institutes, *Table 12*, are a structure created to operate in different fields of science. The research institute could provide support in basic research or applied research. In this project, some research organizations are involved, such as ICCS (Institute of Communication and Computer System) or ICOOR (Interuniversity Consortium for Optimization and Operation Research), to support start-ups and SMEs, but also implement and test innovations. Research institutes are very important in innovation since they provide scientific knowledge and experience ensuring public knowledge. Their objective is cooperating for the progress. An obstacle they may encounter is the difficulty to obtain information or completely understand how the logistics work.

Table 12: Research institutes Actor ID

Actor: Research institutes
Actor Type: Stakeholder/User Actor Description: a research institute is a structure created to operate in different fields of science Social-Economic stratification: university, research associations

Actor situation

Job
The research institute could provide support in basic research or applied research. In this project, some research organizations are involved, such as ICCS (Institute of Communication and Computer System) or ICOOR (Interuniversity Consortium for Optimization and Operation Research), to support start-ups and SMEs but also implement and test innovations.

Gain	**Pain**
- Partner to the project - Data analysis and evaluation - Provide knowledge and experience - Provide new technologies - Cooperate for the progress	- New framework - Reputation - Difficult to obtain information

5.1.11 The European Commission

The European Commission represents the interests of the European Union. The European Commission proposes several projects, including building a European industrial supply side for 5G technology in the logistics sector. This way, it is possible to improve logistics from different point of views

and each European country could benefit. Once the technology is developed; the European commission could make innovation accessible or define standards. On the other side, it is possible that there is a resistance in adopting the technology. In *Table 13* is presented the Europan Commission Actor ID.

Table 13: European Commission Actor ID

Actor: European Commission
Actor Type: Stakeholder/User Actor Description: the European Commission represents the interests of the European Union Social-Economic stratification: Policy maker, creator of the project

Actor situation

Job
The European Commission proposes several projects, including building a European industrial supply side for 5G technology in the logistics sector. In this way, it is possible to improve logistics from different point of views and each European country could benefit.

Gain	**Pain**
- A new European supply chain - Achieve innovation - Making innovation accessible - Data sharing between authorities - Create standards	- New framework - No market available - Innovation not accessible - Resistance (from some country)

5.1.12 Local governments

Local governments are public authorities limited to a small area, such as a city. In *Table 14* the Actor ID of these stakeholders is presented.

Table 14: Local Governments Actor ID

Actor: Local Governments
Actor Type: Stakeholder Actor Description: local governments are public authorities limited to a small area, such as a city Social-Economic stratification: Policy maker, creator of the project

Actor situation

Job
Local government ensures that the activities in a city, in a country or in a state are carried out according to the local rules, they have an interest in ensuring order and legality.

Gain	**Pain**
- Improve infrastructure - Reputation - Data sharing between authorities - Smart city	- New framework - Conflicts of interest - Innovation not accessible - Political interests

Local government ensures that the activities are carried out according to the local rules, they have an interest in ensuring order and legality. For local government of the city-port is useful to establish a rapport with the port itself to improve infrastructures, data sharing and create a smart city. In this context, it can come into play political interests or conflicts that risk limiting and preventing innovation.

5.1.13 Regulators

Regulators are institutions universally recognized that supervise and eventually sanction business activities or industries. Regulators are important, but they only have the powers specified to them by government authorities. In *Table 15* is presented the regulators Actor ID.

There are several types of regulators, in particular in this project is considered the International Telecommunication Union, whose goal is to coordinate telecommunication operations and services throughout the world. But also the ECC (Electronic Communications Committee) and the CEPT (European Conference of Postal and Telecommunications Administrations).

Table 15: Regulatos Actor ID

Actor: Regulators
Actor Type: Stakeholder Actor Description: regulators are institutions that supervise business activities or industries Social-Economic stratification: Policy maker

Actor situation

Job
Regulators are important and supervise activities, but they only have the powers specified to them by government authorities.

Gain	**Pain**
- Universally recognized - Supervise business activity - Sanction business activity - Reputation - Data sharing between authorities	- Difficulties in supervision - Unclear rules - Limited powers - Unclear scope of application

5.1.14 Policy makers

Policy makers are members of a government organization who are universally recognized and is responsible for making new rules or laws, their Actor ID is presented in *Table 16*. Policy makers provide the highest authority and must regulate relationships between all the stakeholders of the ecosystem considered. They could be national, international or European government authorities that set the limits of policies and legal aspects. Often is difficult establish right policies, not knowing the new technology and its possible effects or unclear scope of application.

Table 16: Policy makers Actor ID

Actor: Policy makers
Actor Type: Stakeholder Actor Description: policy makers are members of a government organization who is responsible for making new rules or laws Social-Economic stratification: Policy maker

Actor situation

Job
Policy makers provide the highest authority and must regulate relationships between all the stakeholders of the ecosystem considered.

Gain	**Pain**
- Set the rules/laws up - Universally recognized - Data sharing between authorities - Ensure security - Ensure safety - Environmental topics	- Difficult to establish new laws - Difficult to establish new rules - New framework - Difficult to understand the technology - Unclear scope of application

5.1.15 Standard Developing Organizations

The Standard Developing Organizations Actor ID is presented in *Table 17*. Standard developing organizations produce technical standards that create value for the technology. A standardization organization intends to address the needs of adopters of new technologies eventually protecting them. In this project, related to 5G industry, there are different and several organizations that cooperate to provide standards (3GPP, ETSI, IEEE, IETF and 5G-related alliance). For safety related-5G applications ISO standards may be significant, such as for autonomous driving in the automotive

industry. Standards ensure interoperability, but are difficult to identify and establish specially for new technologies such as 5G related.

Table 17: Standard developing organizations Actor ID

Actor: Standard developing organizations
Actor Type: Stakeholder Actor Description: a Standard Developing Organization produces technical standards Social-Economic stratification: Standard maker

Actor situation

Job
A standardization organization intends to address the needs of adopters of new technologies.

Gain	**Pain**
- Produce standards - Protect adopters - Protect users - Universally recognized - Ensure interoperability	- Difficult to establish standard - Difficult to identify standard - New framework - Government influence - Difficult to understand the technology

5.1.16 Cargo owners

Cargo owners want their goods delivered, they use port services via transport or logistics company to deliver goods. The cargo owners Actor ID is presented in *Table 18*. During transport liability and/or ownership over cargo may change. For this actor, it is important the tracking of cargo and having continuous information on cargo. Cargo owners would like to have low volumes and transparency during transport.

Table 18: Cargo owners Actor ID

Actor: Cargo owners
Actor Type: User Actor Description: cargo owners want their goods delivered Social-Economic stratification: business, workers

Actor situation

Job
Cargo owners use port services via transport or logistics company to deliver goods.

Gain	**Pain**
- Information of cargo - Tracking of cargo - Low volumes - Transparency	- Difficult to deliver - Lack of system integration - Local government - Regulators

In order to achieve these aims they need information from different actors of the system, the lack of system integration may be a serious problem.

5.1.17 Logistics/Transport companies

Logistics and transport companies have a direct relationship to the port and represents trucks' owner, they have the goal of transporting cargo to or from the port, but also loading and unloading. They usually hire truck drivers to handle the goods. It is possible to consider also railway companies for transporting goods. In order to achieve cost and transport efficiency, they need data and information from the port, but also from the road infrastructure to constantly update the delivery roadmap. Among risk factors, it is possible that visibility to logistics chain and other stakeholders' schedule changes are limited. Transport companies want optimize operations and vehicle management also with a dynamic allocation of container jobs and less trucks waiting time. Finally, they would like to introduce a new type of delivery, related to 5G technology, which is delivered by drone. The Logistics and transport companies Actor ID is presented in *Table 19*.

Table 19: Logistics/transport companies Actor ID

Actor: Logistics/transport companies
Actor Type: User Actor Description: transport companies have a direct relationship to the port and represents cargo owners Social-Economic stratification: business, port workers

Actor situation

Job
Transport companies have the goal of transporting cargo to or from the port, but also loading and unloading by hiring truck drivers to handle goods.

Gain	**Pain**
- Cost efficiency - Transport efficiency - Optimized operations and vehicle management - Need data - Need information - New methodologies to deliver (drone)	- Pollution with trucks - Limited visibility to logistic chain - Limited visibility to schedule changes - Route of truck - New technology too expensive - Regulators - Local government

5.1.18 Security and safety providers

Security and safety providers, generally, are contracted by the port so that they can help ensure a safely workplace. To do this, they would like to use good and new technologies to guarantee automated and coordinate surveillance increasing control. These companies can provide specific tools or adequately trained human resources. Obviously, in the port there are different actors to control and sometimes it may be difficult to supervise all the activities. It is also essential do not forget about privacy, whose boundaries are often difficult to trace. The security and safety providers Actor ID is presented in *Table 20*.

Table 20: Security and safety providers Actor ID

Actor: Security and safety providers
Actor Type: User Actor Description: security and safety providers ensure security and safety in the port Social-Economic stratification: business, port workers

Actor situation

Job
These companies can provide specific tools or adequately trained human resources.

Gain	**Pain**
- Increase control - Good technologies - New technologies - Automated and coordinate surveillance	- Different actors - Difficulty to control all activities - Lack of information - Privacy

5.1.19 Stevedoring

Stevedoring is very important in the port; the aim is to conclude agreements with a port to loading and unloading ships by using specific infrastructure and machinery that must be available. Usually, there are also some trained dockworkers who use or monitor machineries, moreover operations must be well-defined to perform the job properly. There is, however, a high risk of serious bodily injuries. First of all, the risks related are competition between other port and port operators, but also lack of information and, possibly, human errors that can create malfunctioning. In *Table 21* is presented the stevedoring Actor ID.

Table 21: Stevedoring Actor ID

Actor: Stevedoring
Actor Type: User Actor Description: a stevedoring firm with few dockworkers Social-Economic stratification: business, port workers

Actor situation

Job
A stevedoring firm has the aim to loading and unloading means of transportations (ships) by using specific infrastructure and machinery.

Gain	**Pain**
- Local available infrastructure - Data available - Well-defined operations - Dockworkers trained - Good machinery - Good working environment - Security	- Malfunctioning - Human error - Competition between other ports - Competition between other port operators - Lack of information

5.1.20 Physical port infrastructure

The physical port infrastructure is made up of terminals, sea fairway signs, but also warehouses and other facilities which are massive and costly. It is the base for every port operations to serve ships, cargo or vessels and should anticipate the needs of logistics and transport sector. One of the main problems in a port is the traffic jam and quay side queues within the container terminal. At the port, there are human resources involved in port operations and there is a high risk of serious bodily injuries, especially for those who work at the quay side. Logistics and transport sector are in deep transformation; the port should adapt to the development of new waterborne activities, but also to climate change according to policies and standards. The impact of the port on the surrounding urban area should not be overlooked. The aim is owning automated handling equipment and more flexible infrastructures, providing connectivity and integration of the system and data (IoT). The port would like to reduce operational costs and optimize not only operation, but also maintenance, always ensuring safety. A significant cost is, for example, the spare part inventory for maintaining yard vehicles and that is why it is necessary collecting data for predictive maintenance. The physical port infrastructure Actor ID is described in *Table 22*.

Table 22: Physical port infrastructure Actor ID

Actor: Physical port infrastructure
Actor Type: User Actor Description: a port infrastructure is made up of terminals, sea fairway signs, but also warehouses and other facilities, such as road, lighting ecc.. Social-Economic stratification: port infrastructure and human resources

Actor situation

Job
A port infrastructure is the base for every port operations to serve ships, cargo or vessels and should anticipate the needs of logistics and transport sector.

Gain	**Pain**
- Adapt to the development of new waterborne activities - Adapt to climate change - Respect policies/standard (European) - More intelligence infrastructure (automated handling equipment) - More flexible infrastructure - Connectivity and integration - Providing data (IoT) - Reducing operational costs - Optimize operation and maintenance - Ensure safety	- Logistics and transport sector are in deep transformation - Natural condition - Technology expire - Massive and costly infrastructure - Environmental regulation/protection - Safety issues

5.1.21 Port-city residents

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

In *Table 23* the port-city resident's Actor ID is presented.

Table 23: Port-city resident Actor ID

Actor: Port-city resident
Actor Type: Stakeholder Actor Description: a port-city resident represents all the people who live near a port Social-Economic stratification: every citizen

Actor situation

Job
In everyday life, people carry out various activities; they move to one part of the city to another for work or to go to school by car or public transport.

Gain	**Pain**
- Travelling made easier - Not much traffic - Not too much trucks - Not pollution - Little noise pollution	- Logistics and transport sector are in deep transformation - Big cargos - Many trucks - Inadequate road infrastructures - Disorganization - Delivery method

5.1.22 Road infrastructure operators

Road infrastructure operators had to ensure safe and reliable road infrastructure for travelling and transporting goods. They are national or regional entities in charge of maintenance and deployment of physical road and every country has its rules. Road infrastructure operators need to manage and operate road infrastructure to increase value for public transport, drivers and logistic firms, but also monitoring traffic pollutions and implementing performance measures. In this project their role is also to provide road infrastructure data access and traffic real-time data to the port and logistics companies to better organize the delivery roadmap or even make communication with vehicles possible. A green light solution for huge vehicles and for future automated truck platoon would be to implement. In doing so, road infrastructure operators must have a massive and costly infrastructure following legal obligations and environmental protection, but they may also have resources constraints.

In *Table 24* is presented the road infrastructure operators Actor ID.

Table 24: Road infrastructure operators Actor ID

Actor: Road infrastructure operators
Actor Type: Provider Actor Description: road infrastructure operators had to ensure safe and reliable road infrastructure for travelling and transporting goods Social-Economic stratification: public or private business

Actor situation

Job
They are national or regional entities in charge of maintenance and deployment of physical road and every country has his rules. Road infrastructure operators need to manage and operate road infrastructure to increase value for public transport, drivers, logistic firms and pedestrians but also monitoring traffic pollutions.

Gain	**Pain**
- Maintenance of roads - Provide road infrastructure data access - Provide real-time data - Monitor traffic condition - Create communication with vehicles - Implementing performance measures	- Resources constraints - Legal obligations - Logistics and transport sector are in deep transformation - Technology expire - Massive and costly infrastructure - Environmental regulation/protection

5.2 Value Ring

By carefully analyzing the stakeholder ecosystem it is possible to give priority to the stakeholders most involved in the applications in the Living Labs related to the 5G-LOGINNOV project. These stakeholders are represented in the Value Ring, *Figure 24*, following two variables that are the stakeholder influence and the priorities or importance.

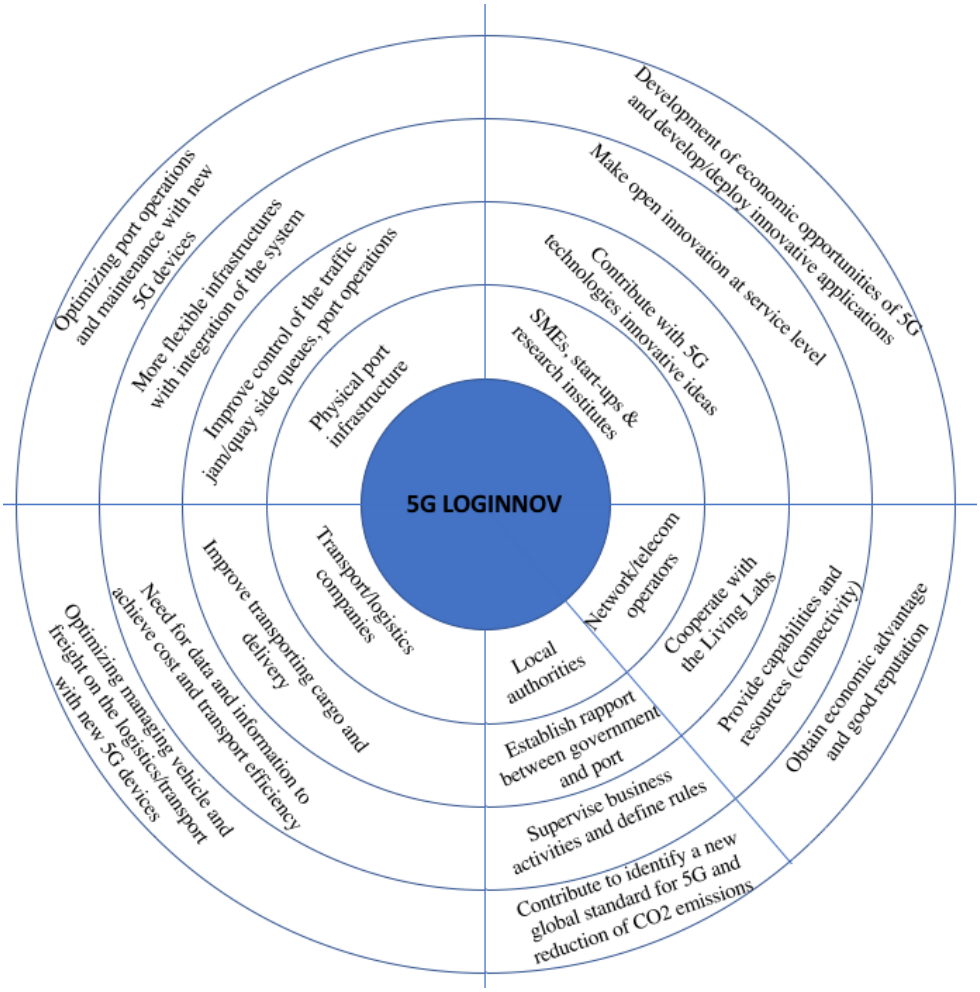

Figure 24: Value Ring

SMEs, start-ups and research institutes can contribute to the project's experiments with innovative ideas and, taking advantage of the growing adoption of 5G technologies, make possible open innovation at service level. Thanks to the opening innovation and the support provided, especially for innovative SMEs and start-ups, it is possible developing

economic opportunities of 5G, but also developing and deploying innovative applications offering new business opportunities for established SMEs and creating high-tech start-ups. Transport and logistics companies want to improve, at a first place, transporting cargo and delivery. This project can enable these companies to better manage vehicles and freights thanks to the 5G-related technologies, connectivity and all network functions, that the living labs can experiment and provide. In fact, transport and logistics companies need a certain amount of data and information to achieve cost and transport efficiency.

Even the physical port infrastructure can reach an optimization of port operations and maintenance thanks to the 5G-LOGINNOV project, just thinking, for example, of real-time truck location. With more flexible infrastructures with integration of the system, it is possible to improve the control of the traffic jam or the quay side queues along the terminals achieving a better organization and a safer and more adaptable work environment.

Network and telecom operators seem to be the most important stakeholder among the 5G-related connectivity providers. They can be considered as partners for the living labs because different providers supply the 5G network architectures at the three European living labs in the project considered (such as MNO, eMBB, mMTC, M2M), they provide capabilities, but also resources. This way, network and telecom operators can obtain economic advantage and gain a good reputation for the market and for other 5G-related projects. These 5G network architectures can obviously be integrated with new augmented 5G capabilities.

Naturally, all the activities carried out are controlled by the authorities respecting safety and security of all the actors involved. A relationship between the local government and the port is important to cooperate and create an innovative environment that also has a positive impact on the urban area, in doing so authorities have to supervise businesses and establish rules to follow. This way, it is possible to obtain important progress in policies and standards. Thanks to this project, authorities can contribute identifying the emergence of new global 5G standards taking account of logistics and port circumstances. Another important aspect for

authorities is the environment and the impact that air pollution may have on climate changes. An important objective is reducing the Co2 emissions that it can be reached up thanks to 5GLOGINNOV because it contributes to decarbonizing transport, providing 5G solutions for significant reduction of emissions, satisfying not only important local policies, but even European, such as the European Green Deal.

5.3 Business model development: the Uniform phase

After defining ports' stakeholders and identifying those that have a far greater importance, within the 5G-LOGINNOV project, the next step is to continue applying the GUEST methodology. In fact, the second phase of this method is the Uniform phase.

The objective is to consolidate information collected during the first phase, but also create a knowledge base of the company and make a standard format. This way, it is possible to make potential comparison between different cases.

The aim of this analysis is to elaborate and develop two different business models, each of which focuses on a main 5G core innovation technologies for port operations:

- Maintenance,
- Operation efficiency.

Innovations related to these fields are among the main innovations required in order to implement the new vision of European logistics. In fact, these would contribute to meeting the objectives of the 5G-LOGINNOV project.

The business models will be implemented using the Business Model Canvas, the instrument used in the Uniform phase of the GUEST methodology and created, especially at the beginning, for the stat-ups world. The Business Model Canvas presented will be described starting from the center of the template, then right and finally left, as the Canvas has to be read this way in order to better understand it.

Since the two business models that will be developed within this thesis are part of the same project and require similar technologies (5G-LOGINNOV), some sections of the Canvas will have almost identical characteristics.

5.3.1 Maintenance Business Model Canvas

Table 25: Maintenance Business Model Canvas

<table>
<tr>
<td rowspan="2">Key Partners

-Network and telecom operators
-Hotspot providers
-Service providers
-Physical port infrastructure
-Research institutes
-Public-private partnership (e.g. ERTICO)</td>
<td>Key Activities

-Research
-Development of platform
-Equipment data and maintenance data collection
-Preprocessing and training AI model
-Schedules, overview of assets and purchase optimization
-Testing and roll out</td>
<td rowspan="2">Value Proposition

-Reduced operational costs
-Reduced maintenance and repair costs
-Anticipate eventual breakdowns
-Reduced asset downtime
- Optimize spare parts inventory
-Reduced total cost of spare parts, tyres and batteries
-Elongated yard equipment life-cycle
-JIT spare parts inventory</td>
<td>Customer Relationships

-Co-creation, collaborating relationship
-Personal assistance
-Automated services
-Community</td>
<td rowspan="2">Customer Segments

-Physical port infrastructure and terminals
-Yard vehicle operator
-Transport /logistics companies</td>
</tr>
<tr>
<td>Key Resources

-Support for the development and supply of 5G technologies
-Support for advanced machine learning algorithms
-Past projects (e.g. Corealis Predictor tool)
-Data sources (e.g. sensors)</td>
<td>Channels

-Living Lab
-Face-to-face interaction
-Website
-Trade fairs
-Smartphone applications or other devices
-Marketing campaigns
-Raise awareness through presentation of use cases or past projects</td>
</tr>
<tr>
<td colspan="3">Cost Structure

-Initial investment (necessary services)
-Testing, maintenance and updating platform
-Salary
-Computational power and facility costs
-Data management and data updating
-IT-administration</td>
<td colspan="3">Revenue Streams

-European funds
-Sales (e.g. of access point, sensors and Terminal Operating System)
-Usage fee (e.g. for MANO platform)
-Licensing fee</td>
</tr>
</table>

The Business Model Canvas presented in *Table* 25 is related to maintenance and will be explained describing all the nine sections.

5.3.1.1 Value Proposition

The aim of the Value Proposition is to create value for a specific customer segment. In this case, within the 5G-LOGINNOV project, it is necessary to consider the 5G core innovation technologies to solve problems and meet needs in port operations. The focus is on the maintenance and the new way this operation can be optimized.

The first thing to consider is the cost aspect. One of the most expensive feature of port operations is the spare part inventory for maintaining yard vehicles. The established method of maintenance is the preventive one, that is characterized by periodic inspections by engineers with the aim to fix problems before they get worse, or the corrective one. These methods are costly and do not keep track of specific asset conditions. On the contrary, having the opportunity to make preventive decisions would certainly be more convenient. The development of predictive maintenance using 5G technologies has the aim not only to reduce operational costs, but also maintenance and repair costs. This way, it is possible to anticipate eventual yard vehicles breakdowns that obviously lead to higher costs if preventive or corrective maintenance is used. The benefits that will be obtained will be linked to the optimization of spare parts inventory, almost trying to reach Just In Time inventory, and the reduction of the total cost of spare parts, tyres and batteries. These have a positive impact on the physical port structure. Moreover, the goal is to bring value with new technologies in order to elongate yard equipment life-cycle. Improving storage and management of assets, it is possible to contribute to increase port efficiency and related logistics system.

5.3.1.2 Customer Segments

The customers that this business wants to reach and serve are different. The first customer to be identified is the port and the physical port infrastructure with terminals. The major problem that would be solved is the optimization of inventories allowing to better manage spaces creating alternative opportunities. This way, even the port workers have the possibility to better

organize their activities improving productivity. Reducing downtime and yard vehicles breakdowns the transport and logistics companies that own the vehicles may increase efficiency and better respond to the needs of the port. For this reason, transport and logistics companies have a great interest in this new 5G technology solution. The other actor presented in the Business Model Canvas is the yard truck operator. Paying attention to all these aspects related to storage and efficiency, it is possible to increase service life of yard vehicles and improve yard vehicle operator safety. Only in this way the working environment and the operators' satisfaction be improved.

5.3.1.3 Customer Relationship

The relationship between the business and the customers is mainly based on co-creation. In fact, in order to better respond to the port's needs and solve problems, the company and the customers have to create a collaborating relationship sharing knowledge and information constantly monitoring the service. Personal assistance is also required for communication, especially for the port infrastructure. In certain cases, it is possible to offer automated services, for example for yard truck operators or transport companies, to provide a self-service relationship in which they can monitor the equipment life-cycle.

5.3.1.4 Channels

The main way to interact with the customers presented in the Business Model Canvas is the Living Lab. Each port taken into consideration in the 5G-LOGINNOV project has a Living Lab structure in which start-ups, SMEs, partners and customers can meet and where the Value Proposition developed can be delivered in order to be implemented and tested. In this regard, face-to-face interaction is important and very useful to increase customers' awareness and customize the service. The port and the workers will use the service with smartphones or web applications or other devices. It may be important present different use cases, for example in fairs, especially for new technologies, such as 5G technologies, that have not yet spread widely. In the project, it will be important marketing campaigns, such as video conferencing and demonstration, to promote service beyond research.

5.3.1.5 Revenue Stream

The main revenues will come from European funds as the business that it is proposed to be developed is related to the European 5G-LOGINNOV project. Any other revenue might come from selling devices to collect data, such as sensors, or 5G access point. Moreover, considering the use by ports of the platform developed for a more efficient maintenance, predictive maintenance, it is possible to foresee revenues by usage fee or licensing fee according to the type of agreement between the company and the port.

5.3.1.6 Key Activities

The initial phase of the project is linked to the research and study of 5G technologies solutions that best meet the needs and values presented in the Value Proposition. So, in light of this, it is necessary to make agreements to better develop the necessary technologies, such as the platform that is able to process all the data collected through sensors and manage them. In order to optimize maintenance in port and logistics hubs it is also needed a preprocessing and training Artificial Intelligence model related knowledge to create an adequate service and efficiency. Problem solving key activities, like schedules and overview of assets are fundamental to create the Value Proposition and generate revenues. The proposed idea must be approved by the European Union. After this, it will be implemented and tested in the port and inside the respective living lab structure. Finally, if the results are satisfactory, the solution can be rolled out.

5.3.1.7 Key Resources

The first resource needed to implement this business is the support for the development and supply of 5G technologies, but also the support for advanced machine learning algorithms brought by human resources and their know-how. Past developed projects related to 5G innovations can be an excellent intellectual resource from which to draw experience and knowledge. Moreover, having regard to the maintenance context and the need for more data, even data sources are necessary; in fact, the use of sensors is the basis of the development of the new maintenance system.

5.3.1.8 Key Partners

One of the most important key partners are the network and telecom operators together with hotspot providers and service providers because they are essential for the company and the business as they provide technologies and knowledge, resources to develop the new 5G related maintenance concept. Obviously, also the port infrastructure has a huge interest in collaborating with this business and in particular in providing data. To better organize, optimize and develop the new business research institutes and the public-private partnerships play an important role in this business model.

5.3.1.9 Cost Structure

The highest costs will be given from the amount of the initial investment, so there are variable costs together with salary considered among the fixed costs. Having regard to the type of technology that it is developed, computational power and facility costs for AI algorithms and the platform will have to be taken into account. Other costs will certainly be given by testing, maintenance and updating the platform and the service provided together with data management and data updating. Among costs IT-administration is one of the most significant.

5.3.2 Operation efficiency Business Model Canvas

Table 26: Operation efficiency Business Model Canvas

<table>
<tr>
<td rowspan="2">Key Partners

-Network and telecom operators
-Hotspot providers
-Service providers
-Device and software providers
-Physical port infrastructure
-Research institutes
-Public-private partnership (e.g ERTICO)</td>
<td>Key Activities

-Research
-Development of platform
-Design an innovative process modelling framework for the CT
-Data collection
-Transmission of location data
-Testing and roll out</td>
<td rowspan="2">Value Proposition

-Reduced operational costs
-Minimization of breakdowns
-Avoid traffic jams and queues
-Decreased fuel consumption
-Decreased CO_2 and NO_x emissions
-Increased productivity
-Better assignment of container jobs to yard trucks
-Minimization of empty container runs
-Automated trucks platoons and automated handling equipment</td>
<td>Customer Relationships

-Co-creation, collaborating relationship
-Personal assistance
-Automated services
-Community</td>
<td rowspan="2">Customer Segments

-Physical port infrastructure and terminals
-Stevedoring
-Cargo owners
-Transport /logistics companies</td>
</tr>
<tr>
<td>Key Resources

-Support for the development and supply of 5G technologies
-Past projects
-Data sources (e.g. sensors)
-Information management system</td>
<td>Channels

-Living Lab
-Face-to-face interaction
-Website
-Trade fairs
-Smartphone applications or other devices
-Marketing campaigns
-Raise awareness through presentation of use cases or past projects</td>
</tr>
<tr>
<td colspan="3">Cost Structure

-Initial investment (necessary services)
-Testing, maintenance and updating
-Salary
-Computational power and facility costs
-Data management and data updating
-IT-administration</td>
<td colspan="3">Revenue Streams

-European funds
-Sales (e.g. of access point, sensors and Terminal Operating System)
-Usage fee
-Licensing fee</td>
</tr>
</table>

The Business Model Canvas in *Table* 26 is related to operation efficiency.

5.3.2.1 Value Proposition

In this second business model the focus is on operation efficiency that represents one of the fundamental characteristics in order to improve ports and logistics. The reduction of operational costs and the minimization of breakdowns are aspects that create value, here as well, providing higher quality of the port operations. By considering terminals and port traffic, one of the most critical aspects is managing port traffic itself. Therefore, to make port transport, loading and unloading operation more efficient and reliable, traffic jams and queues are to be avoided. A better assignment of container job allocation to yard trucks through the reduction of total kilometers run per day is important and, in doing so, even the status of the port benefits. In fact, other important value that operation efficiency leads are a decrease of the fuel consumption and a decrease of the CO_2 and NO_x emissions, responding to the need to reduce air pollution and to the most important European agreements linked to climate change. Increasing operations productivity and minimizing empty container runs, it is definitely a costs reduction. Automated trucks and automated handling equipment are novelties that contribute in efficiency and the 5G technologies will bring all these values into the business.

5.3.2.2 Customer Segments

The first customer to be identified is the port with terminals; the major problem that this business would be solved is the traffic jam and the queues created along terminals, but also the issue that comes from moving around loads by yard trucks within the port infrastructure. As regard stevedoring, the most important aspect is to manage loading and unloading in a better way and, thanks to 5G technologies, these operations would be done more safely trying to avoid any human errors and using advanced handling equipment. Cargo owners and transport and logistics companies also have benefits. In fact, increasing efficiency the waiting times decrease speeding up all the port operations and reducing remarkably the costs. For logistics companies the decreasing of fuel consumption and emission is the solution to one of the major problems of the industry, the air pollution. Moreover, through automation, information can be easily available by all the actors making efficient the entire supply chain.

5.3.2.3 Customer Relationship

Also in this business model the relationship between the business and the customers is mainly based on co-creation. In fact, the company and the customers have to create a collaborating relationship sharing knowledge and information. This is necessary given the novelty of the technology and its applications. Personal assistance is also required for communication, especially for terminals and stevedoring. In certain cases, it is possible to offer automated services, for example for cargo owners or transport companies, to provide a self-service relationship in which they can monitor the status of the terminals and cargo or the condition of the vehicles (volumes) to know how manage them better.

5.3.2.4 Channels

The main way to interact with the customers presented in the Business Model Canvas is the Living Lab. In this regard, face-to-face interaction is important and very useful to increase customers' awareness and customize the service. The port, the terminals and their workers will use the service with smartphones or web applications. It may be important present different use cases, for example in fairs, especially for these new types of technologies. In the project, it will be important marketing campaigns, such as video conferencing and demonstration, to promote service beyond research. A website and its use can be very helpful for communication and the relation between the company and all the customers.

5.3.2.5 Revenue Stream

The main revenues will come from European funds as the business that it is proposed to be developed is related to the European 5G-LOGINNOV project. Any other revenue might come from selling devices to collect data, such as sensors, or automated equipment to improve the port infrastructure, necessary for transport and logistics activities. It is possible to foresee revenues by usage fee or licensing fee taking into account that information technology services are provided.

5.3.2.6 Key Activities

The initial phase of the project is linked to the research and study of 5G technologies solutions that best meet the needs and values presented in the Value Proposition. It is necessary to make agreements to better develop the necessary technologies, such as the platform that is able to process all the data collected through sensors and manage them. In order to improve operation efficiency, it is required the development of a platform and to design an innovative process modelling framework for the computational thinking (CT); in fact, it is necessary recreate a set of problem-solving methods to choose from. These methods consist in decomposing a problem, using data, and express a generic solution in a way that a computer can execute and that can be used to solve algorithmically all the variations of the problem. Obviously, data collection is important in order to identify the main variable involved. Considering the use of trucks within a very large area, such as the port, transmission of location data is required for container job allocation and traffic management. The proposed idea must be approved by the European Union, implemented and tested in the port and in the respective living lab structure. Finally, if the results are satisfactory, the solution can be roll out.

5.3.2.7 Key Resources

The first resource needed to implement this business is the support for the development and supply of 5G technologies. To develop the platform and design an innovative process modelling framework for CT, it is necessary to have a specific know-how and competencies provided by specific professional figures. Data sources are essential to set up and implement problem-solving methods, moreover, having an effective and well-managed information management system is a key resource to provide value and problem solution to operation efficiency. Past developed projects related to 5G innovations can be an excellent intellectual resource from which to draw experience and knowledge or from which to learn and improve.

5.3.2.8 Key Partners

Network and telecom operators together with hotspot providers, service providers and device and software providers are the most important key

partners in developing a new concept of operation efficiency using 5G technologies. Their knowledge and their specific resources are fundamental in order to create this business. The main aspect for the development of the proposed technology is the need for a large number of data, only by cooperating with the port infrastructure and terminals and, in some cases, also transport companies, it is possible to gather enough information to create problem solving models. Obviously, even in this second business model research institutes and public-private partnerships are important and help in implementing the business model itself.

5.3.2.9 Cost Structure

Not being able to assess accurately and in detail the cost structure, the operation efficiency Business Model Canvas has characteristics equivalent to the first business model presented. In fact, it is possible to consider an initial investment and the variable costs together with the fixed ones. Presenting an information technology solution, facility cost, but above all IT-administration is significant. Other costs will certainly be those for testing, maintenance and updating the platform and the service provided together with data management and data updating.

5.4 An economic overview

The 5G-LOGINNOV is a 3-year project co-financed by the European Union.

Although the project is at its inception, it has been possible to identify the main partners and their economic contribution.[4]

The project leader is ERTICO. In fact, the European Road Transport Telematics Implementation Coordination Organisation (ERTICO) is the organization which coordinates the 5G-LOGINNOV project. Its goal is to put together private and public stakeholder across Europe to create smarter and cleaner transport service and networks in order to achieve competitiveness in industries and to optimize services for users [https://ertico.com/].

Other project partners are research institutes, leaders in engineering consulting and R&D services, service companies or IoT solutions providers. These come from various European countries and contribute financially to the project.

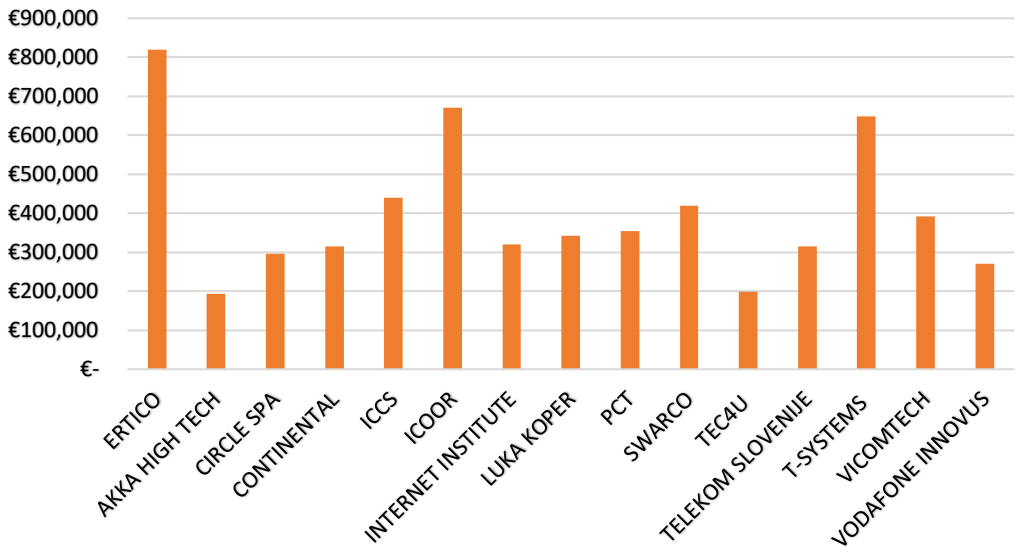

Figure 25: Main partner and their contribution

[4] The reference used to collect data is https://5g-loginnov.eu/.

In *Figure 25* are reported all the partners and their contributions. The influence of European countries participating in the project, according to partner companies is reported in *Figure 26*.

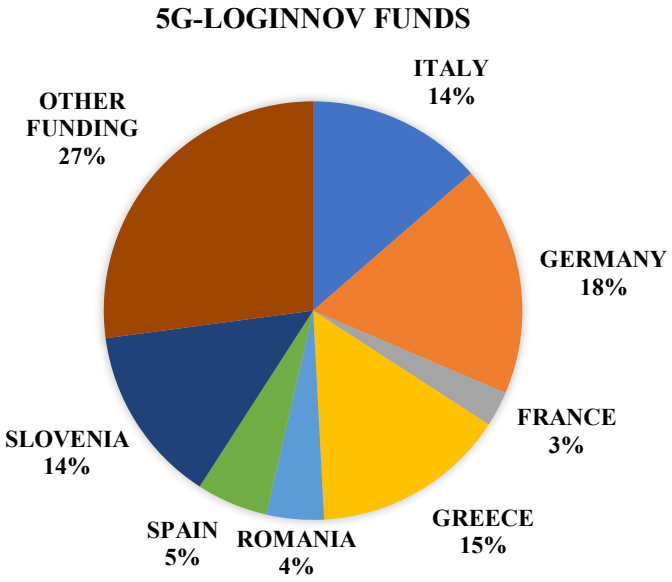

Figure 26: 5G-LOGINNOV funds

By observing the pie chart, it is possible to underline that the 73% of the funds are European. The overall budget calculated is € 7.926.474,29 of which € 5.999.702 are European.

It is important to take into account the open call organized by the 5G-LOGINNOV in order to select five innovative SMEs and start-ups that will contribute to the development of 5G-based solutions. The Call Closing Date was June, 30 2021 while the planned date for the selection of the applicants was September, 17 2021. For each selected applicant, a service contract is stipulated in order to incorporate it in the 5G-LOGINNOV consortium. This contract provides a global funding of €50.000 max for each selected applicant.

Conclusions

The innovation turns out to be fundamental nowadays, in particular the technology-driven innovations. In the last decades, the world has become more and more connected and digital technologies have assumed a main role in changes. Among digital technologies, 5G and companion technologies are considered disruptive innovations, for this reason they have a strong impact not only for companies but in society and everyday life.

Among the structured industries across the globe that are going to be changed by these technologies, the transport and logistics sector is the one that uses 5G business process transformation [Attaran, Attaran 2020].

The 5G-LOGINNOV project arises in this context. This European project has the aim to develop new technologies and new solutions in order to create opportunities for logistics value chain innovation. In doing so, the involvement of start-ups and SMEs is fundamental. In fact, it is crucial to validate new business models in order to identify sustainable strategies to best increase and deploy the solutions developed. In this thesis, two business models related to 5G technologies in port operations were developed: operation efficiency and maintenance.

To better understand the port ecosystem, the stakeholders involved in the project were analyzed. By applying the GUEST methodology, it was possible to identify twenty-two stakeholders belonging to six main categories: Technologies providers, Connectivity providers, Businesses and associations, Authorities, Port workers and City. Assessing the importance of these stakeholders, in the Value Ring were highlighted:

- Transport and logistics companies,
- Physical port infrastructure,
- Local authorities,
- Network and telecom operators,
- SMEs, start-ups and research institutes.

Subsequently, the Business Model Canvas was used to develop the two business models with the aim to detail the nine parts that make up the document. The main aspect of the analysis carried out for the business models is characterized by the value proposition.

In the maintenance Business Model Canvas the first thing to consider is the cost aspect. In fact, the development of predictive maintenance using 5G technologies has the aim not only to reduce operational costs, but also maintenance and repair costs by anticipating eventual yard vehicles breakdowns that lead to higher costs, especially if preventive or corrective maintenance is used. The benefits in developing this new business model related to predictive maintenance is the optimization of spare parts inventory and the reduction of the total cost of spare parts, in addition to elongate yard equipment life-cycle. With this new technology, it is possible to increase port efficiency and related logistics system.

In the operation efficiency Business Model Canvas, it was possible to emphasize the importance of the reduction of operational costs and the minimization of breakdowns. These are aspects that create value, providing higher quality of the port operations. A better assignment of container job allocation to yard trucks through the reduction of total kilometers run per day is important in order to make port transport, loading and unloading operation more efficient and reliable. Automated trucks and automated handling equipment are 5G technologies that contribute in efficiency. Another important value related to operation efficiency is a decrease of the fuel consumption and a decrease of the CO2 and NOx emissions, responding to the need to reduce air pollution required from European Green Deal.

By analyzing the two business models, it is possible to identify similarities in different parts of the documents. In fact, the technologies that want to be developed within these business models are comparable.

The type of Customer Relationship and the Channels used are quite the same for both models.

The Customer segments differ only for some actors. Whereas the first model submitted presents yard vehicle operators, the second one meets the stevedoring and cargo owners' needs.

As regards the part of Key activities, these are managed in accordance with the same procedure. Both require a large amount of data, but for the maintenance business model the focus is on preprocessing and training AI model in order to schedules, overview of assets and purchase optimization; while in the operation efficiency business model, the focus is on design an innovative process modelling framework for the ICT and the transmission of location data.

The Key partners section represents some of the stakeholders identified through the GUEST methodology, such as network and telecom operators, hotspot providers, service providers, device and software providers, the physical port infrastructure, research institutes and public-private partnerships.

Finally, the Cost Structure and Revenue Streams parts are quite similar in the business models and it is necessary to make some clarifications.

In particular, the analysis carried out in this thesis are at a high level, not customized. The data and the information used have been collected in the first year of the project. Since the development of the entire project still takes two years, it is not possible to have more detailed information. Moreover, the results of the open call are not yet available, thus, it is not possible to correctly evaluate the cost of the technologies developed through the business models and their revenues since at the time of the analysis the five SMEs and start-ups have not yet been chosen. Therefore, it is not possible to make a comparison with what is foreseen in this thesis compared to what is actually proposed.

Based on past and similar projects, it would be possible to predict an annual reduction of noxious emissions into the atmosphere of 8,2% for each modernized port. This 5G-LOGINNOV project, following the line of COREALIS for example, might be able to grant an annual saving of 2.5 million euros and a 25% improvement in productivity thanks to the new 5G technologies. But only future analysis will be able to deepen these aspects.

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