Industry 4.0 and Supply Chain 4.0· a roadmap for Makios Logistics S.A. transition to Logistics 4.0

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I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

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Abstract

This consulting project was written as part of the MSc in Management at the International Hellenic University.

The constantly increasing need for goods, along with the need to turn to a sustainable growth model have triggered the Fourth Industrial Revolution. Correspondigly, latest technological breakthroughs in the field on Information and Communications Technology, Artificial Intelligence, Cloud Computing, IoT, 3D printers etc. have provided the necessary means for the Industry 4.0 realization.

Industry 4.0 and Logistics 4.0 and two inherent concepts, with Logistics 4.0 being more focused. This research topic has been gaining increased interest ever since Logistics started operating as autonomous service providers, addressing industries' need for reliable and efficient deliveries. The advantages from encompassing the 4IR are significant yet the necessary investments to achieve realization are rather capital intense.

In this consulting project we have evaluated the digital maturity of Makios Logistics as a 3PL provider candidate for transiting to the Logistics 4.0 model. The company has done many steps towards this direction and may reflect a perfect candidate for encompassing the 4IR. Most of the technological advances supporting Logistics 4.0 are already used at Makios Logistics, yet there is still some distance to be covered in order to characterize them as a Logistics 4.0 adopter.

Keywords: Industry 4.0, Logistics 4.0, Makios Logistics, 4IR, IoT

Athanasios Giannousis

15-12-2019

Preface

This consulting project is original and independent work by the author, Athanasios Giannousis. At this point, I would like to express my gratitude to my family who supported me throughout my studies and to my supervisor Dr. Korina Katsaliaki for her assistance and for the insights she provided into operations management. Moreover, I want to express my gratitude for the company supervisor, Mr. Dimosthenis Karalis, Chief of the Technical Department for his aid throughout conducting this thesis and for navigating around the company facilities.

In memory of my father

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1. Introduction

In this consulting project we are going to examine the literature in the field of Industry 4.0 expanding our findings to Supply Chain and Logistics 4.0.

We are going to examine literature in order to identify what Industry 4.0 stands for, especially for the Supply Chain Management and for the Logistics sector, and how a transition to this model can be achieved.

Upon literature review findings and data provided by the company, we will identify potential benefits of Industry 4.0 and we will design a roadmap for the transition of Makios Logistics S.A. to Logistics 4.0.

1.1. Motivation and contribution

My professional track and my academic experiences, during my first degree and during my MSc in Management studies triggered me in order to conduct this consulting project. Being an engineer renders me familiarized with concepts like automation and machine aided decisions, while upon following the Operations and Information Management course I have been intrigued about this specific field. Moreover, I had the chance to run an engineering project for Makios Logistics, during which I had the opportunity to not only get to know the operations ran by the company but also to realize their great interest in innovation and information management.

Furthermore, I have identified lacking literature for the very specific term of “Logistics 4.0”. Although there are numerous references for Industry 4.0, I had a hard time to find references specializing in the Logistics sector.

Finally, Thessaloniki, where I reside, is considered a place of increased interest for logistics, thanks to the geographical position, the port and the railway. Given the fact that some big investments have already commenced for interconnecting the city port with the railway network and for the expansion of the city port, and given the increased interest of foreign investors, mainly Cosco who have already invested in the port of Piraeus and in the port of Thessaloniki, I believe that the Logistics sector is expected to flourish in the next years. This will give added value to this thesis and to my CV, aside the experience expected to gain digging into logistics.

This thesis contribution will be dual; a Logistics 4.0 framework, including the Logistics 4.0 underlying technologies, its advantages for the specific sector and a diagnosing tool for evaluating a Logistics firm suitability for evolving to Logistics 4.0, as well as a roadmap for Makios S.A. transition to Logistics 4.0.

1.2. Objectives

This project aims to contribute in the growth of the company and in their leading position retention by providing applicable, totally or partially, outcomes.

Finally, as stated in the RMS , this consulting project aims to enhance the International Hellenic University synergies with the business world and especially with Makios Logistics S.A. and pave the way for more intense future collaboration.

This project objectives may be broken down to the following;

- Examine the degree at which the company is suitable for transitioning to Logistics 4.0
- Examine whether data is collected from the physical world and evaluate upon
- Recommend a roadmap to transit to Logistics 4.0

1.3. Outline

The consulting project is structured in four chapters. The first chapter serves as an introduction to the consulting project, including the motivation and expected contribution as well as the objectives of the project.

The second chapter includes the literature review findings on the Fourth Industrial Revolution, focusing from Industry 4.0 to Supply Chain 4.0 and Logistics 4.0. In this chapter We are providing some necessary definitions as well as the technologies supporting the transition to Industry 4.0 and Logistics 4.0.

The third chapter is a short company presentation for the Makios Logistics S.A., in which We are providing the growth vision of the company apart from information regarding their operations.

The fourth chapter includes the analysis conducted for the purposes of this consulting project as well as the produced outcomes. Firstly, we are assessing the company's maturity in terms of culture and in terms of infrastructure for transiting to a holistic Logis-

tics 4.0 model. Then we are listing down technologies and procedures used by the company designating the Logistics 4.0 facet of Makios Logistics S.A..

The consulting project report closes with a conclusions section, where we are presenting the contribution of this thesis and we are referring to potential project restraints.

2. Literature review

In this chapter We are presenting the literature review findings on Industry 4.0. We are providing an introductory paragraph in order to set the foundations for Industry 4.0 and then we refer to Industry 4.0 in general before focusing on Logistics 4.0.

2.1. Introduction

Since the First Industrial Revolution, which was triggered and supported by the steam machine invention, a lot of changes, inventions and technological breakthroughs have appeared marking radical changes in the way industry operates. Below, in Figure 1, we provide a timeline of the four industrial revolutions along with the supporting technologies;

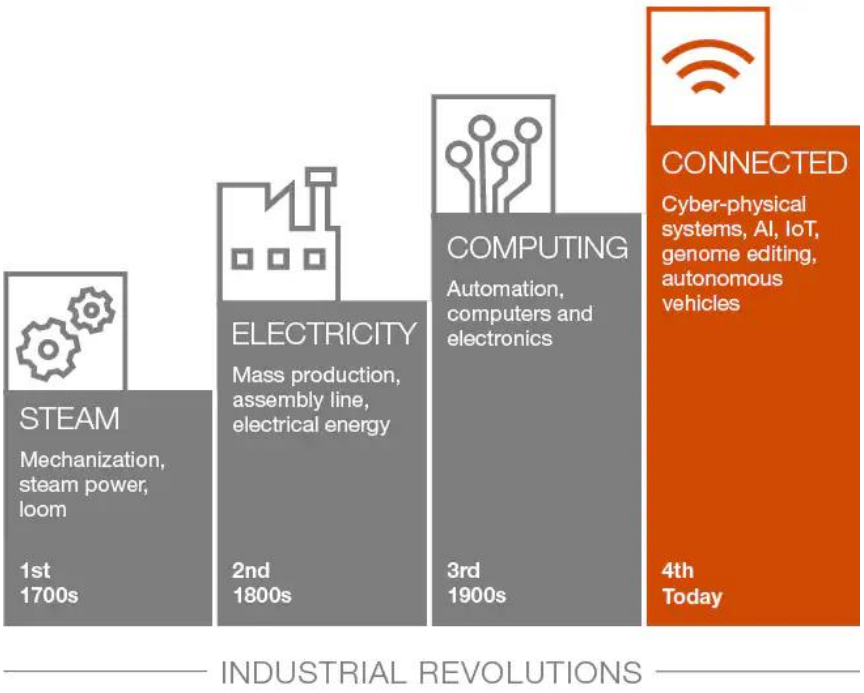

Figure 1: Industrial revolutions timeline (PwC, 2019)

The main reasons that triggered the Fourth Industrial Revolution are the need for transiting to a sustainable growth model, via operating resource efficiently, the need to meet the constantly increasing demand for goods, which mandates operating more effectively and cutting down production times and the radically changing consumer needs.

Thus, enormous technological breakthroughs such as 3D printers, cloud computing, IoT[1], IoS[2], smart devices, the Web 2.0, artificial intelligence, advances in the ICT[3] technology etc, provided the means for the Fourth Industrial Revolution. (Ustundag & Cevikcan, 2018), (PWC, 2016), (PwC, 2019)

2.2. Industry 4.0

Industry 4.0 stands for the Fourth Industrial Revolution, also referred to as 4IR. It was first proposed during the 2011 Hannover Messe trade fair in Germany by Professor Wolfgang Wahlster, Director and CEO of the German Research Center for Artificial Intelligence during his opening speech. (Lydon, 2014), (Qin, et al., 2016)

Industry 4.0 aims to achieve higher productivity and higher efficiency by incorporating automation into industries and by interconnecting the physical with the virtual world. According to many references, Industry 4.0 is considered as a Cyber Physical System of production, which is based on collecting heterogeneous data and rendering current manufacturing processes able to collaborate autonomously, by adapting IoT networks, consisting of interconnected sensors and actuators, and feeding data to a central processing centre where the technological breakthroughs in data analytics and Big Data, artificial intelligence, algorithms can process the data fetched from the physical world of an industry and create value out of it.

The processed data can drive automated manufacturing processes, control intelligent industrial robotics and facilitate maximizing the productivity and the efficiency of industries.

Industry 4.0 allows for machine to machine and machine to human communication and interaction, thanks to the above-mentioned sensors networks and promises to reshape factories into smart factories and render manufacturing smarter than ever in the past.

For a factory being capable of collecting data from every stage of a product's life cycle, Industry 4.0 will allow for taking the best decisions in order to maximize productivity,

[1] Internet of Things

[2] Internet of Services

[3] Information and communications technology

cut down producing times and increase efficiency and essentially turn to developing smart procedures, processes and products.

Finally, for current industries to encompass the Fourth Industrial Revolution, they do not have to turn only to digitalization of their manufacturing processes· gathering data from suppliers and customers, from the moment raw material is shipped and until goods are delivered to final customers will allow for holistic transition to Industry 4.0. (Alcácer & Cruz-Machado, 2019), (Baena, et al., 2017), (Hofmann & Rüsch, 2017), (Wagner, et al., 2017), (Weyer, et al., 2015),

Below, in Figure 2, we provide a framework for Industry 4.0 along with the supporting technologies, to which we will refer later in this chapter.

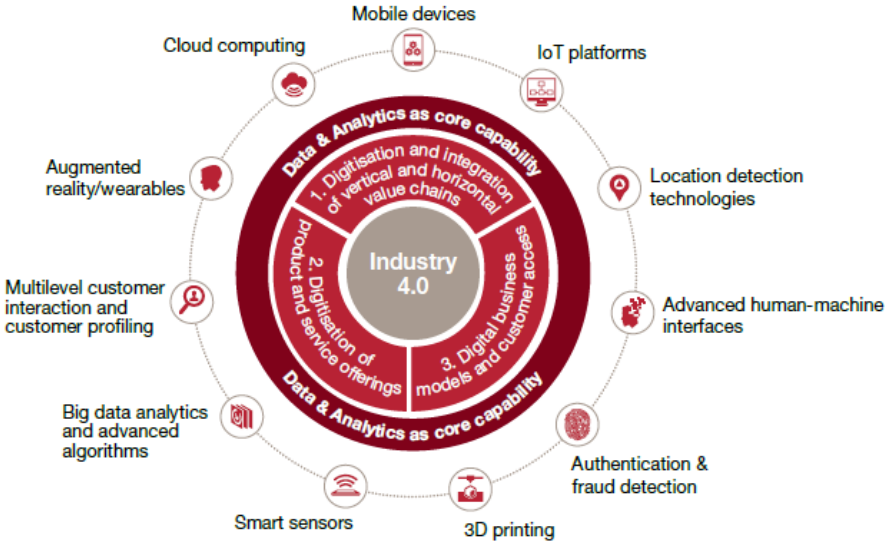

Figure 2: Industry 4.0 and underlying technologies (PWC, 2016)

Before focusing on Supply Chain 4.0 and Logistics 4.0 we will refer to the Reference Architecture Model for Industry 4.0, which serves for identifying the existing Standards applying to Industry and identify the gaps and potential overlaps between them in the direction of transiting to Industry 4.0.

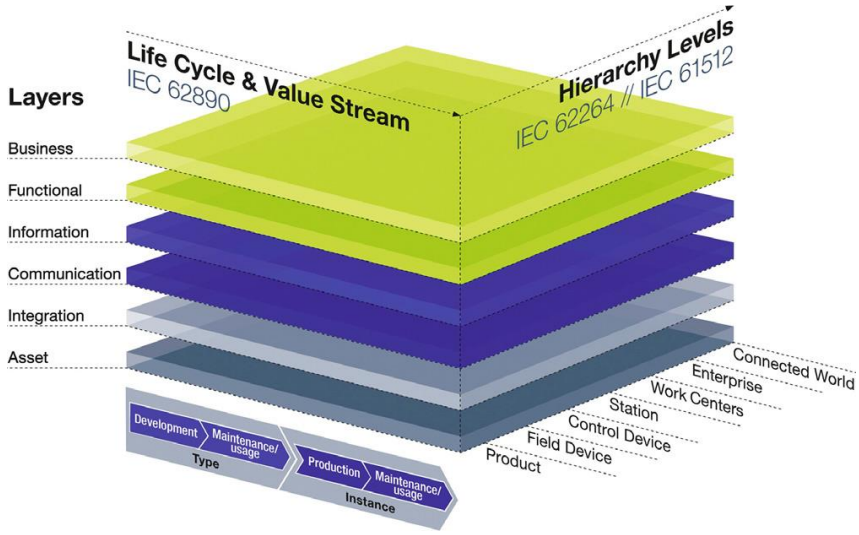

Figure 3: Reference Architecture Model for Industry 4.0 (ZVEI Die Elektroindustrie, 2015)

2.3. Supply chain 4.0

Over the last years, logistics has experienced a great change, shifting from a merely operational function which reported to sales, ensured that production lines were supplied with raw materials and goods were delivered to final customers to an independent function.

This change brought along sophisticated planning and routing processes relying on demand forecasting in order to simultaneously deliver the best possible services to its customers, inside an organization or outside organizations if referring to 3PL[4] services and achieve high efficiency. Actually, this shift has played a significant role in the growth of 3PL companies, which could assure optimum delivery of raw materials and goods at a lower cost than the cost induced by industries for investing in inhouse logistics.

The Fourth Industrial Revolution has disrupted the industrial world triggering the need to redesign the supply chains. For modern supply chains to meet the radically changing consumer needs, including increasing demand, need for products and services personalization, as well as the global move to decelerate the climate change, they need to become smarter, more efficient and more effective.

[4] Third part logistics

The digitalization of supply chains, presented in Figure 4, in the same rationale with factories digitalization under the concept of the Fourth Industrial Revolution, will play a catalytic role in meeting the above-mentioned needs.

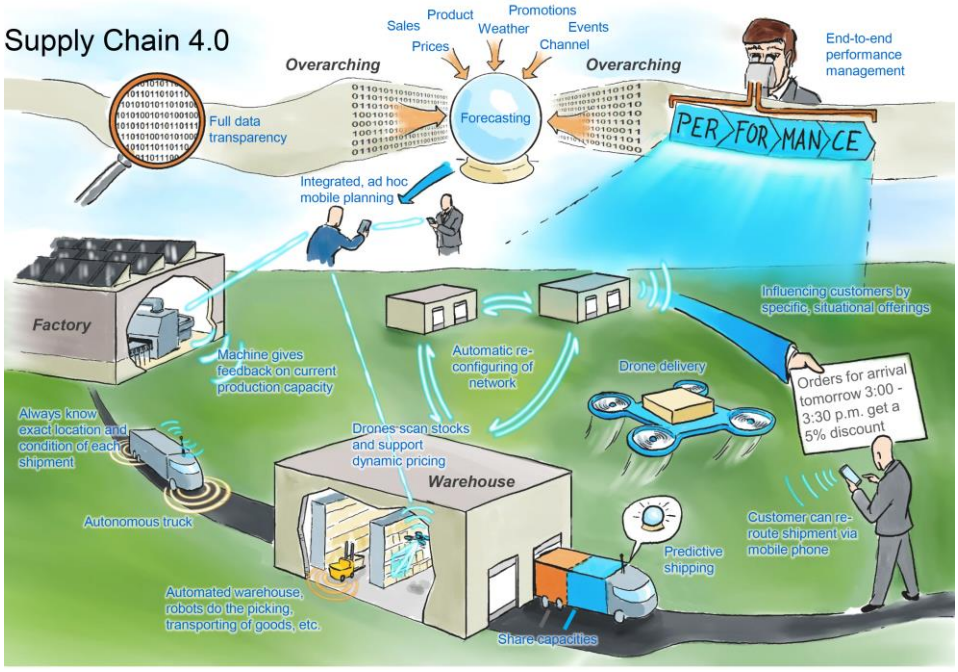

Figure 4: Supply Chain 4.0 (McKinsey & Company, 2016)

2.4. Logistics 4.0

Upon literature review, there are not many references for Logistics 4.0 exclusively. Therefore, we expect this consulting project to be a significant contribution to the concept of Logistics 4.0.

Logistics 4.0 is the evolution of Logistics following the Fourth Industrial Revolution, while referring to Logistics 4.0 is preferable in order to make a connection with Industry 4.0, since the supporting technologies are common. (Lasi, et al., 2014)

We define , Logistics 4.0 as the evolution of Logistics, under the context of the Fourth Industrial Revolution, which allows for sustainable logistics services provision, supports industrial growth and essentially financial growth with achieving maximum cost and operating efficiency thanks to digitalization and incorporation of smart technologies.

According to literature, Logistics 4.0 is the result of the current Logistics model transformation realized by turning to software instead of hardware. (Timm, et al., 2015)

According to another reference, Logistics 4.0 is the result of the combination of the existing logistics model with latest technological breakthroughs such as Cyber Physical Production Systems. (Barreto, et al., 2017)

Finally, we provide another, more focused definition, according to which Logistics 4.0 is a logistical system incorporating Big Data and Data Analytics, for optimum warehouse management, optimum routing planning, information flow along with goods throughout their life cycle in the logistics function and artificial knowledge based systems to optimize the decision making process for all the processes ran in the Logistics sector. (Strandhagen, et al., 2017)

Below, in Figure 5, we provide a framework for Logistics 4.0;

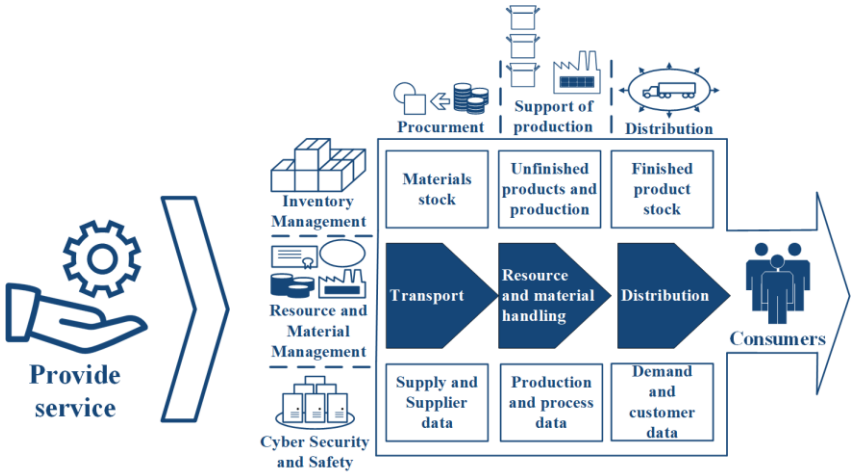

Figure 5: The framework of Logistics 4.0 (Kozma, et al., 2019)

2.5. Underlying technologies

As mentioned above, Logistics 4.0 is the equivalent of Industry 4.0, or smart factories, therefore, we could characterize Logistics 4.0 as smart logistics. Smart logistics is a close loop process which is described in stages below in Figure 6;

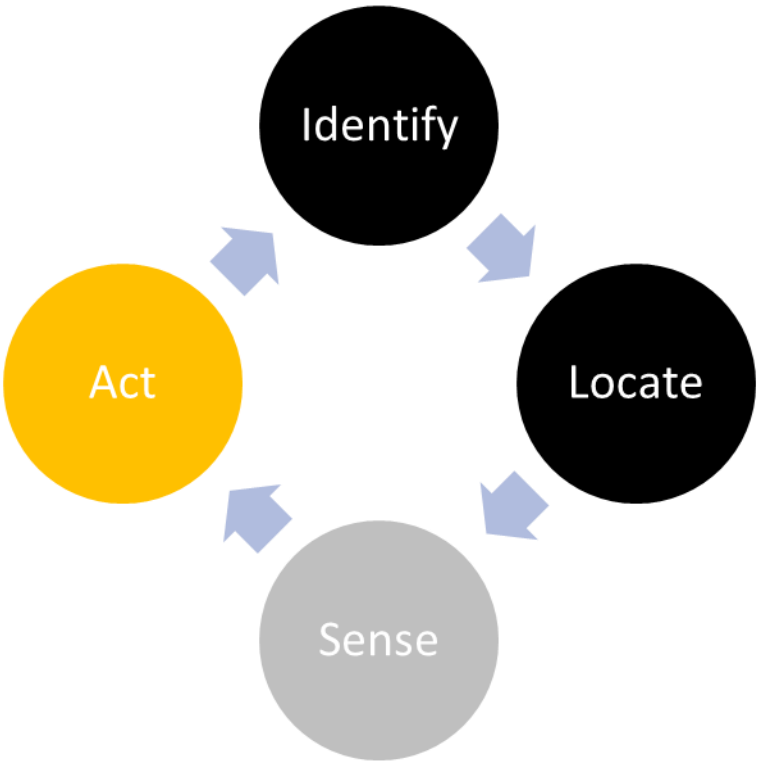

Figure 6: Logistics 4.0 is a close loop process

Further on, we are referring to the underlying technologies which are essential for doing smart logistics.

2.5.1. Sensors

Logistics are not only about storing or transporting goods, but it is crucial to deliver products in good conditions. Therefore, installing a network of sensors, like thermometers or humidity meters is important especially in case refrigerated, frozen or fresh goods are handled.

Moreover, for Logistics 4.0, it is essential that the sensors can communicate with a control center, in order to provide the necessary data for decision making. Taking decision making into consideration, under the context of Logistics 4.0, sensors are combined with actuators, which are devices controlled remotely by the control center in order to perform specific operations. For Logistics handling refrigerated goods, a typical operation controlled remotely is regulating a cooling chamber's temperature or humidity. (DOUAIOUI, et al., 2018)

2.5.2. Identification

Identifying goods is fundamental in Logistics 4.0, since identification is the bridge between the physical and the virtual world. Once a pallet is identified, a central control system can take decisions about its handling.

RFID is a very popular identification supporting technology. RFID stands for Radio Frequency Identification and it consists of a RFID tag attached on goods or pallets and a reader attached to a fork lifter or other carrying vehicle. Once the reader passes close by a RFID tag, it sends information about the product identified to a central control system.

RFID offers a more convenient, less time consuming and more reliable identification technique, which can facilitate eliminate inventory mistakes, than older ones likes RF terminals, where employees have to scan a tag attached on goods or pallets and send data to the central control system wirelessly. (Uckelmann, 2008)

2.5.3. Location awareness

Knowing the exact location of a pallet along with identifying the pallet itself is crucial for transiting to Logistics 4.0.

In case of goods inside a warehouse, there are two main technologies supporting location awareness;

- Triangulation of radio frequency signal
- Dividing a warehouse into sectors and subsectors and placing extra RFID or RF tags for correlating data from identification with the location tag

In case of goods being transported in trucks, the most favorable technologies are GPS and GPRS. Mounting a GPS or GPRS transmitter on trucks can provide the central control system with location data, along with other data that may be transmitted in case GPRS is selected. Such data may be collected by temperature or humidity sensors mounted on refrigerator trucks and facilitate monitoring the condition of refrigerated goods.

System integrating location awareness with goods identification are known as real time locating systems or RTLS shortly according to literature and consist a Logistics 4.0 fundamental supporting technology. (Uckelmann, 2008)

2.5.4. IoT

IoT enables Logistics firms to supervise every product inside their supply chain in real time. Apart from monitoring the products' location IoT allows for collecting and analyzing real time data which can feed other operations. For example, data collected from the warehouse or the transportations can provide feedback to cost calculating algorithms or forecasting models and assist in generating more accurate results. This in its turn can facilitate a Logistics 4.0 company meeting the market needs.

The IoT consists of an interconnected network of sensors, actuators and other devices which communicate towards every direction, mentioned above in paragraph 2.5.1, which are the medium for connecting the physical with the virtual world, and are therefore called Cyber Physical Systems.

IoT enables taking machine aided decisions and machine to machine communication. (Zhang, et al., 2018)

2.5.5. Data analytics

Logistics 4.0 implies collecting huge amounts of highly heterogeneous data. The heterogeneity is dependent on the physical attributes measured, which means that installing diversified sensors in a Logistics company will generate equality diverse data.

Apart from typical data such as location, product ID, temperature, humidity and delivery route, other kind of more complex data may be collected under the concept of Logistics 4.0. Such data may include real time images, X-ray images etc. used to ensure high quality of services.

Huge amounts of data mandate the deployment of Big Data Analytics, which are tools capable of handling complex databases consisting of trillions of data.

The successful analysis of data collected is a prerequisite for creating value through data, taking machine aided decisions and essentially transiting to Logistics 4.0. (Witkowski, 2017)

2.6. Advantages and disadvantages

Logistics 4.0 mainly have advantages, yet for the needs of this thesis we are presenting advantages, referring to the potential benefits a company could enjoy upon transiting to Logistics 4.0, and disadvantages referring to potential obstacles and increased capi-

tal needs for transiting to Logistics 4.0. Such obstacles may be both technical and organizational, since for example a company may not only need to invest to a new W.M.S.[5] software but they should also have to train their employees in order to operate it optimally.

Therefore, it is obvious that shifting to a Logistics 4.0 model successfully can return the money invested as fast as possible. Below, in Table 1 we are providing the Logistics 4.0 advantages and disadvantages upon reviewing the cited literature. (Barreto, et al., 2017), (Kolberg & Zühlke, 2015), (Lichtenthaler & Ernst, 2009), (Szymańska, et al., 2017)

Table 1: Logistics 4.0 advantages and disadvantages

Advantages	**Disadvantages**
Real-time supply chain monitoring, leading to increased flexibility	High investment costs
Real-time supply chain components communication	Potential need to replace partially or totally currently used hardware and software
Increased efficiency for all the supply chain processes	Need for employees training
Decreased throughput and lead times	Difficulty in integrating various software, in case of a company operating multiple subsidiaries
Holistic real (humans) and virtual (machines) world integration	Need to shift to a Lean approach
Increased data analysis capability, leading to better forecasting	
Decreased human mistaken decisions	
Every supply chain component can propose or take a decision	

2.7. Industry 4.0 maturity model

According to literature, some common restraints for an Industry to transit to the Industry 4.0 may include cultural or organizational incompatibilities, line of business inappropriateness or high implementation costs mainly related with the need for invest-

[5] Warehouse Management System

ing in new infrastructure, in technical equipment, software and hardware, along with the necessary costs for training. Such factors may render the transition unviable due to extra-long payback periods.

In this paragraph we are presenting our literature review findings on Industry 4.0 maturity models, which serve as a tool for evaluating a company suitability for transitioning to Industry 4.0. Later, in the Analysis chapter we are presenting the results from an Industry 4.0 maturity questionnaire distributed to the company's top and middle management. The questionnaire was based on the literature review findings cited in this paragraph upon considering the Makios Logistics scope of business.

Following other high cost technological breakthroughs, the Fourth Industrial Revolution and its underlying technologies do not spread at lightning speeds. Firms have to follow a specific course of actions in order to integrate all the underlying technologies of the Industry 4.0 and take advantage of it respectively.

There are many references for the term "Industry 4.0 maturity model" which all evaluate a company's readiness for transiting to Industry 4.0 on different dimensions, to which we are referring shortly below. Under the context of this consulting project we are examining the Logistics 4.0 maturity. (Nagy, et al., 2018), (Schumacher, et al., 2016), (Schumacher, et al., 2016), (Schuh, et al., 2017), (Ustundag & Cevikcan, 2018, pp. 67-74)

The organizational strategy should be favoring the transition to Logistics 4.0, by adopting a suitable business model and allocating sufficient resources, mainly financial ones, towards investing in implementing the above mentioned Logistics 4.0 underlying technologies.

The organizational culture should incorporate knowledge sharing, while the organization should be innovation driven, eager for continuous change and with high awareness of the value of ICT technology.

As far as the employees are concerned, they should be highly ICT[6] capable, according to the positions they hold, and they should be receptive to change. We must point out the Human Recourses Department responsibility to take action in order to render the

[6] Information and communications technology

employees receptive to change and in order to provide them the necessary ICT training.

The organizations' operations should include decentralized processes and should be based on different departments digital collaboration.

As far as the products and the customers are concerned, the products should be digitalized, generating data throughout their journey in the Logistics chain, while the customers should feed the organization with data in order to allow for services individualization and essentially facilitate value creation through data.

For the context of this consulting project we have taken into consideration three main dimensions; management decisions favouring the transition to Logistics 4.0, data flow through products handling in every stage of their life cycle within the 3PL services provided and value creation through processing the acquired data.

The latter consists of a two concepts; potential for value creation through data and ability to create value through data.

2.8. Roadmap towards transiting to Logistics 4.0

According to a PWC report on Industry 4.0, the roadmap presented in Figure 7 for transiting to Industry 4.0 is proposed.

Figure 7: Blueprint for Industry 4.0 transiting (PWC, 2016)

According to the PWC report, a company should follow some consecutive steps to transform integrating the Fourth Industrial Revolution. Desiging an Industry 4.0 strategy can be done by evaluating the current digital maturity and by prioriting the

measures needed to improve in terms of digital maturity.
The measures prioritarization can be made on a basis of defining the desired capabilities from a transition to Industry 4.0. Apart from improving the “hard” digital maturity, a company should invest in data analytics tools and acquire a significant level of expertise in order to maximize the benefits of the transition.
The proposed roadmap can result in a succesfull Industry 4.0 transition, where under the new situation context the company will be totally digitalized and will be taking decisions based on data analysis to effectively reduce operating costs, increase all operations’ efficiency and utterly create value out of data.

3. The Makios Logistics S.A. company

In this chapter we are presenting the Makios Logistics S.A. company. We are first providing essential information about the company, their history, vision, and then we are referring to their operations with an eye for the operations we are tackling in the context of this consulting project.

3.1. Company presentation

Makios Logistics S.A. is a family business established in 1927. The company is head-quartered close to the Thessaloniki port and is an integrated logistics services provider. They operate two Logistic Centers in the broad area of Thessaloniki, and they provide a wide range of integrated logistics services, ranking in the top three 3PL companies in Greece and first in handling refrigerated and frozen goods. They deliver goods all over the Balkans, apart from Greece via trucks and rail freight.

Makios Logistics S.A. is a market leader in Greece, while they are investing intensely in innovative, mostly IT, solutions and efficient assets in order to maintain their leading position. Their competitive advantage derives both from the variety of services provid-ed and by their high quality.

Their vision is to provide their clients state of the art services based on a dual customer and quality-oriented culture. Below we are providing some key facts and figures about the company;

The company provides three main services;

- warehousing
- packed goods transportation
- bulk and liquid goods transportation

They have a total of 20.000 pallets warehouse capacity for refrigerated and frozen goods and a 30.000 pallets warehouse capacity for dry goods.

For dry and refrigerated or frozen goods transportation, they have a 110 refrigerated trucks fleet, while for liquid goods and powders transportation they have a 40 powder silo trucks fleet and a 100 liquid foods truck fleet. Moreover, they provide cow milk

collection and transportation services with a 60 milk pick-up trucks fleet, having gained an astonishing 40% collection of cow milk produced in Greece.

Apart from the three main services mentioned above they also provide customs clearance services, container handling services in the port of Thessaloniki, cross-docking services.

3.2. Milestones

In *1927*, the company was initially established in Kavala as a tobacco transportation services provider.

In *1975*, they signed their first agreement with Nestle Hellas, taking over the transportation and warehousing of liquid foods and packed foods for Nestle.

In *1977* the company was renamed to Makios S.A. in Thessaloniki.

In *1988*, upon a European Union funding, they constructed their state of art warehouse facilities in Kalochori Thessaloniki.

From *1999* to *2004* the company invested in their facilities in Kalochori, Thessaloniki reaching 15.000 pallets capacity for refrigerated or frozen goods and 20.000 pallets capacity for dry goods. Moreover, they invested in expanding their trucks fleet.

The Intermodal Logistics Center in Gefyra, Thessaloniki, was constructed in *2007*. The company was granted with a permit to handle rail cargo at the Gefyra facility which is adjacent to the railway. (Makios S.A., 2019)

3.3. The growth vision

In this paragraph we are presenting the vision of Makios Logistics S.A. for rendering Greece and Thessaloniki an important hub for the Eastern Europe and Balkans. All the information has been extracted from the company's Deputy Managing Director, Mr. Thrasyvoulos Makios, speech during the 14th Aristoteles conference "Greece as a 21st century hub" held by the Hellenic Management Association in November 2018. (Livemedia, 2018)

Mr. Thrasyvoulos Makios perception about innovation is "To be able to invest thinking out of the box", which reflects the company's perception about innovation. According to his words, in the above-mentioned conference, if we had to divide Europe in half, in terms of geographical area, we could draw a line from the eastern borders of Germany

down to Slovenia and Italy. This line would leave around 200 million of population to the east, almost equal to half the European Union population, not counting the population of Russia.

Other countries, like Italy and Slovenia, have realized this fact much earlier and have followed a strategy for shipping products from the Koper port in Slovenia and the Trieste port in Italy toward the area described above.

Thessaloniki compared to the above-mentioned ports can supply the eastern Europe as well as the main Balkan cities much faster, since the distance to these markets is essentially smaller, taking for example the distance from Thessaloniki to Sofia and Bucharest.

On the other hand, Thessaloniki is in a much stronger geopolitical position compared to the ports of the Black Sea, since crossing the Bosporus Strait comes along not only with added costs but also with added time.

Shipping products in our area mainly commences from container vessels arriving from the East, like China, to European ports, then reloaded onto trucks or freight trains and then forwarded to each separate market.

The privatization of the Thessaloniki port and of the railway is very promising and moves in the direction of following the above-mentioned vision of Mr. Thrasyvoulos Makios, which summarizes below;

“Make Greece and Thessaloniki an international logistics center for Eastern Europe, playing the same role that Netherlands and Rotterdam play for Western Europe. Greece has the opportunity to put their geopolitical stamp on the 21st century following this vision.”

4. Analysis and outcomes

In this chapter we are examining whether the company is suitable for transiting to a Logistics 4.0 model, in three major pylons; infrastructure, operations and organizational culture.

Firstly, we are evaluating the company's maturity to transit to Logistics 4.0 and secondly we are examining the company infrastructure and operations in order to evaluate whether their are consisive with Logistics 4.0.

While gathering data from the company supervisor for this consulting project, it was increasingly evident that the company is on an Industry 4.0 track. Therefore, we have defined the parameters in Figure 8 as indicators of Logistics 4.0 implementation;

Figure 8: Logistics 4.0 parameters; the Makios Logistics Case

4.1. Maturity evaluation

Previously, in chapter 2, we have referred to the Logistics 4.0 maturity model. Under the concept of this consulting project, we have distributed an 11-questions questionnaire to the company's top and middle management. Below, we are providing the results from the statistical analysis of this questionnaire.

First of all, the respondents are not highly familiar with Industry 4.0 according to their answers, as depicted in Chart 1;

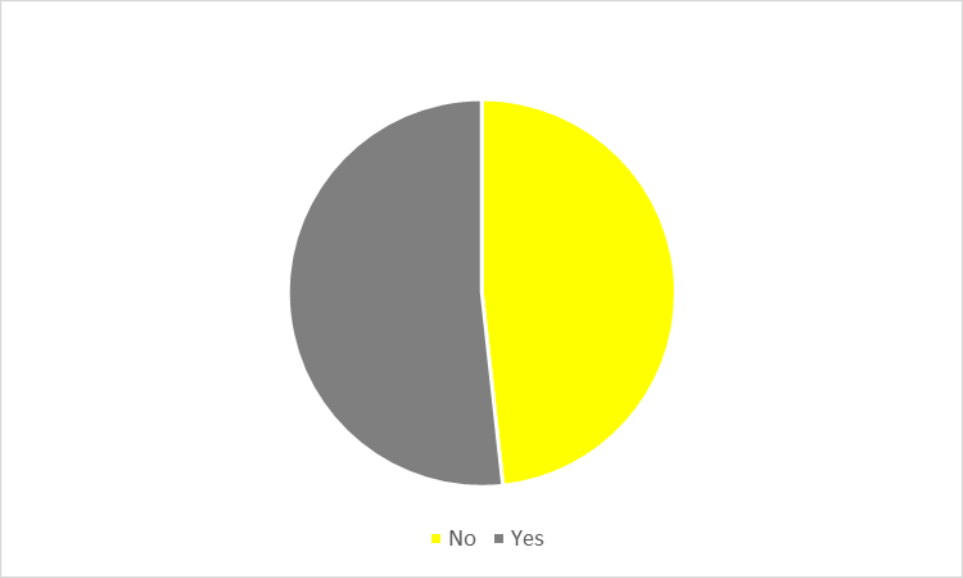

Chart 1: Are you familiar with the 4th Industrial Revolution, often referred to as Industry 4.0, or some concepts that govern it?

Moreover, we found that analyzing data collected from various components of the business model, such as customers, products, fleet and facilities, is highly important for the company, as depicted below in Table 2. More specifically, a cumulative 72,4% responded that the usage and analysis of data collected is at least quite important.

Table 2: How important is the usage and analysis of data collected from products, customers, facilities and fleet?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Of little importance	1	3,4	3,4	3,4
	Just important	7	24,1	24,1	27,6
	Quite important	7	24,1	24,1	51,7
	Very important	14	48,3	48,3	100,0
	Total	29	100,0	100,0	

As far as the pricing system, the majority of the respondents, scoring 41,4% as shown below in Table 3, consider it to be quite dynamic and customer tailored, since the pricing is mostly based on calculating the actual cost for handling goods. This percentage is reasonable, since during high rush seasons, actual handling costs increase due to waiting times to load and unload.

Table 3: How dynamic and customer-tailored is your pricing system? (do you charge flat per customer or do you charge per capability to provide your services)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A little	2	6,9	6,9	6,9
	Quite	12	41,4	41,4	48,3
	Quite a lot	7	24,1	24,1	72,4
	Very much	8	27,6	27,6	100,0
	Total	29	100,0	100,0	

As far as the value creation from data collection and analysis, 51,7% of the respondents believe that the company is highly to very highly capable of creating value through data, as shown below in Table 4;

Table 4: How would you rate your capability to create value from data? (collected from customers, products, facilities, equipment etc.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low	2	6,9	6,9	6,9
	Low	4	13,8	13,8	20,7
	Medium	8	27,6	27,6	48,3
	High	8	27,6	27,6	75,9
	Very high	7	24,1	24,1	100,0
	Total	29	100,0	100,0	

Accordingly, 62% of the respondents stated that the digital features integrated in products handled and services offered is contributing highly to very highly to the overall value creation, as shown below in

Table 5: How would you rate the contribution of digital features, products & services to the overall value creation of your portfolio?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low	1	3,4	3,4	3,4
	Low	3	10,3	10,3	13,8
	Medium	7	24,1	24,1	37,9
	High	11	37,9	37,9	75,9
	Very high	7	24,1	24,1	100,0
	Total	29	100,0	100,0	

As far as the company capability and the resources spent towards automation and machine taken or aided decisions, 88,3% of the respondents answered that they are medium to very highly capable towards that direction, as shown below in Table 6;

Table 6: How would you rate your capabilities and resources spent towards automation and machine aided decisions or machine taken decisions in your organization?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low	2	6,9	6,9	6,9
	Low	3	10,3	10,3	17,2
	Medium	10	34,5	34,5	51,7
	High	8	27,6	27,6	79,3
	Very high	6	20,7	20,7	100,0
	Total	29	100,0	100,0	

As far as vertical and horizontal value chain digitalization is concerned, the responses show that both are highly to very highly digitalized, as shown below in Chart 2 and Chart 3.

Yet, in order to make a comparison between the two value chains we present some aggregated data below in Table 7, which suggest that the average cumulative percent for respondents stating high or very is 60,35%, with 42,1% representing the vertical value chain.

Table 7: Vertical and horizontal value chain digitalization

		How would you rate the degree of digitization of your horizontal value chain? [%]	How would you rate the degree of the digitization of your vertical value chain? [%]
Valid	Low	10,3	10,3
	Medium	31,0	27,6
	High	20,7	20,7
	Very high	37,9	41,4
	Total	100,0	100,0

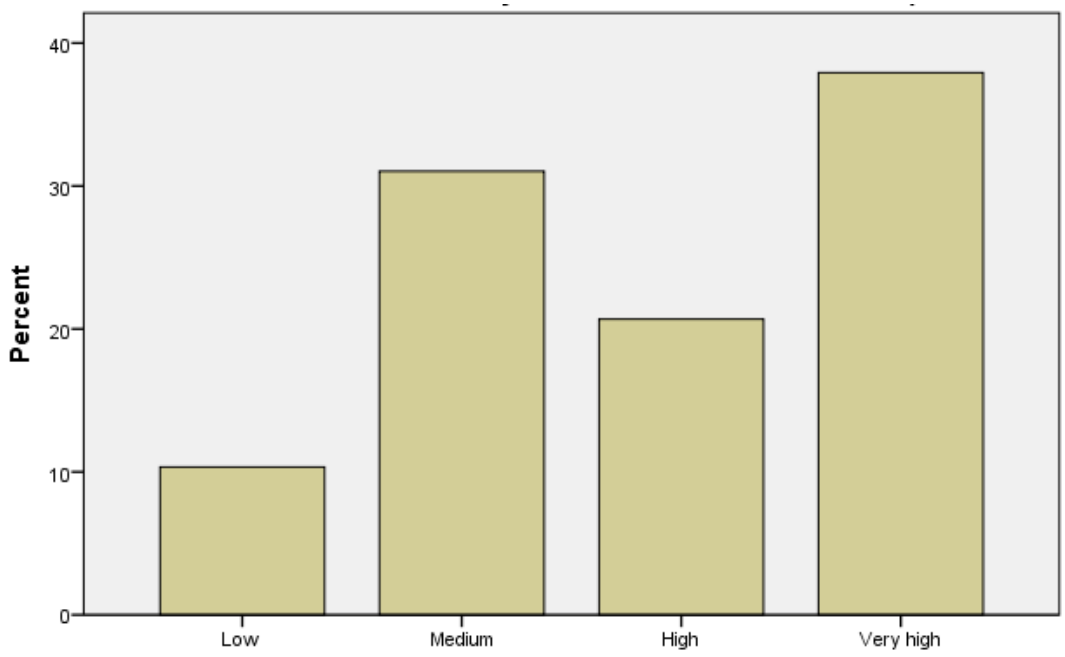

Chart 2: How would you rate the degree of digitization of your horizontal value chain? (from customer orders to routing and warehousing management – if customers ERP is interconnected with your software tend to score a 5)

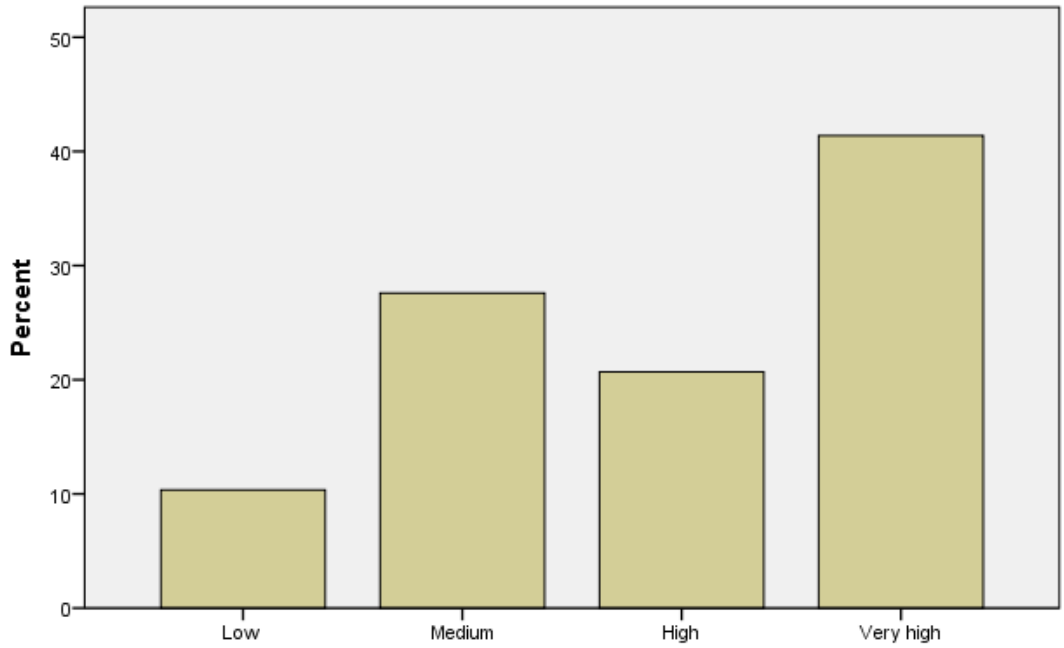

Chart 3: How would you rate the degree of the digitization of your vertical value chain? (from routing to forecasting – if different departments use the same software or interconnected software tend to score a 5)

As far as data acquisition means evaluation, we have posed questions 3 and 7 in order to examine the usage of sensors or sensors networks, IoT, digital monitoring of the equipment operation etc.

As shown below, in Chart 4, we have collected no answers stating very low or low digitalization, while almost 90% of the respondents stated that the company used advanced digitalization means in their equipment to monitor the products handled and services provided.

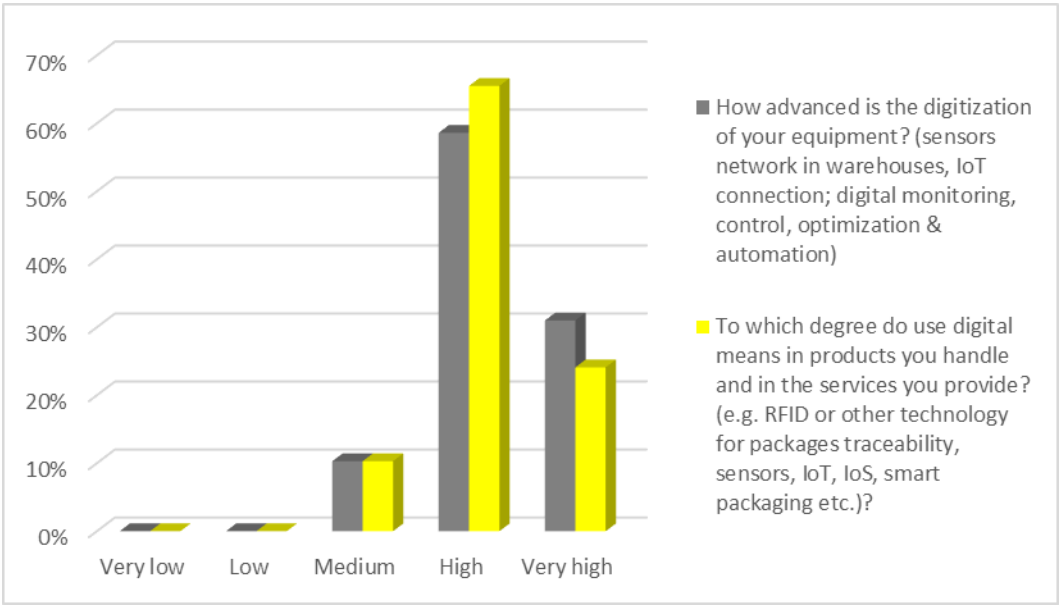

Chart 4: Degree of equipment digitalization

Moreover, these questions are asking the same question upon rephrasing, which was intended in order to evaluate whether the respondents provided conscious answers via the Cronbach's alpha measure.

Table 8: Reliability Statistics – Cronbach's Alpha Measure

Cronbach's Alpha	N of Items
,758	2

The 0,758 Cronbach's Alpha indicates high data reliability, which we could already diagnose judging on Chart 4.

Finally, we are providing the answers regarding the company's ability to have a real time view on their warehouses' capacity. Given the fact that we have already collected answers indicating the presence of digital means, such as sensors networks to monitor products location, we expect highly positive answers.

In fact, as shown below, in Chart 5, 83% of the respondents stated that the company has a real time view on the warehouses' capacity, while the remaining 17% stated that they do not have a good picture at all. The latter may be justified by respondents experiences of products stored without scanning or potential system breakdowns which

lead to crucial inventory inaccuracies, since the installed RF systems allow for scanning all the goods stored and feeding the WMS system with real time data.

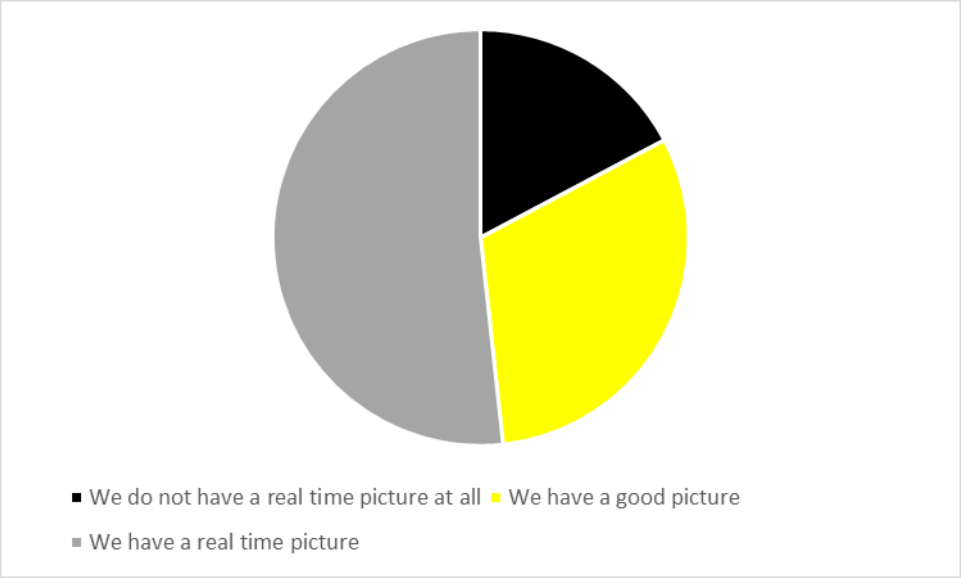

Chart 5: To which extent do you have a real-time view on your warehouse capacity?

Conclusively, Makios Logistics seems to have made important step towards transiting to Logistics 4.0, according to the maturity model questionnaire analysis. We mention some critical points out of this questionnaire;

- 52% of the top and middle management are aware of the fourth Industrial Revolution
- 72,4% recognize the importance of collecting and analysing data from products and procedures
- 83% stated that they have a good or real time picture of the warehouses' capacity
- 52% believe that the company is very to highly capable of creating value through data
- 62% believe that digitalizing the company's operations contributes highly to very highly to the overall value creation capability

4.2. Packages identification

The company is using RF terminals in order to scan products in their warehouses. Every pallet entering the warehouse is scanned and the data is sent to the WMS. Moreover,

pallets are scanned again when loaded onto trucks, facilitating tracing goods throughout their life cycle.

Yet, according to the Deputy Managing Director, investing on RFID is yet unaffordable, since the expected benefits render such an investment unviable, not if examined solely, but taking into account the company's cost efficiency plan.

We will refer to this cost efficiency strategy at the end of chapter 4, but at this point we can mention that investing on RFID technology would render the company uncompetitive, given not only the intense competition in their sector but also the fact that their main competitors have not invested in such technology yet.

4.3. Packages traceability

In this paragraph we are referring to means used for tracing packages inside the warehouses. As mentioned in the previous paragraph, every pallet entering or exiting the warehouse is scanned via mobile RF terminals. Moreover, employees scan RF tags placed in different sectors of the warehouses. The data generated is sent to the WMS and ERP system and includes location information apart from information about the stored good. This enables the company ability to have a real time view on the warehouse capacity and on the actual location of stored goods.

As far as goods being transported are concerned we are providing information below, in Paragraph 4.4;

4.4. Trucks fleet telematics

The company has installed a telematics system based on GPRS technology which monitors the trucks location and sends data to a central management system in the company headquarters in Kalochori.

This system gathers data about routes, mileage as well as temperature and humidity for refrigerator trucks. This enables monitoring the condition of the goods transported and delivering high quality services.

Moreover, every pallet is scanned by RF terminals when loaded onto trucks and then again scanned via smartphones and PDAs the drivers carry on them. All this data is fed back to the ERP and WMS system which is always aware of the location of goods.

Moreover, this data enables calculating the actual cost of each transport, since the goods have been traced throughout their life cycle in Makios Logistics.

We are going to mention more information below, in paragraph 4.6 where we are presenting the company's cost efficiency strategy.

Apart from the previously installed telematics system, the company has taken on the SUITS project, which is a Supporting Urban Integrated Transport Systems project, co-funded by the European Union. The project is part of the E.U. Civitas 2020 project with aims to shift to a sustainable urban transport model both for people and freight. (Civitas.eu, 2017)

Under the SUITS project, the company has installed the e-TRACK system in a total of 16 trucks delivering goods in the area of Kalamaria, Thessaloniki. Makios Logistics have contributed significantly to the Civitas 2020 project. They have been collecting and analysing telematics data from frigo trucks delivering goods in the district of Kalamaria. Moreover, they have interconnected their e-track system with a traffic management system running in a pilot mode in Kalamaria. This has allowed Makios tracks featuring the e-Track system access to traffic data and optimum route planning, while the traffic management system is fed with data about preplanned routes in advance.

In Figure 9 we provide the three main e-track operations and in Figure 10 we provide a screenshot from the e-Track user interface.

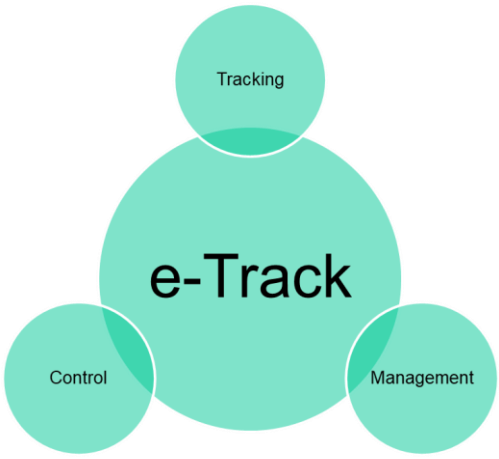

Figure 9: e-Track operations

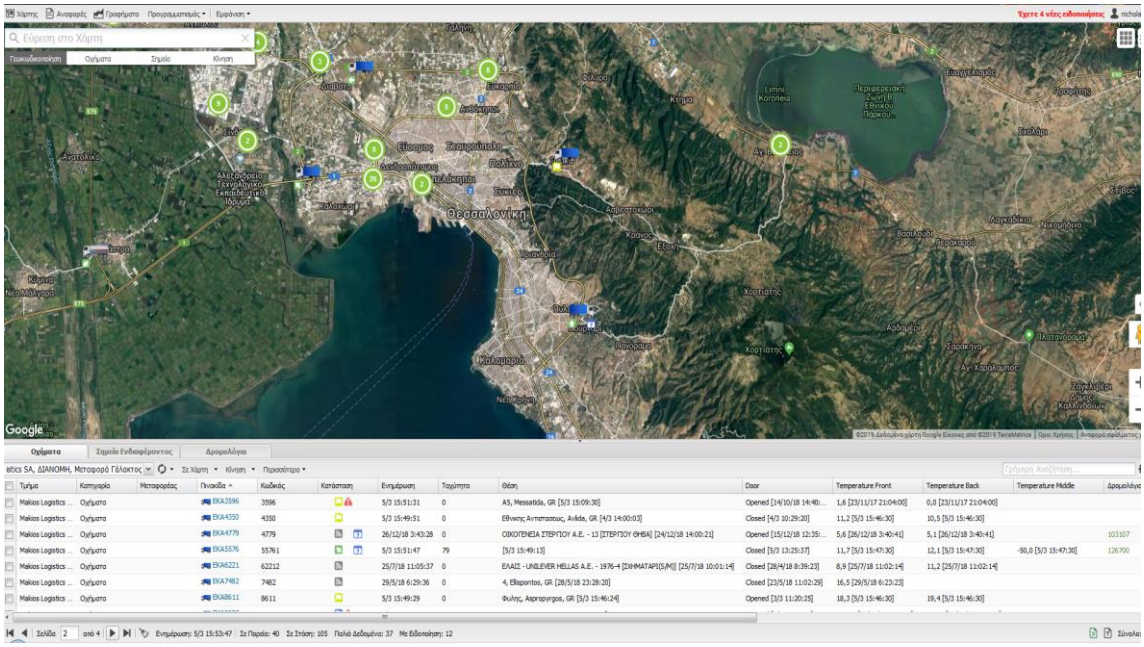

Figure 10: Screenshot from the e-Track interface

4.5. SCADA systems

SCADA systems are widely used, mainly abroad, in industry as means of reducing operational costs. We will refer shortly to SCADA systems in this paragraph, but we have to point out that these are powerful systems for industrial operational costs management since they provide industries with technical systems stability, flexibility and faults tolerance. (Sajid, et al., 2016)

They have installed a SCADA[7] system so as to monitor the energy spent as well as the cooling chambers operating conditions in real time. SCADA are sophisticated systems gathering data from the installed equipment.

In terms of energy spent, they have installed smart energy meters in every electrical substation feeding cooling chambers. All the data is transmitted wirelessly to the SCADA control center.

In terms of cooling chambers operation, the SCADA system is gathering data from the cooling chamber control units (PLCs[8]). Every cooling chamber consists of machines, mainly pumps, compressors and ventilators. Every machine is controlled by a central PLC unit where the machines' real time parameters, such as turns per minute, pres-

[7] Supervisory Control and Data Acquisition

[8] programmable logic controllers

sure, energy consumption etc., are monitored. In order for the main control unit to be able to regulate the cooling chamber temperature, other data such as chamber temperature and humidity, doors opening etc, is monitored by wired sensors located inside the chambers as well as mounted on cooling chambers' doors.

All this data is transmitted to the SCADA control centre, where it is processed and fed to a graphic user interface (GUI). The Technical Department has access to this GUI via the department's employees' computers as well as via their smartphones.

The SCADA system is not only providing the Technical Department with information, but it actually establishes a bidirectional communication with the cooling chambers. The employees can turn on or off machines remotely as well as alter their operating conditions without having to visit the machine rooms.

The SCADA system provides a real time report about the cooling chambers operation, alerting the company's engineers and maintenance staff in case of breakdown, not only during working hours but 24/7 365 days per year. In case the personnel working in a shift cannot resolve a complicated breakdown the Department's chief can intervene remotely since the system sends alarms in the Department's personnel smartphones.

4.6. Cost efficiency

The above-mentioned practices have facilitated the firm's cost of services calculation methods. Actually, Makios Logistics is proud about the ability to calculate the services provided costs accurately, which has been catalytic for the company to gain a competitive advantage in the 3PL sector in Greece.

Being able to know where every single package is throughout its life cycle within the 3PL services provision, the firm can allocate all the costs induced by resources spent for each package being served.

More specifically they gather data about the time each package has been stored in their warehouses, about the mileage required for its transportation to its final destination, time spent for each transportation to be routed, invoiced, loaded and unloaded etc.

Upon processing the time spent per department they relate it to salaries, fuel spent by trucks, taxes and other administrative costs.

The company's picture up to the point described above is very useful yet, not taking into account a very significant variable· energy spent.

As mentioned above, the company has installed a SCADA system which not only monitors the equipment, mainly cooling chambers operation, but it also monitors the energy spent in real time.

This allows for the company to add up the costs for energy spent, mainly electricity, which is rather high, but also costs for reactive cooling chambers' maintenance. Finally, they take into account costs for proactive maintenance to build up the whole picture.

The final result is in form of cost per minute per pallet space, including all the costs mentioned above.

4.7. A roadmap for Makios Logistics S.A. transition to Logistics 4.0

Before proceeding with the provision of a roadmap for Makios Logistics to Logistics 4.0, we sum up our findings;

- the results of the Logistcs 4.0 maturity indicate that the company is on right track towards Logistics 4.0
- the company has adopted many of the Logistics 4.0 supporting technologies

As far as the organizational culture and the management position towards Logistics 4.0 realization are concerned, we found an innovation driven culture and a strategy towards creating value from data. In Makios Logistics they are highly aware of the benefits and the value creation potential from automation and digitalization. Yet, the top and middle level managers seemed to not be highly aware of Industry 4.0.

Towards, this direction the company should provide some insights to the employees regarding Industry 4.0, in order make them more passionate about collecting data and creating value out of it.

As far as their infrastructure is concerned, they are already featuring most of the Logistics 4.0 supporting technologies. Yet, they have not invested on two major supporting technologies; cloud computing and RFID. Currently the data is transmitted to their server which is located in the company headquarters.

Data is flowing bidirectionally from the physical to the virtual space, thanks to the installed sensors networks, SCADA system, GPS based telematics system installed on their trucks fleet.

More specifically, they have already digitalized the data flow channels gathering data from products handled, trucks fleet, customers and technical equipment. Their ERP, WMS and routing software are inteconnected, composing a holistic picture over the whole company system.

However, some of the applied technologies substitution by other more sophisticated ones, such as shifting from barcode labels to RFIDs mounted on pallets may generate more valuable data.

Moreover, bringing more automation in the orders placement procedure, by interconnecting all the customers ordering software with the Makios Logistics ERP will add up to the system's efficiency further.

Investing further in data analytics will facilitate the company take a step further and adopt systems capable of taking automatic decisions about routing planning and warehouse management.

The company is currently using machine aided decision systems, since their routing software is fed with real time data about the warehouses free capacity, the planned transportations, loadings and unloadings, as well as about the trucks current location and expected direction.

Towards these directions, investing on cloud computing could assist them achieve even faster data acquisition and proccessing, while it would augment the data integrity and security. However, investing on RFID is not a top priority for the firm as mentioned above in paragraph 4.6.

All in all, the company has already taken a lot of steps towards digitalization and towards Logistics 4.0. We could characterize Makios Logistics on the verge of a Logistics 4.0 model. Following the proposed roadmap, the company is expected to transit to Logistics 4.0 succesfully.

4.8. Benefits from transiting to Logistics 4.0

We were not able to have access to actual business data, due to legislation regarding the protection of personal data to which the company adheres. However, having

captured a broad picture about the way Makios Logistics is running we are concluding that transiting to Logistics 4.0 will create significant benefits.

The cost-efficiency strategy which is already implemented is expected to become more efficient, since more data will be collected and processed faster. This can play a catalytic role in maintaing the company's competitive advantage and generate room for increased income.

Given the fact that the company is client oriented, devoted to providing state of the art logistics services, the transition to Logistics 4.0 will act in favor of providing high quality services, by further improving the quality of services, cutting down delivery times and maintaining clients' good in even better conditions.

Contribution and project constraints

Having reached the end of this consulting project we conclude that we have successfully provided the essential knowledge about Industry 4.0 and Logistics 4.0. Upon this provision, we recognize the fourth Industrial Revolution value not only for maintaining a constant growth track but also for making a turn to sustainable growth.

Undoubtedly, the technological breakthroughs in other fields have facilitated the Industry 4.0 become a reality, but this was the case for previous Industrial Revolutions.

The benefits for the Logistics sector are significant, especially in terms of meeting the demands of the rapidly changing global market. In that direction, we expect Greece, Thessaloniki and the Makios Logistics S.A. to take advantage of these benefits if a turn to Logistics 4.0 is to take place.

The company is already in a digitalization track, demonstrating awareness about the opportunities created via digitalization, automation, data collection and other Logistics 4.0 technologies. The company is already implementing methods for live tracing goods stored in their warehouses and for live tracking their truck fleet, while they are already analyzing this data in order to accurately calculate the services provided costs and conduct reliable demand forecasting.

The potential investment in other Logistics 4.0 components and the synergistic operation of all these components is expected to render the Makios Logistics S.A. a Logistics 4.0 adopter.

Closing, we must comment on two main project constraints; the difficulty of getting primary data due to personal data protection legislation and the sample size for our maturity assessment model, which was intentionally selected. In case more employees, like workers were to answer the questionnaire, we would definitely get a bigger picture of the company's Logistics 4.0 maturity but with less statistical power, given the fact that the organizational structure of the company is rather simple.

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Appendix I

Logistics 4.0 maturity assessment questionnaire

This questionnaire is distributed in the context of writing my thesis - Consulting Project for the MSc in Management at the International Hellenic University (I.H.U.). The consulting project is titled "Industry 4.0 and Supply Chain 4.0; A roadmap for Makios Logistics S.A. transition to Logistics 4.0 ".

Thanks in advance for your time.

Except for the first question, you are required to score from 1 to 5 by 1 indicating absolute disagreement or low rating and 5 indicating absolute agreement or high rating.

1. Are you familiar with the 4th Industrial Revolution, often referred to as Industry 4.0, or some concepts that govern it?
2. How would you rate the contribution of digital features, products & services to the overall value creation of your portfolio?
3. To which degree do use digital means in products you handle and in the services you provide? (e.g. RFID or other technology for packages traceability, sensors, IoT, IoS, smart packaging etc.)?
4. How important is the usage and analysis of data collected from products, customers, facilities and fleet?
5. How dynamic and customer-tailored is your pricing system? (do you charge flat per customer or do you charge per capability to provide your services)
6. To which extent do you have a real-time view on your warehouse capacity?
7. How advanced is the digitization of your equipment? (sensors network in warehouses, IoT connection; digital monitoring, control, optimization & automation)

8. How would you rate the degree of digitization of your horizontal value chain? (from customer orders to routing and warehousing management – if customers ERP is interconnected with your software tend to score a 5)
9. How would you rate the degree of the digitization of your vertical value chain? (from routing to forecasting – if different departments use the same software or interconnected software tend to score a 5)
10. How would you rate your capability to create value from data? (collected from customers, products, facilities, equipment etc.)
11. How would you rate your capabilities and resources spent towards automation and machine aided decisions or machine taken decisions in your organization?

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