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CONTENTS

TRANSFORMABLE DECENTRAL PRODUCTION FOR LOCAL ECONOMIES WITH BIO-BASED RESOURCES

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Abstract: *The process industry is currently highly dependent on fossil resources which poses serious challenges for different sectors like transportation and power generation as well as raw materials for commodities. As fossil resources are limited and global warming is imminent, the minimization of CO_2 emissions and utilization of alternative feedstock with bio-based resources is indispensable for the process industry. This reduction of the carbon footprint by renewable resources leads to new challenges from accompanying changes of the availability, type, amount and location of these. At the same time, rapid innovation for fine and specialty chemicals is accompanied by shorter product life cycles leading to an increase in market volatility. The resulting uncertainty of demand in terms of product type, volume and location needs to be addressed by production systems accordingly. Transformable production concepts based on modular apparatuses offer the necessary additional flexibility to meet market demand and to handle the occurring challenges from renewable resources. These production facilities can be opened, closed or relocated as the modular production and logistics units are installed in transportable ISO containers. Furthermore, production volume and type is adaptable to market demand and resource availability via change of process modules. This results in an increased flexibility of the production network and supply chain compared to centralized production with large-scale plants. Additionally, local economies for supply and demand can be quickly established to minimize transport distances and greenhouse gas emissions. Hence, this work combines named concepts with a system approach consisting of five elements minimizing the carbon footprint: transformable production systems, local bio-based resources, CO_2 as feedstock, renewable energy and decentralized production networks with local economies. Concluding, suitable use cases on the basis of these five elements are determined within the fine and specialty chemicals.*

Keywords*: Transformable Production, Modular Logistics Systems, Decentral Production Networks, Dynamic Supply Chain*

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1. INTRODUCTION

Today's process industry has to face increasingly uncertain market conditions due to the current trend of an increasing product diversity and thus shorter product lifecycles [1,2]. Focusing on the fine and specialty chemical industry with its volatile market conditions, generally speaking it is no longer possible to continuously produce large quantities economically on centralized large-scale plants. Consequently, the original supplier market in the process industry has developed into a customer-oriented demand market [3]. As a result, higher flexibility requirements for production systems are necessary. Therefore, production systems must be able to deal with this uncertain and volatile market demand relating to the product type, volume and production site [4].

The increased need for flexibility regarding the production site originates not only on the volatile market conditions but also on the procurement situation. Most products in the process industry are still based on fossil resources, e.g. crude oil as a carbon source, due to advantages such as low prices, simple further processing and constant available quantities [5,6]. However, the global sources of these fossil resources are regionally limited, which leads to enormous transport efforts and therefore to high CO_2 emissions [7]. In the face of climate change and the global objective to minimize carbon emissions, the process industry has several opportunities to reduce CO_2 emissions in various areas. Therefore, the following chapters describe potentials to reduce carbon emissions in the process industry by designing local economies as well as transformable production and logistics systems.

2. BACKGROUND

From an ecological viewpoint, the substitution of fossil resources by bio-based resources like biomass as a locally available carbon source for production in the process industry is a chance to face climate change. On the one hand, CO_2 emissions can be saved by utilizing climate-friendly raw materials in the process industry [8]. On the other hand, renewable raw materials can be procured locally. By contrast to bio-based resources, there only exist a limited number of companies worldwide which provide fossil resources in sufficient volumes. This results in high transport volumes over long distances with ships or trains and over short distances via trucks to the final destination. Especially transport routes by road entail a higher carbon emission ratio (80g CO_2 per tonne-kilometre) compared to the transport by ships or train (14 - 25 g CO_2 per tonne-kilometre) [9,10]. Moreover, a rise in transport costs by road can also be observed, which is a further incentive to minimize transport efforts and thus the carbon footprint [11].

However, the utilization of renewable sources entails the risk of varying quantity of supply and prices concerning local conditions leading to an increased need of flexibility in the production processes [12]. Furthermore, a local procurement of renewable sources implies the possibility of a decentralized production, but conventional production processes are usually not designed to utilize bio-based resources in decentralized production networks.

Additionally, most electrical and thermal energy worldwide is still generated on the basis of fossil resources [13]. Since the process industry is mostly dependent on energy-intensive production processes, CO_2 emissions can also be minimized by the utilization of energy from renewable sources. However, for the flexible production systems it must also be considered that by the utilization of renewable energy sources the output quantities, generated e.g. from solar or wind, vary at different times and in different locations [14].

Analyzing the processes of a supply chain from procurement over production to distribution, the processes of strategic long-term planning models and contracts do not meet the requirements of a dynamic supply chain anymore. The supply chain design is based on static long-term planning models which are optimized for large-scale and constant production volumes. However, considering the increasingly uncertain and volatile market conditions, supply chain processes must also become more flexible. Otherwise, the risk of a growing spread between supply and demand over longer periods of time cannot be answered. Summing up, an inflexible supply chain network in volatile market conditions constitutes a major competitive disadvantage for companies in the process industry. [15]

Therefore, production and logistics systems in the process industry must be designed focusing on flexible processes and equipment. However, a lack of flexibility has already been illustrated in the supply chain models and logistics systems for volatile market conditions. Additionally, today’s production concepts in the process industry do not provide the required flexibility to face those market conditions. Current production systems can be divided in continuously operated mono-product or batch operated multi-purpose or multi-product production systems offering different characteristics. On the one hand, mono-product systems are designed for an efficient large-scale production of one single product working on an optimized operating point with long start-up and shut-down times. Generally, this type of production is located at one centralized production site over decades, e.g. in a chemical park. Within a constant high volume demand situation those production systems are able to perform efficiently. One the other hand, there is a lack of flexibility in production volume, variety and production site [1]. By contrast, batch-operated production systems provide the needed flexibility but these systems do not work in the same efficiency as continuously operated production systems losing advantages of economies-of-scale [16,4].

As a result, flexible and at the same time efficient production and logistics systems need to be established in process industry. Consequently, the modularization within a transformable production and logistics system is focused [17,18]. Facing the current challenges like global warming and volatile markets, the concept of those transformable systems need to be connected with bio-based resources, renewable energy and decentral production which is described in the following chapter.

3. SYSTEM APPROACH

Transformable, modular production concepts are currently focused in research for the process industry to meet future challenges in chemical production and its dynamic supply chain. The utilization of biomass and CO_2 to reduce carbon emissions constitutes an additional challenge. So far these challenges in combination with adaptable production concepts in local economies have not been analyzed. To address this research gap, we analyze a combined system approach to minimize the overall carbon footprint. This approach consists of five elements: Transformable modular production (1), local bio-based resources (2), CO_2 as a raw material (3), energy from renewable resources (4) and decentralized production networks with local economies for procurement, production and distribution (5). This system approach and its five system elements are displayed in Figure 1 and elucidated in the following.

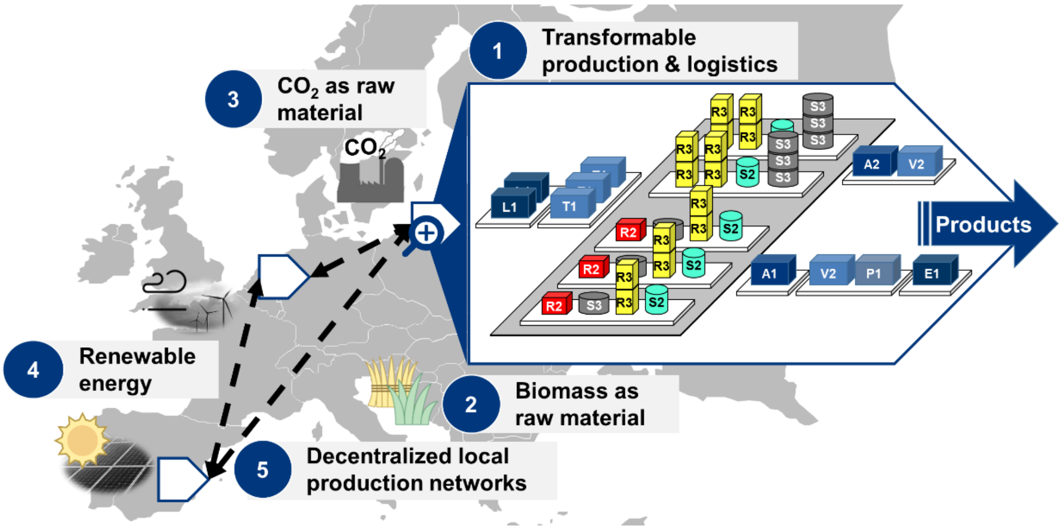

Figure 1: System approach for local economies with minimized carbon footprint

In the process industry, **transformable production** is characterized on three levels: unit operations, production plants and intralogistics. The production systems are established by a toolbox of modular unit operations with standardized interfaces which are assembled to build a production process. These unit operations are working at their resource and energy-optimized operating points. Hence, alternative processes for the production of alternative products are quickly generated by the use of other equipment and/or connection of compatible unit operations by the plug & produce principle. These production processes are assembled on a mobile platform like an ISO container to gain the advantage of production mobility. Additionally, the transformable production plant has a shorter development and market entry time due to standardized apparatus modules which allow a fast construction of the plant and due to the container-sized assembly that allows an easy transportation and installation. The production capacity can be adjusted by varying the number of process-lines within one production system or by varying the amount of production systems, so called numbering-up or -down. First demonstrators of the concept of transformable modular production have be developed in projects like F³ Factory and CoPIRIDE. [4]

Within transformable production intralogistics modules for supplying and distributing the production process need to be developed requiring flexibility in type, capacity, time and location of production [19,18]. These modules also need to be standardized in scale and size to allow for flexible, functional and mobile entities with plug & produce principle in the production system [4,17]. First intralogistics modules have already been designed by [20,21] but need to be complemented for various intralogistics processes according to different use cases. The equipment with smart devices and modular enabled automation solutions ensure a fast and compatible (re-)configurability in dynamic production environments with reduced planning efforts [22,23].

The demand of **biomass and CO_2** as renewable, emission-free and biocompatible feedstock rises because the substitution of traditional fossil resources with bio-based resources is an overall objective for sustainability. Therefore, the utilization of biomass as a resource is considered as the only permanent solution facing global warming. However, from an ethical point of view, only biomass which is not usable as food should be considered as an alternative resource [8]. A promising option to utilize biomass for the process industry is the processing into platform chemicals. These function as feed material for various chemical intermediates and products, e.g.

biopolymers, [24] which makes them versatile and therefore suitable for transformable decentralized production. According to the U.S. Department of Energy the twelve most promising platform chemicals are based on sugars and can easily be processed to higher bio-based chemicals [25]. Additionally, lactic acid has been identified as another promising platform chemical due to its well-known fermentation route and its large following product assortment [26]. Furthermore, CO_2 itself can be used as a carbon resource for various production processes. This is either possible by direct air capture which is currently challenging concerning economics, or by capturing the CO_2 from other high carbon emission processes [27].

Within this context of a sustainable feedstock for raw materials, the utilization of **renewable energy** based on wind, solar, hydropower, geothermal and also biomass is suited for providing a sustainable energy supply. However, these sources of renewable energy vary regionally. This involves dealing with the accompanied changes and challenges for the temporal availability of energy [28]. For the electricity generation based on hydropower, geothermal and biomass the output is nearly constant and leads to a supply guarantee. In contrast, the energy supply based on solar or wind varies depending on current local weather situations and also during seasons. For this system approach the energy supply from renewable resources is advantageous. On the one hand the carbon footprint is lower compared to fossil-fueled power plants and on the other hand the renewable energy production is decentralized. However, the high volatility of some renewable energy sources implies new challenges for the operation of chemical production plants. [19]

The trend of growing globalization of markets would suggest a rise in transportation efforts and therefore carbon emissions. But the changing demand to more customer-specific products while utilizing bio-based resources in the production process constitutes the advantage of locating the production plant in direct proximity to both resources and customers. This impels manufacturers to a worldwide dispersal of their production plants to supply international markets through local production [29] which leads to **decentralized production networks with local economies**. Thus, in the field of fine and specialty chemicals the paradigm of large-scale chemical plants hast to change to decentral small-scale production plants [30]. This causes additional planning efforts for sourcing, production and distribution for every entity in the production network. The installation of production and logistics modules in ISO containers allows for a standardized and therefore cost-effective transportation to decentral production sites [18]. This mobility enables a more flexible design and configuration of the production network as locations can be changed. As a result of this increased flexibility, the production network can react to dynamic supply and demand developments. The type, amount and location of production can be adjusted flexibly considering both the allocation of capacities and products to customers and the availability of resources. Figure 2 visualizes the shift in the structure of the supply chain network as well as the according production and market volumes. On the left side, the supply chain of the conventional centralized large-scale production with its long transport routes is illustrated. The decentralized production network with local economies and bio-based resources is shown on the right side.

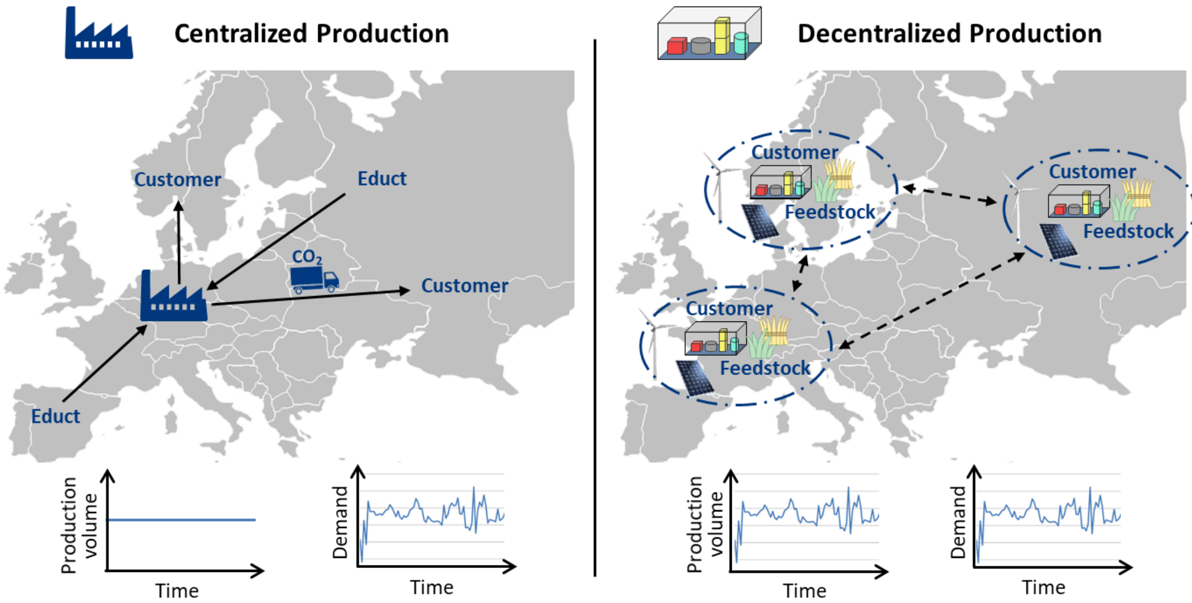

Figure 2: Centralized vs. decentralized production

Within this system approach local procurement of resources in close proximity of each production plant is desirable because biomass as a feedstock has a lower density than the resulting product [31]. This saves transportation efforts, costs and carbon emissions. The availability of biomass fluctuates over time and location as it dependent external factors, e.g. meteorological conditions and harvesting time and amount. The medium-term relocation of production plants to various regions depending on the harvesting time for different crops is possible. On a global scope, the relocation between northern and southern hemisphere is also feasible.

For the design of the supply chain, in addition to location of resources, the customer has to be considered. Though, the customer and resource locations are geographically dispersed independently. Transportation is necessary to close this gap between these locations. Hence, the design of the production network is closely colligated to the allocation planning of procurement and distribution, as well as the availability of resources and renewable energy. The geographically and temporally varying demand is manageable due to the increased flexibility of production capacity at the production site and within the network. Therefore, the relocation of existing production containers and the installation of new or the removal of existing containers are possible. This allows for a dynamic response to changing market condition. [30,3]

Being in close proximity to not only the resources, i.e. biomass, CO_2 and renewable energy, but also to the customers an ideal local supplier-production-distribution economy with minimized transportation efforts can be established. This decreases the warehouse sizes at the decentralized locations which leads to reduced inventory, capital commitment and warehousing costs [7,3]. Furthermore, transformable modular production concepts minimize the risks when entering emerging markets since the initial capital investment by the use of reusable production and logistics modules is low compared to large-scale systems. This allows for an analysis of the market behavior before gradually expanding the production capacity by numbering-up [3]. If the geographically dispersed production plants require additional reactants, the risk of longer procurement times and transportation efforts for these could occur.

4. CONCLUSION AND OUTLOOK

The chemical industry has to encounter new challenges due to the dependence on fossil resources, energy-intensive processes and the centralized supply chain structure. The adaptation to renewable resources, e.g. biomass, to substitute fossil resources requires an additional flexibility in the production system as these vary in time, amount and location. Moreover, the increasingly volatile demand requires companies to provide small-scale production volumes flexibly and economically. Furthermore, local procurement and distribution reduces transportation efforts and thus minimizes CO_2 emissions.

Transformable production concepts show beneficial characteristics in certain applications, but they are not yet fully integrated into the production environment of variable resources. Hence, the integration of the benefits of transformable production concepts into a decentralized production network with local economies can therefore lead to a reduction of greenhouse gas emissions and ultimately to the design of carbon minimizing economies. In this context, a holistic system approach has been developed which is associated with numerous challenges and has to be addressed by the following tasks:

- Development of apparatus modules for transformable production processes – appropriate dimensions and at the same time appropriate throughputs are not available for separation processes
- Development of intralogistics modules to be able to supply and distribute from modular production modules based on in- and output parameters
- Development of a supply chain planning tool to identify the best supply chain configuration regarding production locations and site-specific volumes. The allocation of suppliers and customers as well as dynamic market situations needs to be addressed

The system approach must be evaluated in volatile environments for attributes such as throughput, cost, flexibility and sustainability to show the benefit of decentral production within local economies.

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TOWARDS MORE EFFECTIVE AND SUSTAINABLE PURCHASING OPERATIONS THROUGH PROCESS MAPPING

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Abstract: *The basic characteristics of the modern business environment are the dynamic of changing business conditions. In these new conditions the way of competing, organization, the business models, and the way of operations managed were changed. The modern concept of doing business requires from every company that wants success to have connected and integrated operations with other companies. The concept of the supply chain enables this efficient integration of all included members in order to fulfill customer demand. An important role in achieving business challenges in the group of companies that makes up a supply chain have the purchasing whose main purpose is to provide the company with the optimal quantities of goods necessary for smooth and effective functioning. In this paper, the key point is to wake better understandings of the importance of effective purchasing operations, with an emphasis on the spare parts business, through mapping business processes so that efforts which could be made to enhance the information flows, and improve process visibility, would come clear to the management, hence getting a better understanding of the needs for improving the effectiveness and sustainability of purchasing processes.*

Keywords*: purchasing, process mapping, spare parts.*

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1. INTRODUCTION

The importance of cost-, and sustainable-effective process and flow management in modern supply chain management cannot be diminished. The profitability and competitiveness of companies in all industries are judged by how well they manage to provide their customers, which are more and more demanding, with their products [12]. Therefore, as the same author concluded, the challenge of each company is to the provide product at a sustainable price while also following up with a competitive purchasing and delivery service organization. An important role in achieving this challenge in the company, or group of companies that make up a supply chain, has the purchasing whose main purpose is to provide the company with the optimal quantities of goods necessary for smooth and effective functioning. The purchasing has changed through the years, as well as logistics generally, by moving from administrative to more strategic business and logistics function. The strategic importance of purchasing has got growing attention

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over the years and it has been argued that purchasing must ultimately become supply management [1]. The level of purchasing development has also an impact on the after-sales business [1,10], which represents a relevant source of profit and competitive advantage. By focusing on the after-sales services (including maintenance and spare parts sales), as a means to achieve customer satisfaction and retention, companies can gain a strategic advantage.

Managing the purchasing process efficiently is difficult, especially in the area of spare parts. For example, the obligation for delivering spare parts exists after the actual production of the primary products has ended; demand planning is difficult due to hard forecasting; service requirements are higher as the effect of the stock out are much greater [1]. Also, customers are very time-sensitive and their purchasing behaviour is increasingly demanding towards lead times [7]. In many situations, these problems have emerged as the information and process flow are not visible enough. The process of purchasing management has become even harder in the last decades with a significant shift towards greening practices. Many companies started to work on improving their environmental performances, and green purchasing has been a logical extension of this effort. Sustainable purchasing activities often rely on established product standards, labels and certification that declare the environmental attributes or performance of the products or services [4]. The requirements for more greener and sustainable business practices put additional pressure on the purchasing activities in the supply chain.

In this paper, the key point is to wake better understandings of the importance of effective purchasing operations, with an emphasis on the spare parts business, through mapping business processes, so that effort which could be made to enhance the information flows and improve process visibility would come clear to the management, hence getting better understanding of the needs for improving effectiveness and sustainability of purchasing processes. Therefore, the main objective of this paper is to illustrate the importance of increasing visibility of purchasing operations by demonstrating with the help of a case company how process mapping could be used in order to reach the stated objective. Created process maps and results concluded in this paper could act as supporting tools and findings for decision making in the case study company.

2. PURCHASING AND RELATED CONCEPTS

2.1 Supply chain management and principle of sustainability

All actors involved, directly or indirectly, in fulfilling customers' needs are parts of a supply chain [2]. The most common actors are the raw material producers, manufacturers, warehouses, retailers, third-party logistics suppliers, and the end customers. The supply chain encompasses every effort involved in producing and delivering a final product, from the supplier's supplier to the customer's customer [6]. Such a group of actors strives to act on the basis of well-coordinated and integrated organizations with the final goal to be more efficient than the competitive supply chains. The function of the supply chain is to support the organization in achieving its business goals [12]. Four basic processes – purchasing, production, delivery, and planning broadly define these functions, which includes managing supply and demand, purchasing raw materials and parts, producing and assembly, warehousing, order management, and delivery to the final customer. Supply chain management coordinates and integrates all of these activities into a seamless process [6].

Sustainable development, generally, has to meet the needs of the present generation without claiming to have the ability to meet the needs of future generations [8,9]. It can be explained by many factors: a new way to consume energy, a better understanding of climate changes, and an increased transparency of environmental and social actions of the organization [11]. Sustainable development is based on the triple dimensions: economic, social and environmental, which means that business success is no longer defined only by monetary gain but also by the impact that those business activities have on society and the environment [11]. Sustainable logistics is a process for planning and implementation of sustainability as a part of business activities that involve purchasing and production processes, as well as transport operations. Hence, the main challenge in supply chains is to organize logistics activities as efficiently as possible, while taking into account requirements from both supply and demand side, with regards to sustainability as well.

2.2 Purchasing management

Purchasing is one of the basic logistics functions responsible for supplying the organization with all the necessary raw materials, semi-finished products, and materials. Purchasing provides a mechanism to initiate and control the flow of materials through the supply chain. Purchasing is a term that is very commonly used interchangeably with terms procurement and sourcing. However, in the paper [1] authors made a distinction between them in a way that is justified and logical. Procurement refers to operational purchasing activities, such as releasing purchase orders, monitoring supplier performance and managing, in general, the daily order fulfillment process. Sourcing, which is more strategically oriented than operative procurement, refers to the broadened scope of supply management and it includes areas such as the formation of supplier structures and development of supplier capabilities, among others. Purchasing is a general term used to cover both sourcing and procurement [1]. Purchasing consists of a number of connected activities that help the organization to source materials from different suppliers. In most situations, purchasing is not in charge of the physical movement of materials, but more to provide information and to cover all organizational issues. Therefore, purchasing is much more about information processing than the physical movements of the goods. Purchasing collects data from different sources which, after analysis, are transferred to the whole supply chain. This is why enhancing the information flows and improving process visibility is so important if a company wants to approach improving efficiency and sustainability of the purchasing processes.

2.3 Process mapping

The tools that could be used when the company is altering their way of working towards enhanced information flow and increased process visibility, which could lead to improved efficiency, lower level of inventory, and increased sustainability, are process mapping. Process mapping is a visualisation of all the processes and steps that products are taking [5]. It is done with several basic symbols shown in Figure 1. It can be used in different areas in a company or supply chain, from developing a new product to revising information flow, which is a case in this paper.

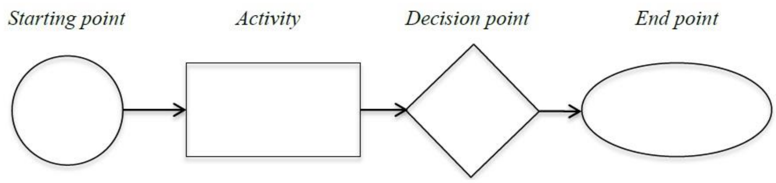

Figure 1. Basic symbols used to map a process, adapted from [5]

There are different types of visual mapping techniques that can be used when mapping processes, such as: value stream mapping, block diagrams, standard flowchart, functional flowchart, swimline diagrams. Each of these methods is suitable for different situations. The process map is usually first drawn on a paper and after that a digital process map can be created using graphic applications and programs [3]. When the map is established, it should be reviewed, validated and approved as a single and shared understanding of the process by all actors included in the process performing.

3. CASE STUDY

Knowledge about the flows (both information and physical), is critical in the company's trying with improvements. The objective of this part of the paper is to demonstrate this, with the help of a case study company. The case study company (hereafter "Company"), is a global company within the area of MRO business (maintenance, repair, and overhaul). The company operates with more than 50.000 different spare part units aimed at their clients. For most of these units, the company also offers maintenance and repair services. The main purpose of the purchasing department within the company is to provide them with the optimal quantities of goods necessary for satisfying the demand of their customers. The purchasing department is positioned between the sales and the central warehouses, with which it participates jointly in the realization of the customer's demand.

When customer's machine needs repairs or maintenance they contact the company for buying a spare part. Some stocks of spare parts are held at the company, so they could be delivered in a push manner. On the other side, for delivering spare parts which are not held in stock, the company uses pull operational model in satisfying customer's request (see Figure 2). Functioning on a push basis is based on an assessment and forecasting of customer needs, on the basis of which a sourcing plan of the necessary spare parts is made. In the company, this is the responsibility of MMP (material master planners) sector within the purchasing department, which based on the sales history, analysis and planning of the spare part sales (obtained from the sales department), makes a certain forecast and procurement plan for a given period. For some spare parts system with an automatic reorder point is applied. That means that whenever the stock-keeping amount of defined pare part registers at less than the predefined reorder point, an automatically generated purchase order request is placed (automatic push). After determining the purchased quantity MMP suggests request for purchasing, which is reviewed by the strategic purchasing sector (in charge of the strategic sourcing issues), and if accepted it's transferred via the SAP system to the Procurement team (in charge of the operative procurement issue), as a final purchasing plan. The procurement team examines and checks the purchasing plan, and after that place an order to the suppliers (vendors). On the other hand, it is very frequent ordering based on a direct customer request (pull process), processed by customer demand management (CDM) sector first, after which the purchasing process is continued according to the described procedure.

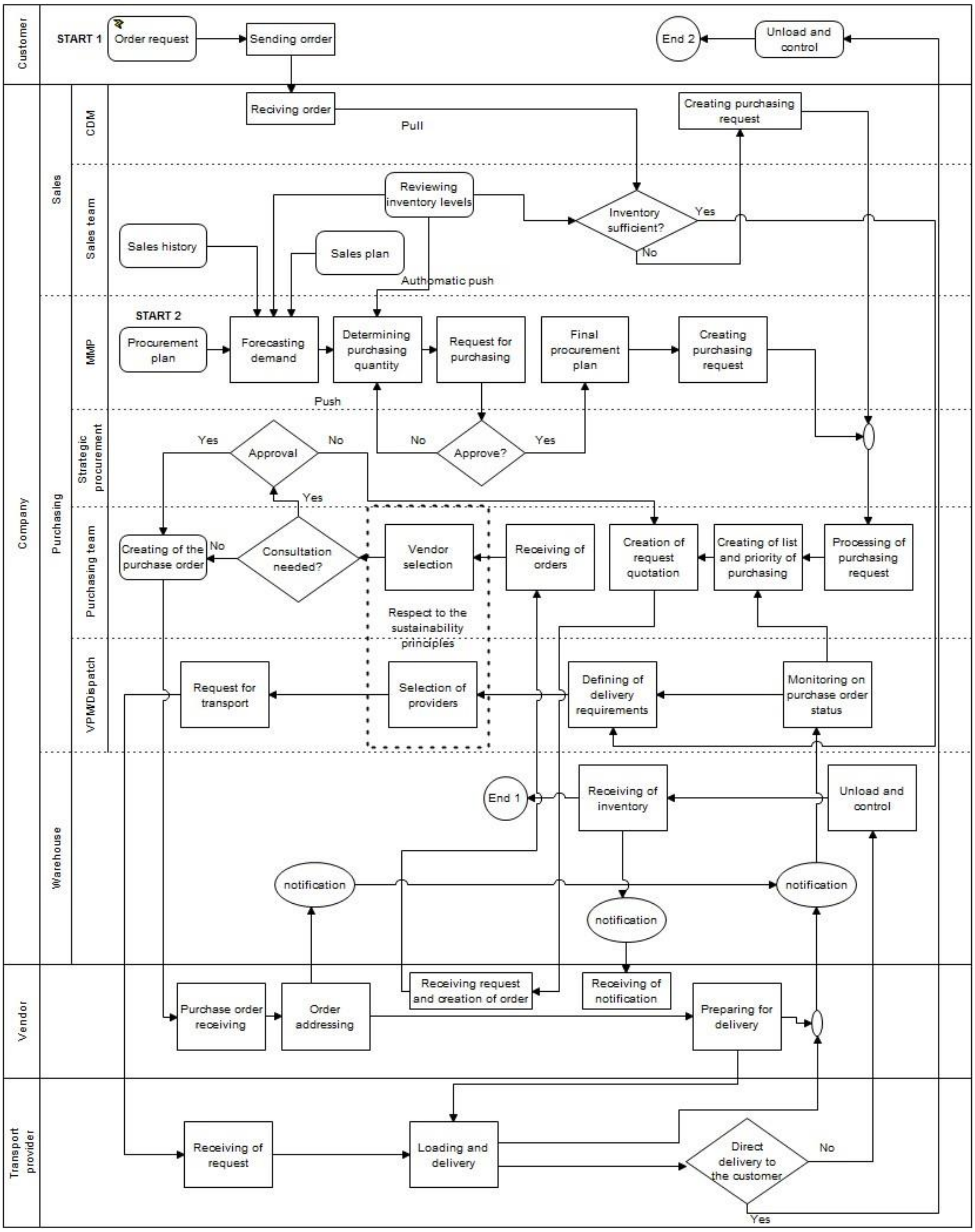

Figure 2. Process map of purchasing processes in the case study company

Whether the purchasing request arrives at the procurement team as a result of a pull or push process, it is examined and checked there, as it's already mentioned, and a Request for quotation is formed based on it. Request for quotation is placed to the suppliers, which after receiving it sends an order confirmation containing a sales condition. Selecting a supplier is the first of two aspects in which a company adopts sustainability criteria when making a final decision (see Figure 2). The strategic purchasing sector is also consulted during the supplier's selection. The list of the best three supplier offers is submitted to the purchasing supervisor, who makes the final decision. After that, a Purchase order is initiated and sent to the selected supplier.

The activities of the procurement team shall end after receiving confirmation from the supplier about their receiving Purchase order and that they agree to all order conditions. Further work is undertaken by VMP (vendor performance management) team, which continues communication with the supplier regarding the delivery and their status. The VPM is also responsible for selecting the appropriate logistic service provider (LSP) to perform the delivery service. This is the second aspect of the purchasing process where the company considers sustainability criteria during the decision making process. LSP handles the transportations from the supplier to the company. The delivery of spare parts to the company is followed by its control and testing, after which it is received into the company's inventory system (warehouse), from where it is delivered to the customer. Delivery can also be made directly to the customer's address.

Developed process maps could be used by the management in order to increase information flow and process visibility, with the final goal of assisting decision making. The company could use developed process maps for identification of customer value, so that they can start working on eliminating activities that are none value-adding (developing of a value stream map). Also, developed process maps could serve as a base for process modelling as an abstraction of a business that shows how business components are related to each other, how they operate, and how they could be redesigned for better functioning.

4. CONCLUSION

In today's global market, companies have to work on improving their business on a daily basis to keep their customers. To succeed they have to live up to the customer's expectations on delivering goods, at the right time, to the right place and so on. Companies have to do this or they will lose out in their competitiveness. An important role in accomplishing this challenge in the company or supply chain has the purchasing. Managing the purchasing process efficiently is difficult, especially in the area of spare parts. In many situations, the main cause of purchasing process inefficiency is a low level of visibility of information and process flow. The process of purchasing management has become even harder in the last decades with a significant shift towards greening practices. The main goal of this paper was to gain a deep understanding of the importance of effective purchasing operations through process mapping so that efforts that could be made to enhance the information flows and improve process visibility would come clear to management. This was accomplished by observing the purchasing process of a case study company and creating of related process map that displayed the purchasing process and all corresponding activities. Created process maps could act as supporting tools and findings for decision making in the case study company.

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LOGISTICS PROCESESS OF ENTERPRISES IN ZALA COUNTY

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Abstract: *The position of small and medium sized enterprises in Zala county develops peculiar to the situation in Hungary. The talents of county is not bad because there are five capitals within a radius of 250 kilometers. This central position and the small distances, the role of logistics is greatly appreciated in the case of local companies. This fact also has a significant impact on the logistics processes of SMEs, many of which are closely linked to these companies, either as suppliers or as service providers. These favorable qualities have been recognized by the county administration and in recent years serious developments have begun in the county council. Our entire research is related to micro-, small- and medium-sized enterprises from Zala County, and especially the service providers within. Under the research we would like to explore and model the logistics processes, connected to the service providers and which we would analyze with a generalized simulation model. In the framework of our exploration, we will try to find the bottleneck for making the previously mentioned processes more efficient. In this article we will show the literature background of the modeling of the problem and the international literature on logistics processes related to service provider companies. We would also like to present the results of the database-processing related to the topic. As a conclusion, we liked to show how service companies have evolved in the local context and how the management of their logistics operations has changed.*

Keywords*: logistics processes, SMEs, provider of logistics,*

1. INTRODUCTION

The situation of small and medium-sized enterprises in Zala County develops in a quite special way in comparison to the average Hungarian circumstances. The county's conditions are not bad at all, as there are five capitals within a radius of 250 kilometres. This central position and the short distance from the capitals help local companies to develop their the logistical role. This fact also has a significant impact on the logistics processes of SMEs, many of them are closely linked to these companies, either as suppliers or as service providers. These advantages have also been recognized by the county leadership and in recent years major developments have started in the county.

The logistics processes related to small and medium-sized enterprises in the county has been developed in a special way - based on the previously mentioned trends -, which led to the idea that these processes should be analysed and critical points should be explored. Our entire

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research focuses on small and medium-sized enterprises in Zala County, and especially the service providers within it. In the framework of our research, we'd like to identify and model the logistics processes which are connected to the service providers, and which would be handled generally in a simulation model analysis. During the research, we will identify bottlenecks to make processes more efficient. In the previous steps of the research, we examined the literature needed for modeling the problem and the international literature on the logistics processes related to service companies. We also examined methodological opportunities related to the research. In this paper we would like to present the results and methodological possibilities of modeling so far. For the purposes of our research, the activities of enterprises, including small and medium-sized enterprises, are manufacturing companies and service providers. The analysis and development of logistics processes is a common task of the logistics experts, and thanks to the discipline, plays an important role in supply chains and in business competition. Basically, we have mainly equipment manufacturers in our region where most of the production processes are previously defined, so it can be rarely changed or modified on site. The requirements of logistics service processes are more difficult than production progresses, so the analysis of them is also harder [2,4,12,18,20]. However, the structure of these processes can be customized locally, specifically for businesses, so there are more possibilities for optimization. In the world's largest economies, the dominance of the service sector is growing, according to statistics from OECD and World Bank databases. The service sector is responsible for more than 63% of world GDP and is even higher in countries with higher GDP (over 75%) [14]. This means that the concept of reorganizing inoperable business processes is still needed in this century, but generally more sophisticated tools and methods are needed [14].

2. ZALA COUNTY, AS THE AIM-LOCATION OF THE RESEARCH AND ITS MACROECONOMIC ENVIRONMENT

Briefly about the county: Zala County is located in the southwestern part of Transdanubia. It's bordered by Veszprém County from the east, Somogy from the south, Vas from north and by the Croatian and Slovenian borders from west. With Győr-Moson-Sopron and Vas County, Zala is the third county in the Western-Transdanubian Region. The change in population is shown in Table 1, which according to 2015 data, was 277,290. It is clearly visible that the population is decreasing significantly above the national average.

Table 1. Population of Zala County (KSH)

Year	1980	1990	2001	2011	2015
Population	317 298	306 398	297 404	282 179	277 290

The end of the 1980s and early 1990s brought a change in the economic life of the county, which was stabilized in the early 2000s, but the economic crisis that began in 2008 led to a significant reduction in the capacity of several larger companies.

However, the county's characteristics are not bad. It is directly bordered by Croatia and Slovenia, and Austria is also close by. Five capitals are within a radius of 250 kilometres.

The road section of the TEN-T network, V corridor, passes west-east through Hungary; the corridor of V corridor is an integral part of the M7 motorway and the M70 motorway passing through the county. (Charts 1 and 2) There are several international ports: Rijeka (Rijeka), Koper, Trieste. There are several ports of international traffic: Fiume (Rijeka), Koper, Trieste. These can

jointly offset North Sea ports. Medium-term plan is M9. The county has several elements of the national railway network (Budapest, Pécs, Szombathely).
The Territorial Development Concept of Zala County 2013 also outlines - which was supported by previous researches - that the availability of Zala County is mostly unfavourable, but as a result of the M7 motorway and the Hungarian-Croatian-Slovenian expressway network development, along the Hungarian-Croatian-Slovenian borders logistics zone can be evolved (e.g. the logistics base of the Müller supply chain), where the premises of Letenye, Nagykanizsa regions can compete with the neighbour countries. It is noteworthy that the weight of logistics is significant in the economy of Zalaegerszeg, even though its geographic location and transport connections do not seem to be ideal for this function. Combined freight transport is not significant. In Nagykanizsa these conditions have been established, but there is no need to use the service in the current market circumstances. Developments in the county will strengthen the logistical role of both Zalaegerszeg and its surrounding areas, and it is likely that these investments will significantly develop the region's role in the supply chain at the same time. Passing a large part of east-west transit traffic of Europe can be a major economic advantage. The European Union places the micro-regions of a separate country into a common economic community and a common region. There are a lot of development opportunities in the area of additional services, which would mean economic and financial benefits. As regards commodity traffic, Zala County can be an important road link between seaports and Central Europe. The Sármellék airport provides an opportunity for air cargo transportation, which in today's world, where lead times are an increasingly important factor, can have a serious importance [7]. It is considered the geographical position as a factor of competitiveness, but it must be emphasized that this can only be exploited with high added value logistics services.
In the following data set of Table 2 the logistical service providers can be visible.

Table 2. Companies providing logistical services in Zala County (31/12/12) (KSH)

TEAOR number	Number of the companies (db)
52 Warehousing and ancillary activities	80
521 Warehousing and storage	8
5210 Warehousing and storage	8
522 Supplementary transport activity	72
5221 Land transport service	14
5222 Water transport service	1
5223 Air transport service	2
5224 Cargo Handling	10
5229 Other supplementary service of transport	45

3. LITERATURE BACKGROUND

For the analysis of the local companies’ logistics processes and for the identification of the bottleneck, we have to model the current processes. For the effective modeling, we have reviewed the literature in order to apply the best solutions during the research. The every-day logistics processes of businesses – as the main processes of the supply chain – make such a multi-factor system, which is really complex. [13]
If we research the production processes within the manufacturing businesses, we will find that analysing and developing them is a joint responsibility of logistics and production professionals and thanks to this, logistics is now a common task and plays an important role in supply chains

and business competition at the same time. At the service logistics processes, we can have quite the same experiences; the only difference is that these processes even more complex, so their analysis is also more complicated. [2,12,20]
The [15] basis of the paper was an overall and deep literature review. Basically, this literature review suggests that many techniques and methods are available to improve the logistics and business processes of businesses. All of them are based on the BPR (Business Process Re-engineering) concept. This concept is the creation of a process structure plan. Subsequently, significant changes take place for better performance and a more harmonious process structure. BPA (Business Process Alleviation) means something else that is described by the logistics structure of the process.

4. THE RESEARCH METHOD

Complex systems can be analysed by using models. We can get much more information about the characteristics, the operation and the behaviour of a real system and the connecting processes with the analysing and studying an appropriate model. It also has several benefits: it is cheaper than testing a real system and it is safer because a real system can work in parallel with model testing.
These systems are typically influenced by the technology, the availability of the infrastructure, the traffic, but also by the weather and other ad hoc factors. Although the problem is multi-factorial, we often talk about systems that are difficult to predict, but it is worth focusing on their simulation. One of the main reasons for this is that, based on the experience of the last decades, a significant competitive advantage can be achieved by increasing the efficiency of logistics process
For the process analysis such a modeling tool is needed which provides a system which is able to describe accurately the real processes and at the same time it's operating in a real time, in a cheap way and able to give clear results. Previous studies showed that these processes can only be examined at the model level without interfering into the real system. Many from the previously studied modelling solutions are really useful and during the research, we'd like to act the similar way as in these examples. [6,9]
Mathematical modeling is not an easy step. The model has to be sufficiently detailed, but at the same time it cannot be too detailed, which can easily impair the transparency and the analysis possibilities. From this, automatically follows that the decomposing of the whole activities into elementary activities is from some opinions arbitrary. In any case, it requires very careful economic consideration. [6] Successful models can be found in the following literatures: [3,14,15,16] Understanding the characteristics, operation, and behaviour of the systems and processes we are analysing is not easy due to their complexity. Without the optimal process structures, the economy can no longer function efficiently, and this task is mainly the process designers' responsibility to find the right solutions. [8] The aim is to increase the efficiency of production and service, which can be solved by changing the values of the parameters and analysing the results obtained. There are many existing tools for the planning, analysing and development of the logistics processes. [2]
The model and the task connecting to the model are split. The model is used to describe a "world" and the task and its solution are used to answer questions related to the "world" through conclusions and calculations. The literature suggest various methods to solve the task connecting to the model. For our model the best suitable solution was the simulation analysis, because there are many connecting elements which are not deterministic in this case. The simulation model

"analyses" the complex system by simulating its real behaviour. Due to the structure of the model, it only considers the most important elements of the complex system, so it is much simpler than the real system. [19] Simulation studies of logistics processes are presented in several literature and successful applications can be found. [5,9,10,11,16,17,21]. Simulation is actually an analytical tool associated with a simulation model by personation of existing or non-existing systems. Today it is one of the most widespread decision-making tools. The typical application fields of simulation is the followings [1]: planning and analysis of production or service processes, optimization of supply chains and planning and analysis of transport systems, etc.

5. CONCLUSION

In this paper we reported the first phase of the research on the logistics processes of enterprises in Zala County. From the characteristics of the county, it seems justified to map out the logistics processes of local businesses and present their critical points. In connection with this task during the period, we looked the literature and the previous researches within this field. It's visible that data acquisition will remain to the next phase, because the local, special data should be collected from local multiple databases. Therefore, we have focused primarily on methodological issues in this article. After the data acquisition, we want to create a model that describes local processes on a high level. Mathematical modeling is well used in logistics systems and there are many good examples in this area. This is the solution we have also chosen. For the solution of the task connecting to the model, the analysis of the cases taken from the literature showed the effective tool. Software analysis and simulation are already common in the study of logistics systems. We will use this solution in our research as well.

The research task we set out is not simple, but if we could answer the main questions, we could also suggest solutions.

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FUNDING INSTRUMENTS AS A SUPORT TO THE SUSTAINABLE TRANSPORT DEVELOPMENT IN THE DANUBE BLACK SEA REGION

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Abstract: *Although there are initiatives for the development of the sustainable intermodal transport in the Danube and Black Sea (DBS) regions, the implementation of development projects often lags behind. As one of the reasons for the delayed implementation is recognized lack of knowledge about the existing financial instruments that can support the sustainable transport development projects. Therefore, within the project DBS Gateway Region an Funding Guideline was developed that includes an overview of the most relevant funding instruments for the countries in the DBS region, followed with the overview of the financially supported development projects that are acknowledged as the best practice projects by the regional stakeholders.*

Keywords*: funding instruments, sustainable transport, Danube - Black Sea region*

1. INTRODUCTION

Transport sector (services, manufacturing, maintenance, construction) accounts for more than 9% of EU Gross Value Added (GVA). Transport services alone account for around 651 billion EUR, or 5 % of total EU GVA in 2015. On the other side, transport generates 24% of total GHG emissions - approx. 1 billion tonnes of CO_2. [2]

Therefore, further development of transport in Europe should be performed in a sustainable way. According to the European Commission, until the 2030, the development will be focused on the completion of the TEN-T corridor network. It is expected that the investments, from 2016 to 2030, needed for realizing the core network in its totality amounts to about 750 billion EUR. Preliminary estimates show that the completion of the Core Network Corridors in accordance with the latest work plans is expected to lead to an overall reduction of CO_2 emissions of about 7 million tons between 2015 and 2030. This will have different impact on different regions within Europe.

Further development of the TEN-T corridor VII - the Danube considers, among others, its better connection with the Black Sea region. Although there are initiatives for the development of the sustainable intermodal transport in the Danube and Black Sea (DBS) regions, the implementation of development projects often lags behind. One of the reasons is lack of knowledge about the existing financial instruments that support the development projects. Therefore, within the

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paper, an overview of the most relevant funding instruments for the countries in the DBS region is provided, followed with the overview of the financially supported development projects, acknowledged as the best practice projects by the regional stakeholders.

2. FUNDING INSTRUMENTS RELEVANT FOR THE TRANSPORT SECTOR IN THE DBS REGION

To make the overview of the relevant FIs more transparent and clear, they are summarized in two tables:

- the first one contains all of the FIs with the types of financial aid provided by them (loan, grant, equity finance, guarantees, investments) and their regional focus (e.g. EU, non-EU);
- the second differs thematic focus of every FI (intermodal transport, environment, SMEs, etc.).

The overview refers to the 2014-2020 programming period.

Table 1. The types and geographical areas of the FIs [1]

Financing instrument	Types of financial support					Region/Country
	Loan	Grant	Equity finance	Guarantees	Investments	
European Investment Bank (EIB)	X		X	X		Non-EU and EU
European Investment Fund (EIF)	X		X	X		Non-EU and EU
JEREMIE	X		X	X		EU
JESSICA	X		X	X		EU
JASPERS	providing technical assistance					EU
JASMINE						EU
European Fund for Strategic Investments (EFSI)	X		X	X	X	Non-EU and EU
COSME	X	X		X	X	Non-EU and EU
European Bank for Reconstruction and Development (EBRD)	X		X	X		Non-EU and EU
Council of Europe Development Bank (CEB)	X	X		X		Non-EU and EU
KfW Development Bank	X	X				Non-EU
Western Balkans Investment Framework (WBIF)	X	X				Non-EU
Western Balkans Enterprise Development and Innovation Facility (WB EDIF)	X		X			Non-EU and EU
Connecting Europe Facility (CEF)	X	X		X		Non-EU and EU
URBACT		X				EU
Urban Innovative Actions (UIA)		X				EU
LIFE		X				EU
Horizon 2020	X	X		X	X	Non-EU and EU
Customs 2020		X				Non-EU and EU
EEA and Norway grants		X				Non-EU and EU
Interreg Central Europe Programme		X				EU
Interreg Alpine Space Programme		X				EU
Interreg Europe Programme		X				Non-EU and EU
Interreg Balkan-Mediterranean Transnational Cooperation Programme		X				Non-EU and EU
Interreg Danube Transnational Programme		X				Non-EU and EU
Interreg MED Programme		X				Non-EU and EU
Interreg ADRION Programme		X				Non-EU and EU
Interreg V-A Austria-Germany		X				EU

Financing instrument	Types of financial support					Region/Country
	Loan	Grant	Equity finance	Guarantees	Investments	
Interreg V-A Slovakia-Hungary		X				EU
Interreg V-A Slovakia-Austria		X				EU
Interreg V-A Hungary-Croatia		X				EU
Interreg V-A Romania-Bulgaria		X				EU
Interreg IPA CBC Hungary-Serbia		X				Non-EU and EU
Interreg IPA CBC Romania-Serbia		X				Non-EU and EU
Romania-Moldova ENI CBC		X				Non-EU and EU
Funding of feeder-lines and terminals (Anschlussbahnen- und Terminalförderung)		X				AT
Innovation Programme for Combined Freight Transport (IKV)		X				AT
Mobility of the Future (Mobilität der Zukunft)		X				AT
Operational Programme "Transport and Transport Infrastructure" 2014-2020		X				BG
Operational Programme Competitiveness and Cohesion 2014-2020		X				HR
Programme for Combined Transport		X				DE
Schienengüterfernverkehrsnetzförderungs-gesetz (SGFFG)		X				DE
IKOP 2.1.0 Improvement of international (TEN-T) waterborne and railway accessibility		X				HU
GINOP 1.2.5 Development of logistics service centres		X				HU
GINOP 2.1.2-8.1.4 The promotion of R&D activities of SMEs combined with refundable loan	X	X				HU
KEHOP 1.4.0 Flood prevention developments		X				HU
TOP 1.1.1 Development of industrial parks		X				HU
Regional Operational Programme 2014-2020		X				RO
Operational Programme for Large Infrastructure Projects		X				RO
Public competition in Vojvodina for the financing and co-financing of projects in the field of transport infrastructure		X				RS
Operational Programme Integrated Infrastructure (OPII)		X				SK

Detailed elaboration of the FIs, in the 2014-2020 programming period, including detailed description how to apply for them is given in the Funding Guideline developed within the project DBS Gateway Region that can be found on the DBS web Cooperation Platform.

Table 2. The main topics of the FIs [1]

Financing instrument	Intermodal transport	Inland waterways	Infrastructure	Energy	Environment	Transport	Social infrastructure	Private sector development	New economic possibilities	Sustainable economic recovery	SMEs	Customs
European Investment Bank (EIB)	X	X	X	X	X	X	X	X	X	X	X	
European Investment Fund (EIF)											X	
JEREMIE											X	
JESSICA			X	X	X	X	X	X			X	
JASPERS	X	X	X	X	X	X	X					
JASMINE								X	X			
European Fund for Strategic Investments (EFSI)			X	X	X	X	X	X	X	X	X	
COSME								X	X	X	X	
European Bank for Reconstruction and Development (EBRD)			X				X	X	X	X	X	
Council of Europe Development Bank (CEB)				X	X	X	X	X			X	
KfW Development Bank			X	X	X	X	X		X	X		
Western Balkans Investment Framework (WBIF)	X	X	X	X	X	X	X	X			X	
Western Balkans Enterprise Development and Innovation Facility (WB EDIF)								X	X	X	X	
Connecting Europe Facility (CEF)	X	X	X	X	X	X						
URBACT	X			X	X	X	X	X	X		X	
Urban Innovative Actions (UIA)	X		X	X	X	X	X		X			
LIFE				X	X							
Horizon 2020	X	X	X	X	X	X	X	X	X	X	X	
Customs 2020												X
EEA and Norway grants				X	X		X	X	X	X		
Interreg Central Europe Programme	X	X	X	X	X	X	X	X	X		X	
Interreg Alpine Space Programme			X	X	X	X	X	X	X			
Interreg Europe Programme				X	X	X			X		X	
Interreg Balkan-Mediterranean Transnational Cooperation Programme				X	X			X	X		X	
Interreg Danube Transnational Programme	X	X		X	X	X	X	X	X	X		
Interreg MED Programme				X	X	X		X	X	X		
Interreg ADRION Programme	X	X	X	X	X	X		X	X	X		
Interreg V-A Austria-Germany				X	X			X	X		X	
Interreg V-A Slovakia-Hungary	X	X	X	X	X	X	X	X	X		X	
Interreg V-A Slovakia-Austria					X	X		X	X		X	
Interreg V-A Hungary-Croatia			X		X	X	X	X	X	X	X	
Interreg V-A Romania-Bulgaria	X	X	X	X	X	X	X					
Interreg IPA CBC Hungary-Serbia			X		X	X	X					
Interreg IPA CBC Romania-Serbia			X	X	X	X	X					
Romania-Moldova ENI CBC			X		X	X	X	X	X			X

3. BEST PRACTICES OF THE SUSTAINABLE TRANSPORT FUNDING IN THE DBS REGION

In order to evaluate the influence of the funding instruments to the development of the sustainable transport and logistics in the DBS region, an overview of two best practice (BP) implemented projects in every of the seven DBS countries is given in table 3.

Table 3. Best practice of the sustainable transport funding in the DBS region [1]

Country	Project title and acronym	Funding instrument	Why BP	Implementation period	Total value [mil. EUR]
Austria	Expansion of the tri-modal inland port of Vienna by land recovery	TEN-T Multi-Annual Programme	The Freudenau Port of Hafen Wien is the only trimodal logistics location in the greater Vienna area, offering key advantages for the intermodal transport.	2012/2015	12.79
	INWAPO	Central Europe Transnational Cooperation Programme	Focused on three different waterway systems: the Danube river, the North Adriatic and the Czech and Polish waterways. Enabled better coordination among decision makers and logistics stakeholders.	2011/2014	3.8
Slovakia	RIS COMEX: RIS Corridor Management Execution	Connecting Europe Facility (CEF)	Implementation and operation of cross-border River Information Services based on the exchange of RIS data.	2016/2020	6.7
	Danube Ports Network (DAPhNE)	Danube Transnational Programme (DTP)	Well-managed working platform that facilitates balanced development and cooperation of the public and private stakeholders in the region.	2017/2019	2.99
Hungary	Mobile dam project in the Freeport of Budapest	Integrated Transport Operational Programme Hungary 2016	The first flood prevention investment in the Hungarian Danube ports.	2016/2018	4.08
	PAN-LNG-4-DANUBE	Connecting Europe Facility (CEF)	Examined all technical, economic and customer-related requirements for an innovative, modular and openly accessible LNG offshore bunkering for IW vessels and onshore refuelling service for long haulage trucks and trains.	2016/2019	16.98
Croatia	Infrastructure upgrading and development of terminals in the Port of Slavonski Brod	Connecting Europe Facility (CEF)	Upgrading the infrastructure of the Port of Slavonski Brod and its connections with the rail, road and inland waterway TEN-T network. It represents the BP in Croatia due to the large investment with the great co financing support.	2018/2020	11.68
	COnvention for WAste Management	South East Europe Transnational	Promotion on-board waste prevention and pre-treatment, the integration of RIS and waste management activities into a more	2012/2014	1.82

	for Inland Navigation on the Danube (CO-WANDA)	Cooperation Programme 2007-2013	efficient transboundary coordination and monitoring system, the creation of a financing system and the set-up of a software that supports the related administrative tasks, and the improvement of the existing capacities for ship waste management.		
Serbia	Implementation of River Information Services in Serbia	Pre-Accession Assistance (IPA) National Programme 2007	An operational RIS system, consisting of sub-systems for tracking and tracing vessels (through 15 base stations), notices to skippers, voyage planning, the correction of GDP signals according to the IALA standard, etc.	2009/2013	10.5
	Network of Danube Waterway Administrations - NEWADA	South East Europe Transnational Cooperation Programme 2007-2013	Increased efficiency of the Danube as the European Transport Corridor VII by intensifying cooperation between waterway administrations. Created common cooperation strategy and conditions for the Danube administrations' cooperation.	2009/2012	2.86
Romania	Collecting system for ship-generated waste discharged in maritime Danube ports - CODENAV	National Operational Programme for Transport 2007-2013	Implemented an integrated system for ship waste reception in all Romanian ports situated on the maritime sector of the Danube (Galati, Braila and Tulcea).	2010/2013	10.02
	Danube Inland Harbour Development – DaHar	South East Europe Transnational Cooperation Programme 2007-2013	Developed the Integrated strategy for functional specialization of Danube ports and Regional action plans, which particularly helped in development of the Galati region.	2011/2014	1.97
Bulgaria	Vessel Traffic Management Information System (VTMIS)	Operational Programme on Transport 2007-2013	System that improves the safety of navigation and the protection of human life at sea. All communication and information subsystems integrated into a common national maritime information system with an extended scope and functionality.	2002/2015	20.02
	Implementation of River Information System in the Bulgarian stretch of the Danube River (BULRIS)	Operational Programme on Transport 2007-2013	Large-scale and complex project, involving design and construction work, the supply of hardware and software for communication services, radio related lines, telephone, radar systems and system for the monitoring and surveillance of vessel traffic.	2011/214	19.14

4. Conclusions

Constant growth of cargo flows requires continuous development of transport infrastructure. Considering that development of sustainable intermodal transport infrastructure usually falls behind the development of the road transport infrastructure, most of the increased cargo flows are transported on roads, usually due to the aging infrastructure and inefficient services offered by rail, water and intermodal transport.

However, there are existing FIs that can significantly support the development of the sustainable transport infrastructure and services. In order to demonstrate the influence that funding instruments can have on the regional development of the sustainable transport, within this paper, an overview of the existing funding instruments and funding best practices in the DBS region is given.

ACKNOWLEDGMENT

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FUTURE MODELS FOR USING GREEN LOGISTICS IN WAREHOUSES

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Abstract: *Logistics is a word that comes on the scene with growing attention linked with organizing and optimizes complex operation. On the other side, one of the subsystems of logistics and crucial for the flow of goods and information as well as carrying inventories is a warehouse. In order to achieve a higher level of efficiency, the strategy needs to be oriented towards investments in new, smart technology. Nowadays, before optimizing the cost, the new purpose of the research topics in logistics is how to optimize different types of pollution. The focus is on minimizing and reducing waste, gases, processes, and vibrations. This new point of view is named green logistics. Some research says that a number of toxic gases, dangerous vibrations and noises can be found in warehouses. The most alarming consequences for bio systems can generate inadequate mechanisms and processes. One of the ways to ameliorate the quality of the working area in warehouses is focused to make them more ecological. Related to the idea of using green logistics, the main goal of the paper is to give a new, "green" direction to logistics in a warehouse. It presents an overview of negative effects of pollution, processes, green solutions, and smart ideas for organization and optimization in a warehouse.*

Keywords*: Logistics, warehouse, green logistics.*

1. LOGISTICS FIRST LEVEL HEADING

Travel back in time, not all the commodities were produced or were available where people wanted to be. Most of them were available only at fixed locations and at certain times of the year. These limitations forced people to think about new solutions and alternative ideas [1], [2].

People started to develop the efficiently of the production of local goods and started to import goods that were not locally produced. As logistics systems were developing, they play a significant role in reassuring a high level of foreign trade and using all the benefits.

The logistics processes are involved almost every sphere of human activity, directly or indirectly. All areas of logistics have a significant impact on a price, efficient and effective. As customers, we tend to notice logistics only where there is a problem. We often don't

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think of the role that logistics has in our lives until something goes wrong [1], [2]. For example: A consumer uses the Internet to purchase flowers for his wife and the items arrived too late, every thought timely delivery was promised. An order is delivered to the wrong customer, and it takes several days for the mistake to be corrected [3].

We know that the logistics mission is: getting the right goods or services to the right place, at the right time and in the desired condition at the lowest cost and highest return on investment. Logistics is referred to as the seven Rs- Right product, Right quantity, Right condition, Right Place, Right time, Right customer and Right cost [1]. Good logistics management views each opportunity of adding value [1], [4].

2. WAREHOUSE

Warehousing is the act of storing goods that will be sold or distributed later. Whether the goal is storage or storage or with additional activities, warehouses use specialized elements that offer manipulation with goods and safe storage. A good strategy of a warehouse is focused to optimize every unnecessary movement, space and extra costs. For that reason, a lot of mechanization and technology is used in warehouses [2], [3].

In this age, in a world where technology has sprung up in every sequence, the warehouse is not out of the grid [6], [7]. The point is how the technology in the warehouse has evolved, but more interesting is what the next step is?

Available technologies now use hardware such as sensors, scanners, and GPS trackers to give precisely a relation between inventory and associates in the warehouse at any time. Internet availability on handheld devices can connect the data instantaneously and quickly processing. This technology makes a revolution in supply chain management because provides visibility and precision. Users can get a clear picture with tracking through GPS location devices and to make precisely and optimal plans for warehousing [7]. Sensor technology has ensured that can map every warehouse, to make analyses of inventories and reveal the placement and location of every product. While the business may not be able to support all of the changes immediately, smart technology is the perfect opportunity for flexible changes in warehousing [4], [9].

3. POLLUTION IN WAREHOUSES

Air pollution can be defined as the emission of harmful substances to the atmosphere. This broad definition, covered several pollutants, including: sulphur dioxide (SO2), nitrogen oxides (NO_x), ozone (O3), carbon monoxide (CO), carbon dioxide (CO_2) and other greenhouse gases. Same air pollutants can be complex and specific because since some pollutants act as pre-cursors to others. For example, SO_2 and NO_x can react in the Earth's atmosphere to form particulate matter (PM) compounds [5], [6].

The Warehousing industry is involved in air quality. This leads to an expansion in carbon dioxide emissions from the energy sector, directly caused by the expansion of warehousing. Research indicates that one of the worldwide, top contributors to lung cancer is from diesel trucks serving in the warehousing industry [12], [13]. The World Logistics Canter estimates that one in 10,000 residents who live near the warehouses could develop cancer, in addition to one in 50,000 residents in the surrounding area [13]. Air pollution is Skopje is one of the key topics of the World Health Organization (WHO). They recently ranked Skopje, as the third most polluted city in Europe. The organization's data shows that Skopje's annual air pollution 60 per cent higher than EU guidelines and four times higher than WHO guidelines (Figure 1). (Institute of Health Metrics and Evaluation (IHME)) [5], [6].

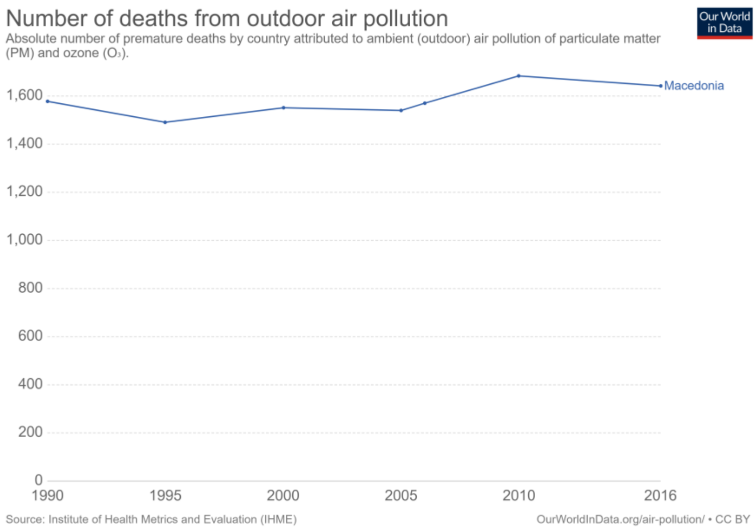

Figure 1. Number of deaths from outdoor air pollution

4. GREEN LOGISTICS IN WAREHOUSES

Improving any segment of the warehouse's work involves a lot of detail. Even if technology can affect the progress of the storage methods', it cannot change the basic functions. New data processing systems cannot reform inadequate information management procedures, e.g. the crane cannot clean the dirty warehouse [15].

According to information from the ,, Fire Foundation", warehouses consume 36% of the total US energy consumption, 65% electricity; 30% raw material and 12% drinking water (Stojanovic, 2012) [7]. Other research shows that 65-90% of the energy stored in warehouses is spent on activities for heating, ventilation, cooling, lighting, and equipment [3], [4]. Not only air pollutants are harmful to the environment, but there are also many other elements. For example, the negative effects of noise are problems in communication, decreased concentration, i.e. reduce overall productivity, mental problems and cardiovascular problems. The last years, the European Union has increasingly introduced rigorous measures to limit noise in road transport and workplaces.

Green Logistics is a logistics which direction is to preserve the environment. As we know, global warming, pollution, natural resource constraints, transportation, waste problems, we are urged to pay serious attention to reduce a big part of it. There are two ways that we can act: rational use of waste materials and rationalization of logistics processes.

Green logistics contains several contradictions. The purpose of logistics is to reduce cost, time savings, increase reliability and flexibility, but with using green logistics (Figure 2) on the first view there is no cost-cutting [12], [13].

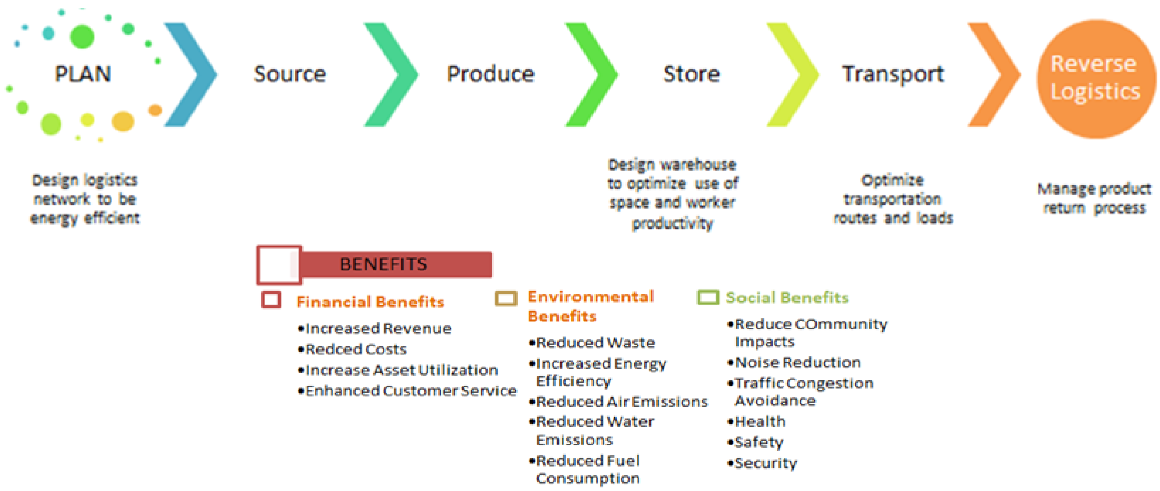

Figure 2. Benefits of green logistics

Time is usually the most important result of logistics operations, and by reducing the time, productivity is increasing [12]. Many studies give hope that "green vehicle technology and mechanization" is the most promising and with the biggest potential for reducing CO and other harmful emissions [15].

Although appear to be very simple and easily applicable, they are in fact interdependent and most of them inversely proportional, for example, NO_x reduction contributes to increased CO and the like.

5. GREEN ASPECTS IN WAREHOUSES

The worldwide energy is covered today mainly by fossil fuels: oil, natural gas and coal. But, solar energy technology has been more and more improved: today, solar cells are six times more efficient than they were 30 years ago [11]. How can solar energy help economic growth, public health and the environment? How can solar energy be part of green logistics?

According to Baker and Marchant (2015, 200-201) [8], green logistics can be used in the warehouse in three parts. In the first, the simplest level of a green warehouse is an energy efficiency building with minimum requirements. This part is focused on the internal factors of the green warehouse such as heating, lighting, air changes and mechanical handling equipment. The next stage is to create a low-emission and green energy warehouse is to consume renewable and green sources of energy to lower carbon emissions. (Baker & Marchant 2015, 201) [8].

Depending on the functions and nature of a warehouse and storage, local weather, design as well as in-house activities, every warehouse has different requirements. The primary sources of energy for heating/cooling systems in the warehouse come from gas, fuel energy, and electricity [10], [11].

Every sequence of giving rise to green warehousing is a step towards, but the most promising methods of future green warehouse: energy self-production and sustainable building design [10].

5.1. Green energy generation

A modern, futuristic warehouse can self-produce partial or nearly full energy needed by using renewable energy sources. This can be a perfect approach to cut off emissions and greenhouse gas as well as save energy costs. Several most modern, smart and clean sources of energy are solar, biomass, and the wind. (Richards & Riding 2015, 367.) [10]. Nonetheless, due to the extensive capital investment, self-production of energy in a warehouse, for now, is just an environmental-friendly method but it is not a cost-efficient justify. Consequently, choosing an affordable way to self-produce energy is a hard task. Solar panels are a very expensive investment and usually require about 15-20 years of payback. On the other hands, electricity wind turbines have much fewer prices, and their return on investment is generally within five years. However, a decision for investment requires a large analysis of payback invest, before managements make a green decision [8]. (Baker & Marchant 2015, 213.) The investment of energy self- production is a good choice only for huge warehousing and also if governments provide necessary incentives as well as enforce compulsory regulations. (Figure 3) It seems that governments' politics and power plays a vital role in green energy generation [10]. (Richards & Riding 2015, 367.)

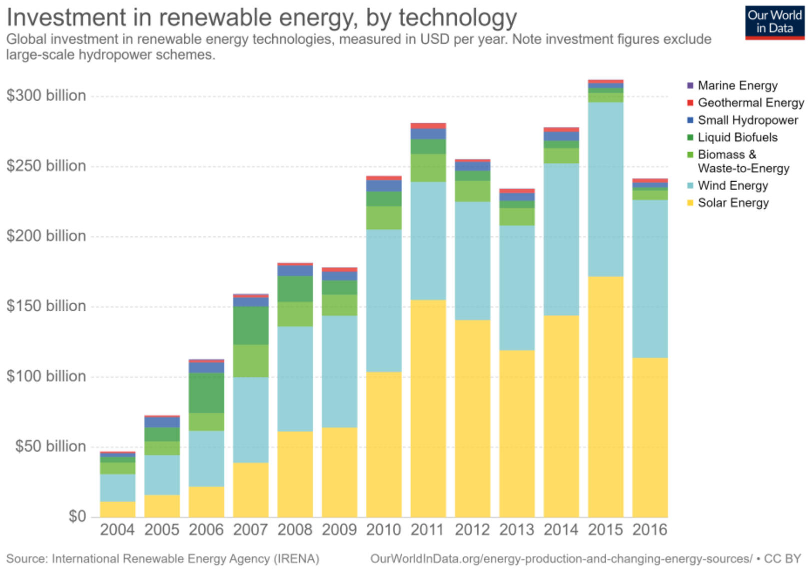

Figure 3 Global investments in renewable energy technologies, measured in USD per year (Our World in Data)

6. CONCLUSION

The research outcome can provide insightful information and directions for green logistics. These data can help to make a global picture of problems and to keep track of the situation of logistics and energy efficiency and as well as to enable better decision- making the process in the future. Last but not least, although the main direction is to implement energy self-production, this paper suggested using different and multidisciplinary solutions. The imagination for green solutions and ideas is without limit. Every idea is an additional approach; there are always needs for continuous research on green energy sources.

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COMPARISON OF BREEAM, LEED AND DGNB CERTIFICATION SYSTEM IN GREEN WAREHOUSING AS PART OF SUSTAINABLE LOGISTICS

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Abstract: *Green logistics consists of various activities that are linked to the environmentally efficient management of product flows and information in both directions from the place of origin to the place of consumption, the purpose of which is to satisfy or exceed customer requirements, and in its scope, it also includes green warehousing. Possible improvements to green warehousing, from the point of view of sustainability, are environmentally friendly, economically and socially-culturally acceptable solutions in return on individual activities of the warehouse process. They can be implemented through the efficient use of storage capacities on scientifically based operations and improvements in the storage system, which implies a sustainable construction of the warehouse facility itself and storage equipment. There are three scenarios of the introduction of green logistics possible, from the imposed rules introduced by the authorities, through the adoption of industry best practices to the mix of the first two approaches through certification systems. Over the last thirty years different building certification systems, which certify also warehouse facilities among others, have been developed. By comparing well-known BREEAM, LEED and DGNB systems, since they were created with a certain time lag, it is possible to see how awareness of ecology and sustainability within the scientific community and the economic system in Europe and the worldwide has changed over time.*

Keywords*: sustainable logistics, green warehousing, sustainable building certification*

1. INTRODUCTION

Warehousing is used to retain and slow down material flows in logistics. The role of warehousing is to dynamically balance material flows, ensuring that material is stored until it is required in production or distribution. From the standpoint of sustainability, improvements and more environmentally friendly solutions are possible. Improving energy efficiency, producing green energy or saving water in warehousing can save on operating costs and reduce the environmental footprint. Green logistics consists of various activities that are linked to the environmentally efficient management of product flows and information in both directions from the place of origin to the place of consumption, the purpose of which is to satisfy or exceed customer requirements, and in its scope, it also includes green warehousing. Possible improvements to green warehousing, from the point

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of view of sustainability, are environmentally friendly, economically and socially-culturally acceptable solutions in return on individual activities of the warehouse process.

Green warehouses as an integral part of sustainable logistics include two aspects:

- construction

The construction considers functional areas such as heating, lighting, water, energy, and waste. The design of a warehouse with environmentally friendly features such as solar walls, natural lighting, proper floors, on-site recycling, and heat-reducing power plants directly affect the level of energy required and the building's environmental footprint. A high rating by these criteria means that using these options makes the warehouse more environmentally sustainable.

- capacity

Another aspect is the capacity of a warehouse to be used efficiently in scientifically based operations: professionally receives inventory and stores it in an efficient manner, scientifically proven, until required by the market. [1] Good warehouse management takes full advantage of specialized tools and technologies, such as environmentally friendly material handling equipment, process optimization, automatic storage systems (AWS), inventory minimization programs and JIT systems, disposal products, and on-site recycling. [2]

Buildings, including warehouses, have a significant environmental impact in terms of the consumption of resources such as construction materials, energy, water, infrastructure and land they occupy through construction and operational work over the life cycle. This impact is long-lasting due to the long life span of the buildings. If mistakes are made initially and buildings are built to require high resource consumption, this will have a long-term cumulative effect. Therefore, planners and builders also have a great responsibility in reducing environmental impact and ensure sustainable development. By assessing environmental friendliness, buildings can be designed and constructed in such a way as to reduce their resource consumption.

2. BUILDING SUSTAINABILITY ASSESSMENT SYSTEMS

The sustainable development as a concept has three main dimensions: economic, social and environmental. The economic pillar is about the impact that the economic growth has on society and the environment Environmental dimension is intending to reduce the production of waste, the consumption of resources, and to preserve the biodiversity. The social dimension is about health and education, the understanding of social institutions and their role in development as well as well-being. [3]

Building sustainability assessment (BSA) systems consider sustainability throughout its life cycle. A building sustainability certificate is an instrument of compromise between the administrative (government) and commercial (industry) parties. They provide reliable marking of the sustainability of the building, through an objective evaluation of the construction and capacity. Sustainability assessment tools have emerged in Europe and have expanded rapidly to other countries, mainly Canada and the US, and to countries such as Japan, Australia. These systems function by defining a set of performance criteria for a building, grouped into different sets of criteria that form a logical structure, allowing partial and overall final assessment of the building. Each of these criteria relates to a weight factor, depending on their importance in terms of sustainability. The more important the criterion, the greater its weighting factor. [4]

The most renowned and most reliable sustainable building certification systems in the world are BREEAM, LEED, DGNB, HQE, and CASBEE. Thay certified, among others, also "green" warehouses as part of commercial buildings and are an almost indispensable condition for the construction of new and renovation of old warehouse buildings. [5]

The comparison of different assessment and certification systems is a little more complicated, given the different aspects of particular standards and the specific local specificities that play a role in the assessment, which have different ways of acting on the environment.

So far, several studies have been made comparing different certification schemes for buildings in terms of sustainability. Table 1 lists some of them covering BREEAM, LEED and DGNB systems. [6]

Table 1. A review of comparative studies that analyzed building assessment systems

Study→	**BBSR study**	**HOLZ VON HIER**	**DETAIL**	**ENER BUILD**	**SIMPLY GREEN**	**HS Mittweida**	**Klima: aktiv**	**UN-Habitat**	**SBi report**
year	2009	2010	2010	2011	2013	2013	2016	2017	2018
BREEAM	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
LEED	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
DGNB	**X**	**X**			**X**	**X**	**X**	**X**	**X**

3. COMPARISON OF SUSTAINABLE WEIGHT FACTORS IN BREEAM, LEED, AND DGNB CERTIFICATION SYSTEMS

It is difficult to compare different methods of building sustainability certification since different certification schemes cover different areas that sometimes partially overlap and sometimes do not touch at all. In addition, in each of these areas, each scheme has different weighting factors. Table 2 provides a systematic comparison of the BREEAM, LEED and DGNB sustainable building certification systems.

Table 2. A review of BREEAM, LEED and DGNB sustainable building certification systems

	BREEAM	**LEED**	**DGNB**
Title	Building Research Establishment Environmental Assessment Method	Leadership in Energy and Environmental Design	Deutsche Gesellschaft für Nachhaltiges Bauen
Launch year	1990	1998 pilot; 2000 LEED NC	2007
Assessment categories:	• Energy • Land use and ecology • Pollution • Transportation • Materials • Water • Waste • Health and wellbeing	• Energy and atmosphere • Sustainable locations • Location and transportation • Materials and resources • Water efficiency • Internal environmental quality • Innovations in design	• Environmental • Economical • Sociocultural and functional aspects • Technologically • Processes •The location

	• Innovations	• Regional priority	
Score	100%	110 bodova	100%
Levels of certification	30% < Pass <44% 45% < Good <54% 55%< Very Good <69% 70%< Excellent <84% 85%< Outstanding[7]	40 < Certified <49 50 < Silver <59 60 < Gold <79 80 < Platinum [8]	35% < Bronze <50% 50% < Silver <65% 65%< Gold <80% 80%< Platinum (Bronze is awarded for pre-existing buildings and is awarded the lowest ranking with an overall performance index of at least 35%.) [9]
Certificate	Pass		DGNB DGNB DGNB DGNB

If we compare the scoring methods of each system, we can see the difference in the importance of the particular criteria included in the assessment and the weight of each individual criterion or group of criteria in the scoring. DGNB has 5 major groups where the weighting factor is 22.5% of the total estimate, except for the quality of the process, which has a weight of 10%. In BEEAM, the weights of the criteria are different, so the main groups do not have a specific weight. The LEED rating system is generally similar to BREEAM in that the criteria have different weights based on their importance. However, the main groups individually do not have specific weights; in fact, the number and weight of existing criteria in each group determine the weight of the whole group. Table 3

Table 3. Comparison of the weighting criteria in building sustainability assessing systems [11]

	BREEAM	LEED	DGNB
Energy	17%	32%	5%
Internal environment	13%	14%	14%
Water	6%	9%	1%
Materials	11%	13%	1%
Waste	7%		4%
Location	13%	13%	10%
Construction phase	4%		1%
Transport	7%	11%	3%
Economy	2%		20%
Innovation	9%	5%	
Other	10%	5%	42%

shows a comparison of the weighting of the individual criteria as they are scored in each rating system. In addition, there is a difference in meeting the minimum requirements. This issue is defined as a prerequisite for LEED, and as a mandatory score in BREEAM; which means that some of the criteria are a mandatory prerequisite and that a minimum score is required for all projects. This ensures that there are some fundamental elements in the project. There are no mandatory criteria in the DGNB; however, the minimum score achieved in each of the five main groups is taken into account. A certain minimum score is required in each of the five major groups, plus the total percentage of assessment points across all groups. This guarantees a minimum level of quality for all project elements. [12]

Comparing the weightings of the three dimensions of sustainability (environmental, economic and social), the environmental criteria for LEED (62.3%) and BREEAM (56.3%) are significantly higher than for DGNB (22.5%). At the same time, LEED does not require a specific life cycle assessment (LCA) of building materials, BREEAM requests an estimate of LCA for building materials, while DGNB requests an LCA for the entire building. [6]

According to Jansen [13], most certificates are developed with a particular focus on environmental or social dimensions, while the economic dimension lags behind. Most certificates focus most on criteria within the environmental dimension (52%). After that, the emphasis is on the social dimension (43%), where special attention is given to the health aspect through the emphasis on the internal environment. The economic aspect is very low in certificates (5% on average, with the exception of DGNB).

4. CONCLUSION

Warehousing and office activities in logistics companies are performed inside buildings. In accordance with sustainable logistics, these buildings must meet environmental, social and economic criteria. The systematic approach tried to work on energy conservation, improvement of working conditions and the internal environment related to the quality of air, water, and light from the design phase, through use to demolition phase, material recycling and final disposal throughout the life of the building. There are various systems for building sustainability assessing on the market. In the beginning of the development of the BSA system, the emphasis was on environmental protection, as shown by the criteria by which to evaluate and their weight factors in the first assessment systems such as BREEAM, while over time, the need to balance assessment and impact and the economic factor in assessment, not just environmental and social. From a sustainability perspective, a holistic approach for all three dimensions ecological, social and economic, is needed in order to keep the system balanced. According to our research, it is obvious that individual certification systems place very different levels of focus on each of the dimensions. Due to its holistic approach and almost equal weighting of environmental, social and economic aspects, the DGNB is more focused on sustainability than other relevant certification systems, making the DGNB a most balanced certification system with a focus on sustainability rather than only on an environment. [13]

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SIMULATION OF STORAGE PROCESSES SUPPORTED WITH BARCODE AND RFID TECHNOLOGY

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Abstract: *Barcode and RFID are widely used in warehouses of the logistics supply chain to track and locate storage units, track manipulation equipment and the state of storage locations. Dependent on the needs and design of the warehouse and the way its operations are executed, one identification system can be used more frequently than the other. The choice of either system can benefit the data accuracy, the increase of resource utilization, in shortening the waiting times for operation execution and help increase the overall efficiency. This paper aims to show certain differences when barcode or RFID technology is used, on the example of the reference warehouse system. Both barcode and RFID systems are tested through the simulation model and the results enable the comparison of key performance indicators, through the needed process and waiting time for checking goods which flow the system and regarding the utilization of the material handling equipment for both cases.*

Keywords*: warehouse management, storage processes, barcode, RFID, simulation*

1. INTRODUCTION

The application of information technology in logistic processes is vast and covers the use of different hardware and software. Logistic companies use information technologies to track their business in real-time through the supply chain. Logistic information systems such as warehouse management systems (WMS) are used for the planning, tracking, and control of logistic processes execution. The successful use of warehouse management system needs to be supported with the information from different sources. Most of the information comes from barcodes or RFID tags. The warehouse storage locations are often labeled with barcode or RFID tags and storage units from pallets to single products also. Warehouse operators are equipped with different reading devices which can also be found on manipulation equipment, and different locations such as warehouse entrance or exit docks. The existing warehouse design and its environment need the right combination of equipment, manpower, data sources, and a control system.

Many research papers report implementations of barcode and RFID in appropriate situations. Besides the item identification role, the barcodes are successfully implemented

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for warehouse operations management. Barcodes are used for inventory management [1], for the purpose of locating the warehouse autonomous mobile lifting robots [2], and also for the optimization of the spare parts warehouse control process in a combination with the cloud application [3].

Previous research report that the application of barcodes in warehouses result in fewer errors and better warehouse management. As concerning the RFID, the implementation field is even larger. Besides locating products in the warehouse [4], there are also other applications of this technology in the warehouse, like in [5], where it is reported that the RFID was used to track storage shelves. The introduction of RFID technology supported the decision management system and reduced transportation costs and lead time. In the case presented in [6], the RFID is combined with drones and blockchain technology to automate the warehouse inventory operations. The performance testing results have shown a significant improvement in the speed of doing warehouse data collection and locating items in favour of the automated system vs. the speed of an operator.

Which combination of the mentioned technological elements (barcode, RFID) has shown time and cost-effective and also as efficient? This paper examines the case of a warehouse designed for pallet storing. Warehouse process mapping is done, covering the use of barcode and RFID. First, the processes mapping via modelling language helped to understand all the necessary process steps and after that, the simulation parameters were set up.

Simulation is used for the comparison of the usage of two different technologies for tracking of goods, as well as barcode and RFID, which are applied on a simulation model of the storage system. For this purpose, the material flows simulation software Enterprise Dynamics was used. For the needs of process mapping and simulation, the general example of the pallet warehouse is used, which covers the most common situations which can be found in real systems.

The example experimental storage system contains six entrance and three exit docks, conventional pallet racks for pallet storage, two forklift trucks and ten pallet trucks of cargo handling equipment in the storage facility. The performance parameters for the given example cases are the result of computer simulation of these processes.

2. PROCESS MAPPING

Process modeling is done with the BPMN modeling language [7], which enables to map the process as a set of connected events and activities. Activities can be additionally connected with organizational and information resources. Logical gateways are also used (and, or, xor) for process flow branching, supporting the parallel flows, decision making, and loops. There are two setups which can be discussed here, first is process supported with barcode only, and the second is the process supported with RFID technology. Because of the process models size, only the storing process supported with barcode is presented in the paper (Figure 1).

Storing products into warehouse storage location is a process consisted of several activities. The process starts when the supplier delivers the products on pallets. Warehouse operator needs to do the qualitative and quantities check. One of the steps during this check is that each pallet needs to be scanned with the barcode reader. If the products don't pass the control, the process ends with the complaint to the supplier. In another case, the reception order is created in the WMS and the pallets are bar-coded for storing purposes. The warehouse operator does the storage location assignment and the available locations are updated in the WMS database. Also, the operator assigns the picker which will do the physical storing of the pallet into the storage location. The data on the reception order is updated in each of the previous steps. The picker scans the barcode of the reserved storage location and the pallet and stores the product. Storing of products results with the WMS database update (storage location content and inventory levels) and the closing of the product reception order.

The RFID technology does not change very much the process itself, but rather improves it. The single pallet scanning is now replaced with vehicle RFID scanning at the warehouse gates, thus enabling the multiple pallet identification. The activity of single pallet barcode creation is eliminated. After the storage location and picker are assigned, the pallet RFID data is updated. Storing of pallets does not involve the barcode reading for each storage location and each pallet. The RFID tags enable reading data remotely thus updating the data for the WMS.

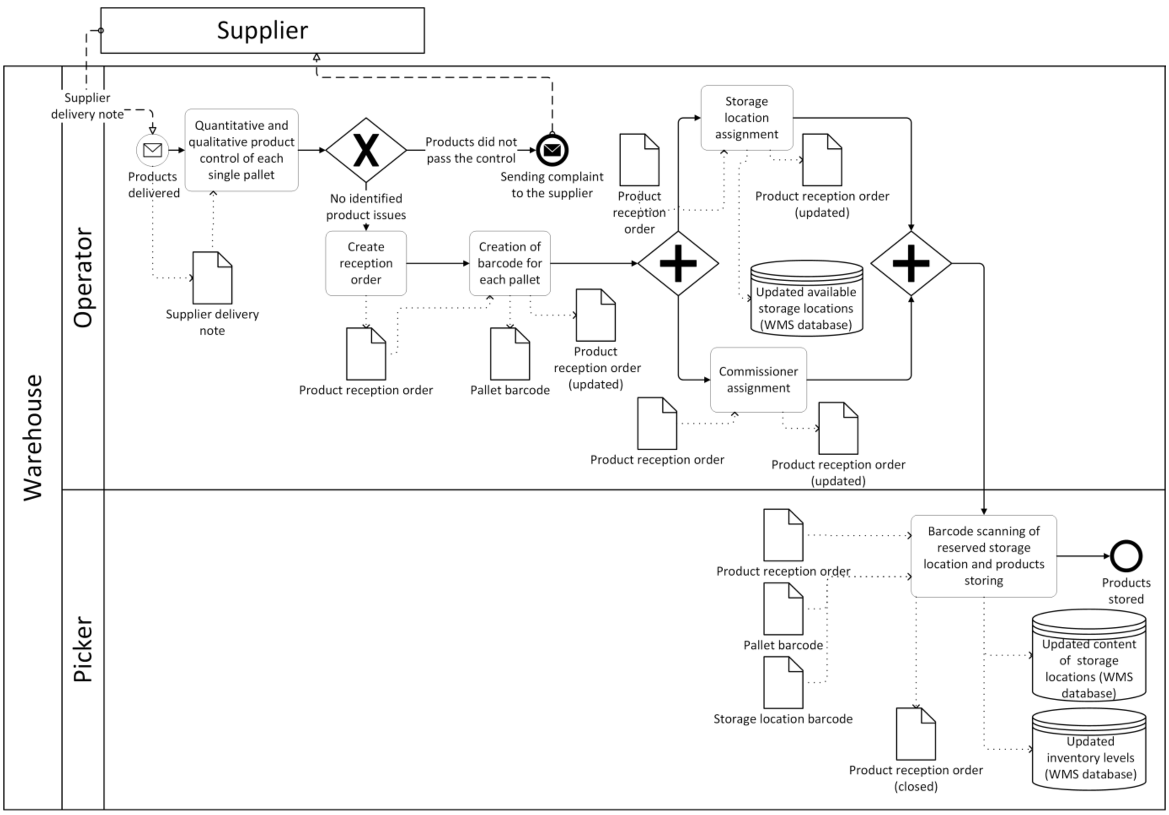

Figure 3: BPMN model for product reception process with applied barcode

Retrieving and dispatching of the products from a storage location is the second observed process. The process begins when the purchase order is received. Based on the purchase order, the operator creates the Products transfer order in the WMS software. After the order is created, the operator uses WMS software to locate the products in the warehouse and to assign the picker. After that, the picking operation can start. For products picking, the picker uses the barcode reader to read the storage location and pallet barcodes. After the products are picked the content of the storage location is updated in the WMS database and the products transfer order is updated. Next operation is products packing and dispatching. The inventory levels in the WMS database are updated and the delivery note is printed and dispatched along with the purchased products. If the process is set up with the RFID technology, then the readings of the pallet and storage location data can be done remotely during the picking step. This makes this step less time-consuming. Also, the barcodes from the initial process setup are now unnecessary.

3. SIMULATION RESULTS

Simulations enable observation of the entire system and detection of eventual irregularities, bottlenecks, and problems that occur in the material flow, as well as testing and validation of potential solutions for their elimination[8]. Optimization of a storage system is a necessary step in the process of material flows optimization, particularly due to the relatively high costs it can generate in a supply chain.

The simulations for both models were performed for the time frame of one working week. In the storage system goods arrive with repeat strategy by a normal distribution of 3 hours with a deviation of 1 hour at the time, within 32 pallets per truck. The pallet trucks carry pallets into the entry zones of the storage, with each of pallets with products passing through bar code (in the first simulation model) and RFID scanning (in the second simulation model). After that, the forklift truck picks them and bring them into the storage area to a predefined pallet place by WMS. When the ordered product needs to be carried out from the storage area, the pickers take required products (articles) and put them into the pallet truck. In the exit zone of storage, the pallet unit that consists of required products is formed, and it is also checked out from the storage by barcode or RFID technology. Further, the pallet unit is prepared to be carried out to the exit dock by a pallet truck. The load and unload time of handling equipment is defined by a normal distribution. Related to that, the pallet trucks that carry pallets into and out of the storage is 10 seconds with 5 seconds deviation. As regards forklift truckload time is 10 seconds with a deviation of 5 seconds, unload time is 20 seconds with 10 seconds deviation. As concerns the storage system with applied barcode technology, the picking forklifts load time is 15 seconds with 5 seconds deviation, and unload time is 7 seconds with 2 seconds deviation. In the case of applied RFID technology, the picking forklift has set up load time 7 seconds with a deviation of 2 seconds, and also the unload time with 4 seconds and 2 seconds deviation. Needed time for goods identification in the input and the output zone also depends on the applied technology. Therefore, the identification time is defined by normal distribution for the applied barcode is 120 seconds with 20 seconds deviation, and in the case of RFID is 2 seconds with 1 second deviation.

Simulation results of the model with applied barcode technology point out (Figure 2) relatively low level of utilization of forklift truck serving the input zone of the storage, only 40%, as well as for the output zone (50%). The utilization of the forklift that carries pallets into the storage zone of the system is 86%. The pallet trucks that perform the picking goods from storage have utilization of 100%, which includes about 60% of traveling full, i.e. with goods by order, and the average time of waiting goods to pass through barcode scanning of 2.5 - 3 minutes.

Simulation result of the model with applied RFID technology (Figure 3) for a pallet truck serving the input zone of the storage has utilization of an average of 40% of the time, which depends on goods arriving time and quantities. Utilization of the forklift truck that carries pallets into the storage zone is 83%, which is higher regarding the results from the first simulation model. The pallet trucks, that perform the picking of goods, have maximal utilization of 100%, including about 70% of traveling full, which implies on higher picking efficiency where RFID technology is used. Utilization of the pallet truck that serves the output zones amounts to 60%, which points out that with RFID technology the output zone accumulates products faster, and therefore, the utilization of the handling equipment that observing them is higher.

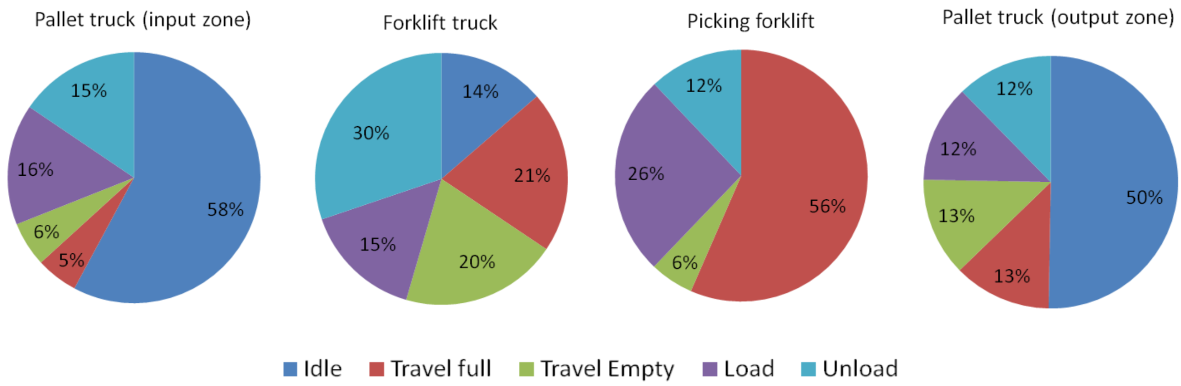

Figure 4: Simulation results of the storage system with applied barcode technology

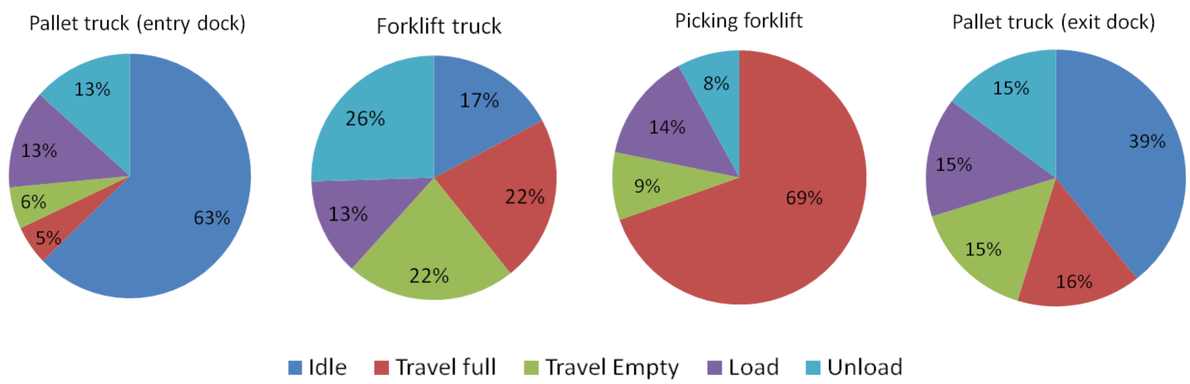

Figure 5: Simulation results of the storage system with applied RFID technology

Based on the parameter comparison presented in table 1, several conclusions can be made. By applying the barcode technology needed time for scanning products that arrive in the storage also depends on the number of goods that the pallet unit containing, while applying the RFID technology scanning occurs simultaneously and it is not dependent neither of goods number or quantity. Order picking efficiency per picker with applied RFID technology is for 10% higher compared to the barcode, because there is no need to scan every product (article) in the picking process, which indicates a great saving of order picking time relative to barcode technology. Further, in this type of simulated storage system, the obtained result also implies consideration of the optimal quantity of handling equipment, as well as pickers. Handling equipment utilization at the output zone, respectively dispatch zone is for the 10%

higher with applied RFID technology, as mentioned so far, there is no waiting when products need to be scanned. The storage system simulation model with applied RFID technology also indicates that using RFID technology provides a greater number of dispatched pallets from the storage, from 15% to 20%.

Table 4: Comparison of storage system simulation results

	Waiting time at the input/output storage zone	Equipment utilization through picking orders	Equipment utilization through dispatching goods	Approximately amount of dispatched goods (pallets/ week)
Barcode	2.5 - 3 minutes	60%	50%	5500
RFID	/	70%	60%	6500

Simulation results also point out that the waiting time of pallet, until it gets ready to be placed at the storage area, is 50% higher with applied barcode technology, and process time for dispatching goods is 73% higher regarding RFID technology.

3. CONCLUSION

Storage systems are an integral part of each supply chain and significantly impact the total supply chain cost. Therefore, it is necessary to make a selection of goods tracking systems in the way that storage can perform optimally regarding the required capacity, utilization of equipment and other performance indicators.

Based on the characteristics of the storage system with applied barcode or RFID technology, a performance of both technologies, the same volume of goods flow and the obtained simulation results, it can be concluded that usage of RFID technology represents time-saving through scanning, tracking and manipulation of goods, better utilization of handling equipment, as well as indications for manpower reduction.

Further research step would be the simulation of the system where each product is labeled with RFID, and regarding this a financial analysis of both technologies, with aim to check if the usage of RFID technology pays off in comparison to barcode in this type of system.

ACKNOWLEDGMENT

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EVALUATION OF SELECTED MATERIAL FLOW SIMULATION SOFTWARE

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Abstract: *Computer simulations are increasingly used for the analysis of complex systems. Several different simulation programs can be customized to different systems and each of them has its advantages and disadvantages. The topic of this paper is the evaluation of two software, Enterprise Dynamics and Simio, used for simulations of material flow. The research was carried out by creating a simple warehouse simulation model with the same input parameters in both mentioned software and performing a parallel analysis of their characteristics. Some of the important characteristics of the software were observed: user interface, the library of objects and symbols, given notifications of possible errors through the model creation process, performing experiments, representation of simulation results. As a conclusion of this paper, a comparison of the defined evaluation criteria for the software is presented.*

Keywords: *simulations, Enterprise Dynamics, Simio*

1. INTRODUCTION

Computer simulations have become a powerful tool in logistics processes that lead to optimization through iterative variations and parameters repetition. They apply to practically all dynamic processes that occur over time in the stages of planning, designing, construction and exploitation. Also, they provide opportunities for analysis and experiments - both with real relationships and parameters in a system, and in dangerous cases of system states that are realistically impossible and difficult to perform, with dangerous consequences for objects and the environment.

Considering that there is significant number of material flow simulation software in commercial use and that all of them offer similar possibilities, but at the same time, significantly differ from each other, within this paper, two material flow simulation software, Enterprise Dynamics and Simio, are compared according to the predefined characteristics. After a year of using and knowing both software, their evaluation was done through the characteristics, advantages or disadvantages of their implementation and capabilities they offer. In this regard, a basic warehouse model is developed, consisting of

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two input/output ramps, two input/output zones and a storage zone. Handling equipment that is used to perform storage processes are two pallet trucks, one of them serves the input and the other one serves the output storage area. It also includes two forklift trucks - one intended for pallet storage and the other for unloading of goods to the exit zone. For the purpose of pallet storage, conventional pallet racks are used (6 racks with 288-pallet positions).

In order to evaluate these two software, the same simulation models have been created in both software and thereafter compared according to the following eleven characteristics: user interface, objects library, input objects possibility, symbols library, creating model network and constraints, programming, user friendliness, notification errors, experiments execution, graphics and simulation, representation of results.

2. ENTERPRISE DYNAMICS SOFTWARE

Enterprise Dynamics is a software package capable of simulating the real life issues of an external problem, as well as for solving any complex problem of people, processes, technology, and infrastructure. The domains in which the software can be applied are automotive, electronics, manufacturing, materials handling, air transport, water transport, port terminals, rail transport, health care, banking and finance, public and services, supply chain management, logistics and distribution, sports and events, as well as for education itself. [1]

It enables complete analysis, visualization, and optimization of the performance of a given system at any time of usage. The software contains a great library of simulation objects-atoms needed to simulate any real system, whether it is real and already existing, or just in the development phase. The installed objects can be subsequently and individually configured to fulfil the user's needs.

Simulation results can be represented through reports, diagrams and histograms, which give an insight into the system's behaviour throughout the simulation, as well as an overview of the characteristics of each atom. Also, within the 2D simulation view, there is a possibility of a realistic, 3D, environment view that provides a better insight into the reality, reliability, and credibility of the analyzed system.

Figure 1 is a 2D visual representation of the basic model, together with a window for adjusting the simulation flow, as well as the duration of the simulation clock, and Figure 2 shows a visualization of the model in 3D.

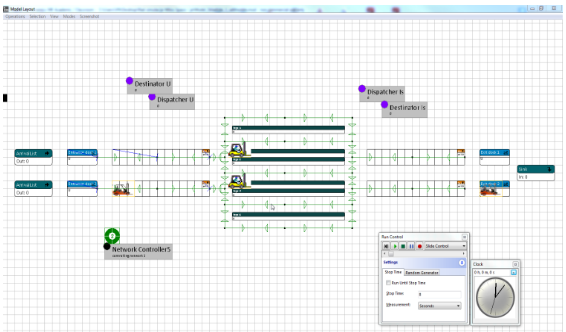

Figure 1: 2D model view of basic warehouse model

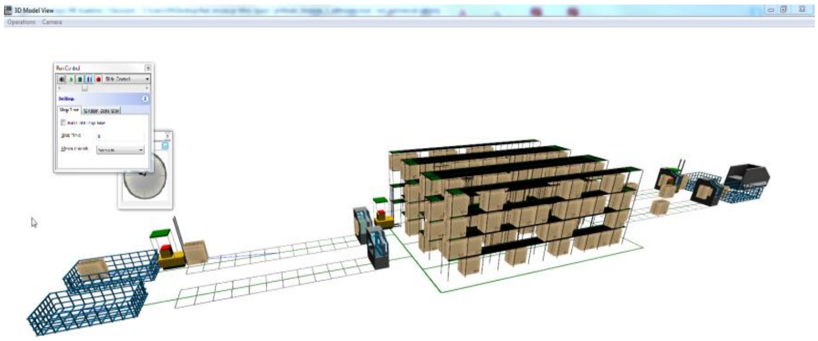

Figure 2: 3D model view of basic warehouse model

3. SIMIO SOFTWARE

The flexibility of Simio software is that models based on systems various risks and failures can be performed. For this reason, Simio is widely used in manufacturing industries, queue-based systems, and primarily in industries with full automation. The basic models on which the software was developed are models of work organization at airports. [2]

Simio software is characterized by having the so-called *Smart* objects. In the model, these objects can interact with other objects and direct the entities where they will move through the model. This enables users to create optimal movement paths in the model, to minimize waiting time at individual places, and to find and remove system bottlenecks. [2]

Another great advantage of this software is that it can be easily linked to different databases. Also, it is possible to import different files exported from the database, which defines the individual characteristics of objects, in which different experiments can be performed.

The basic representation of the simulation results is through the Pivot tables. For each object, these tables represent a number of different information: percentage of time used, percentage of utilized capacity, average number of entities passing through the facility, maximum and minimum number of entities simultaneously located in the facility, total traveled distance (if the objects of the vehicle are observed), as well as the average, minimum and maximum distance traveled by individual operations.

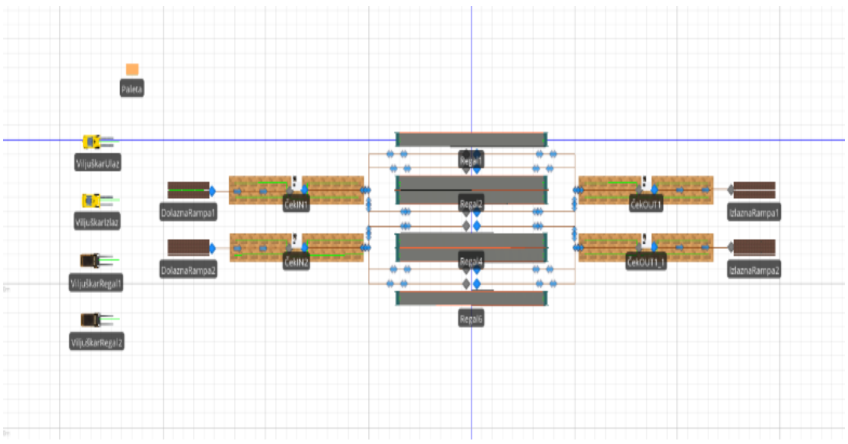

Figure 3: 2D model view of basic warehouse model in software Simio

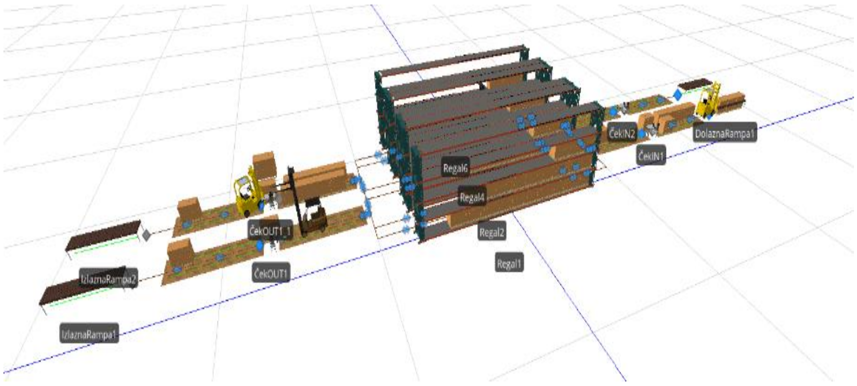

Figure 4: 3D model view of basic warehouse model in software Simio

4. SOFTWARE ANALYSIS

Within the paper, a parallel analysis of two software was performed, Enterprise Dynamics and Simio. For each software, a short description of the basic functions is provided when creating the simulation model as well as the ways of displaying simulation results. Also, included in this chapter is the comparative overview of differences and similarities, that will be mentioned later, followed by an analysis of the advantages and disadvantages according to certain criteria.

Creating Objects - Simio and Enterprise Dynamics software both have a great library of objects from which each object can be applied by simply dragging it to the desktop and placing it in the right place. When an object is inserted into a model, each of the 3 dimensions of the object can be defined as well as its exact position in 3D space. The object library contains a large number of objects for creating different models, such as physical flows of materials, flows of fluids and information. In Simio software, apart from defined objects in the library within the software itself, it is possible to download various defined, completed objects that can be easily imported into the software, unlike Enterprise Dynamics which is, as far as we were able to investigate, not able to do so.

When selecting objects, each contains several parameters that need to be defined. If the selection does not contain the appropriate parameter that needs to be defined in order to describe the object more detailed, there is a possibility of programing or entering certain records (in ED 4Dscript) that can be found in the help section of the program. 4DScript is a powerful simulation language that is a part of the Enterprise Dynamics. When creating objects in Simio, a new tab opens that contains a large number of parameters that can be defined for the correct operation of the object. If more detailed description of the object is needed and definition of his operation, that can be done in an additional Definitions tab, which can describe in detail the characteristics of each object, element, connection, or further explain each function in the model. The more accurate definition of the input parameters of the simulation, which applies to both software, enables more relevant results.

Creating connections between objects – The Simio software is different in the way of creating and defining dynamic objects as well as nodes. Each object contains two nodes, one basic node and one Transfer node. Dynamic objects, or paths, are created simply by connecting nodes in objects by dragging paths from the object library and clicking on two objects that connect. Base nodes are used as input nodes to the object, and Transfer nodes as outgoing ones. Base nodes have a fixed capacity and the type of connection that can reach them can be defined. Transfer nodes also have a fixed capacity and the type of connection that can be associated with them can be defined, but unlike base nodes, these nodes can also define the route the entity will navigate if there are multiple connections, as well as the choice of a transporter that will process entities. Transfer nodes are the basic places where routing and defining the logic of moving entities across a network are performed. In Enterprise Dynamics software, the creation of connections between objects is also done through nodes and the network formed by their connection defines the path and direction of the objects.

Routing - When a system is created, all objects and their connections are built, and every object presented as a symbol in 3D view, it is necessary to define the paths on which the entities will move within the model. This is also the final step in creating some of the basic models of storage and production systems. The routing, that is, the selection of paths along which entities and vehicles will move, is done with Transfer nodes. If there are more than one connection on a Transfer node connecting it to two or more Base Nodes, it is necessary to determine the destination to be reached by the entities. There are 3 basic ways of routing on the network. The first way to select the link along which entities will move is Random selection, where the entities move randomly. The second way is by the importance of connections, where each path is assigned a "difficulty" and the entities first select those connections that have a greater defined importance, and if the object at the other end of the connection is occupied, then the entity selects the next path in importance. The third way of routing is based on a matrix, which defines the exact characteristics of objects that go along specific paths depending on the object located at the other end. If there are multiple paths to the same objects then each of them can be assigned certain "difficulty" on the basis of which the entities make the connection selection in the described manner. In ED, defining the routes along which certain atoms would move does not exist as an option, but it can be defined by adjusting the atoms individually, or by entering a specific 4D script that would define each atom movement.

Review of the results- Once a model is formed, an analysis of its operation under defined conditions can be performed. After finishing the simulation, results are obtained, the basic representation of which can be selected for each object. For each of the observed objects, a number of parameters are displayed, some of which are most significant: percentage of time spent, the percentage of utilized capacity, average number of entities passing through the object, maximum and minimum number of entities simultaneously located in the facility, total distance travelled if observed vehicle objects, as well as average, minimum and maximum distance travelled by individual operations. The results can be extracted in a form of a table, a report can be extracted by object or by group, and can be displayed graphically. All results can be obtained for a defined period of time, and can be displayed in real time during the experiment.

4.1 Evaluation criteria

In the table below software evaluation criteria are presented, including evaluation grades for both software. The grades are from 5 (insufficient performance) to 10 (remarkably).

Table 5. Software Enterprise Dynamics and Simio criterias and rating

Criterion And Rating		**Simio**	**ED**
User interface		10	9
Objects-atoms library		10	10
Input objects possibility		10	9
Symbols library		10	10
Creating a model network and constraints		10	9
Programming		8	10
User-friendly		10	9
Type of notification errors that occur	When creating a model	10	9
	During model implementation (simulations)	10	9
Experiments execution in model		10	10
Graphics and simulation		10	9
Results representation		9	10
Total		9.72	9.45

In Simio software, the User interface is rated 10 because of its simple display, the interface in the program is selected in several tabs that are easy to navigate and can be viewed simultaneously: desktop, tabs with basic categories for model creation and simulation running, basic object library and a space to define the detailed features of an object (ED does not have that possibility). In addition to these tabs, there is a "Back" button that allows you to step back.

The library of existing objects of both software receives a rating of 10 for the reason that the basic library contains a wide range of different objects for creating material and fluid flows. The criteria for the possibility of importing new objects in Simio software is rated 10, as it is possible to download various additional objects on the official software website of the software, which can easily be imported into the software. In addition to the large number of objects in Simio software, there is a wide range of 3D symbols that can be used to 3D presentation of the model, and for this reason Simio is rated 10 by this criterion.

In Simio software, the network is created by selecting any connection and simply clicking on Transfer and on the Base node, so that the two objects become connected, and the definition of the network is done directly in the links, which characterize the conditions of movement on it. For this reason, Simio receives a rating of 10 for the mesh creation criterion. According to the programming criteria, Simio gets a score of 8, because it is possible to create all operations through the logic of performing individual steps, but there is no ability to write codes, which is possible in ED through 4Dscript. Simio is very accessible when creating models for the reason of offering the description of each function when placing an arrow on the same and that is the reason why it receives a rating of 10 in this section. Simio, during the model creation and implementation of experiments, offers constant reports if an error occurs and suggests how it can be eliminated, and for these reasons, in these categories receives a rating of 10.

According to the criterion for experiments execution, both software gets a rating of 10 because the program allows the creation of different scenarios that take place under certain conditions and executes each scenario in parallel and displays the results.

In the criterion of graphics and simulation, ED gets a rating of 9, and Simio 10 because it has a very high quality of 3D models with moving animations that can very well represent a realistic system. When displaying the results, both software has the ability to display the results in plot tables in which the view can be selected by each object, gives the ability to display reports for each object and for the whole model, can graph the results obtained in the form of graphs and histograms, but in Simio they need to be predefined otherwise they will not be displayed. For these reasons, Simio is rated 9 by this criterion.

5. CONLUSION

Using both software throughout the period of one year, after having the same limited knowledge of both software, it can be concluded that both software can help in material flow problem solving of different systems. Both software enable detection of material flow bottlenecks and testing of the potential solutions for their removal. The application of the software allows users to obtain information on the functioning of the system and indicate any irregularities in a relatively short time. The most noticeable difference between these software is that Simio is more user-friendly, which at first glance, makes it easy for users to implement and master program commands and functions. However, Enterprise Dynamics offers us a great programming opportunity during parameters and functions programming in the system, which giving users wide usage capabilities. Therefore, both software can be strongly recommended.

ACKNOWLEDGMENT

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BASIC PRINCIPLES OF INDUSTRY 4.0 AS THE FOUNDATION FOR SMART FACTORIES AND DIGITAL SUPPLY NETWORKS

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Abstract: *In the era of the Industry 4.0 and the IoT, efficient production management and information flow become the task of independent digital systems. These systems are based on rapid data exchange between identification systems, smart control units and implementation systems. The efficiency of data processing represents the crucial step for establishing smart material flow which represents one of the main characteristics of smart factories. IoT provides the possibility for the communication between control units and implementation systems (manipulators, i.e. robots). By giving a certain level of self-awareness to manipulators, a great level of flexibility of the production system can be achieved. In this paper, a short overview of the basic principles of the Industry 4.0 is given. Necessary elements of the Industry 4.0 which have to be adopted in order to establish a smart factory and digital supply networks are shown. The concept of the smart factory functioning is presented. What are the traditional production processes which can be upgraded to the smart level is pointed out and the means for accomplishing are also provided.*

Keywords*: Industry 4.0, IoT, smart factory, digital supply network*

1. INTRODUCTION

Industry 4.0 is the Fourth Industrial Revolution which is currently going on. Three revolutions preceded the fourth one [1]:

- Industry 1.0 – The invention of the steam machine which introduced mechanical operations that slowly replaced human and animal labor.
- Industry 2.0 – The era of mass production began by introducing the first production line.
- Industry 3.0 – Usage of first programmable logic controllers enabled the production automation and introduced the possibility for controlling production processes.
- Industry 4.0 – Represents the industry which consists of full production automation, independent data exchange, cloud data sharing and storing, robots, AI (artificial

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intelligence), IoT (Internet of Things). It connects systems that were separated until now – IT (information technology) engineering and OT (operational technology) engineering. By combining them, it creates unique autonomous system which is not dependent from mankind. Industry 4.0 makes production smart.

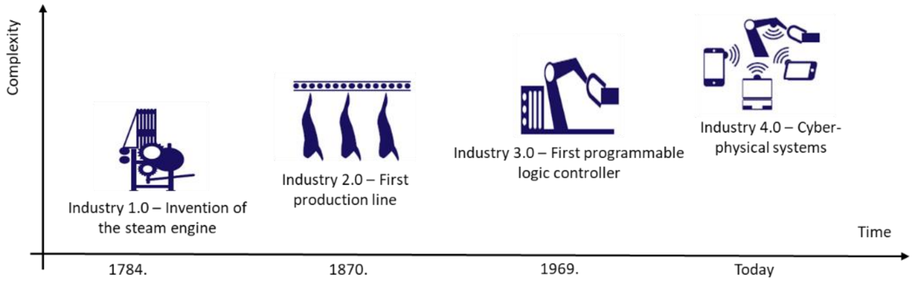

Figure 1. Stages of industrial revolutions

2. INDUSTRY 4.0 & IOT

The easiest way to define Industry 4.0 is to define its product – the smart factory. Within smart factories, the production is done by robots and robotized machine tools. They communicate via IoT, they bring decisions on their own and keep data on the cloud. Data is stored on a remote server. Cloud storage has many traditional storage incomparable advantages, whenever and wherever possible data access, on-demand resource deployment etc. However, Industry 4.0 overcomes simple factories, Industry 4.0 covers complete production systems, from the energy needed for operations, logistics to resource management. Industry 4.0 represents the integration and digitalization of all systems and subsystems important for production.

IoT is the key component of the Industry 4.0. It provides the possibility to network all components of a production system. It enables centralized control of all systems without a physical connection. It also provides the possibility for components of the system to communicate. [2]

3. HORIZONTAL AND VERTICAL PRODUCTION INTEGRATION

One of key features of Industry 4.0 concerning digital supply networks are horizontal and vertical production integrations.

Horizontal integration means networking all participants that are included in the creation of one product. The goal is to upload all relevant information on the cloud so that the communication can go autonomously. The idea is to eliminate the human factor as much as possible. Horizontal integration will be shown in the next example:

The idea of a new product is born based on digital surveys. The human task is to shape the idea and upload it to the cloud where it is available for IT systems. The IT system creates an online marketing campaign which targets people and based on the reactions, first orders arrive. In this step, human influence ends. IT system begins the procurement of raw materials, organizes transport and warehousing of raw materials. Then the system demands new equipment if necessary, gives tasks to the robotized tools and stores all data on the cloud. Later, the system organizes warehousing of new products and the transport to customers by autonomous guided vehicles (AGV). The goal is to achieve greater efficiency with minimal money cost. By integrating AI, IoT, cloud, material flow simulation, energy and money, exceptional profit can be achieved.

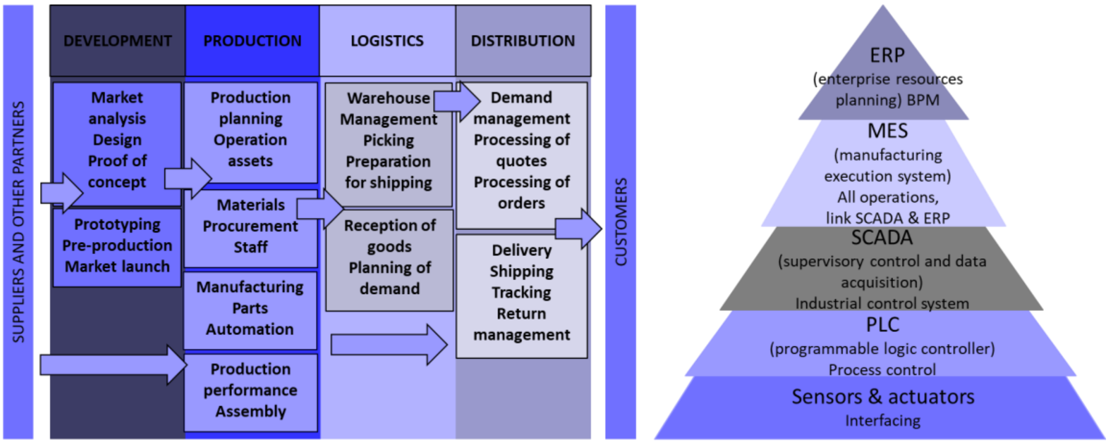

Figure 2. Horizontal and vertical production integration

On the other hand, vertical integration represents the integration of data and IT systems during production processes.

Sensors and actuators are placed into the Field level. They are the interface of every single process. The second level is the Control level. PLC is used for regulation of machine systems. The third level is the Production level. SCADA systems are used for monitoring, control and supervision of the product line. MES systems are placed on the fourth level which is the Operations level. They are responsible for production planning, quality management and OEE (overall equipment efficiency). The fifth and final level is the Enterprise planning level. It is in the control of order management and processing, enterprise planning, business process management (BPM). The goal of the Industry 4.0 is to make the fifth level independent from human interactions [4].

4. DESIGN PRINCIPLES OF INDUSTRY 4.0

There are six main principles of Industry 4.0, fig. 4. They are interoperability and interconnection, information transparency e.g. virtualization, decentralization and autonomous decisions, real-time capability, technical assistance and service orientation and finally, modularity.

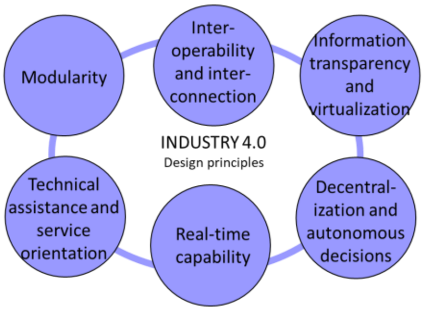

Figure 3. Six main principles of Industry 4.0

System connectivity is based on IoT and it is essential to establish horizontal and vertical integration. By establishing the connection between tools and superior systems, cognitive system management can be implemented, i.e. the possibility to learn based on received information is provided to machines.

The transparency of information does not only mean that all information is available on the cloud, it also means that all objects, processes and systems are transformed into virtual objects which enables simulation and optimization of all processes.

Decentralization and autonomy imply lowering cognitive management on the level of certain objects. It means placing AI in every single tool and enables independence during decision making conceived on information available on the cloud.

Operation in real time implies the possibility to make changes in the production every moment. By connecting systems and giving them the decision-making autonomy, they become capable to react instantly when a problem occurs. It is important that system components can be swiftly changed in order to provide autonomous and predictive maintenance.

Technical support represents the connection of the product and the production system after the product goes to exploitation. All gathered information, which an intelligent product can collect, is returned to the production system. That enables product users to be guided in the case of a product malfunction. Even more, it enables production systems to analyze manifested errors and, based on them, to improve future products.

Modularity is the essence of the production by order. It provides the possibility to change certain parts of a product during production in accordance with customer’s desires.

5. THE SMART FACTORY

The smart factory represents the next step in the evolution of automation. It represents a fully connected and flexible system which processes continuous data flow in order to improve itself and be more adaptive to new demands. Usage of the mentioned segments in previous paragraphs enables crossing from linear, sequent, supply chain operations to interconnected, open supply chain operations, i.e. to digital supply network which integrates information from many different sources and locations, processes them in real-time and drives the physical act if production and distribution[3].

By integration of all data, a more efficient and agile system can be achieved. Also, by less production downtime and better possibility to predict and adapt to production changes can be achieved. This provides a better position of the factory on the market.

The term automation refers to one discrete task or process, for example opening of a valve or starting a pump depending on predefined rules. By introducing AI and sophisticated cyberphysical systems which can integrate physical production processes with the trends on the market, automation gets a new meaning which refers to independent decision making that was done before only by humans.

Based on the new automation definition, the smart factory represents a flexible system which has a self-optimization possibility based on the received real-time data. It is also capable of autonomously running the whole production process. The smart factory changes in regards to requests which arrive – changes of the customer’s desires, breakthrough on new markets, development of new products or services and all of that by virtue of the IT development.

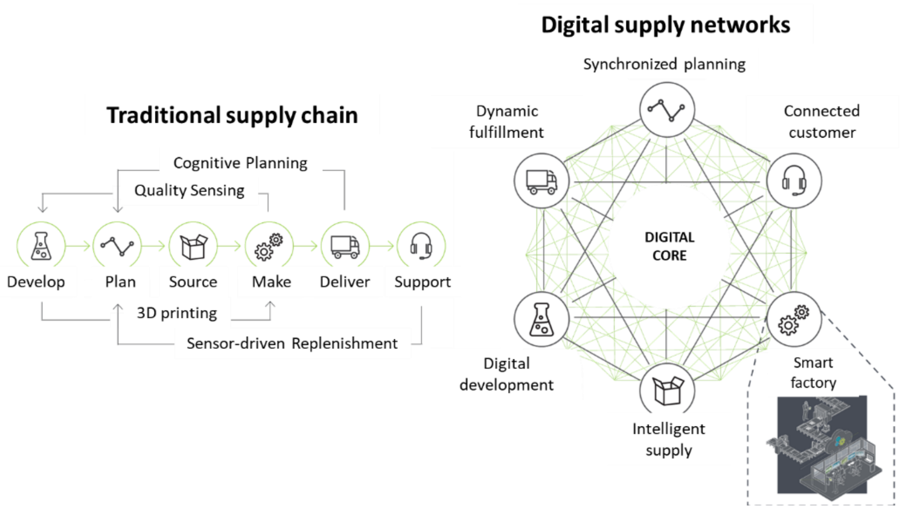

Figure 4. Transition from traditional supply chain to digital supply network [4]

The smart factory can be described through five main characteristics:

- Connectivity – the interconnection of systems is one of the most important characteristics. Smart sensors are used which continuously collect data from the production lines and, with the information which comes from the market, enables a view of upstream and downstream supply chain processes which provides greater supply network efficiency.
- Optimization – optimization of a system represents a balanced production flow and extremely high system efficiency. Furthermore, the energy management gives a great contribution to cost cuts.
- Transparency – it enables a better overview of the production processes based on the available data on the cloud.
- Proactivity – gives the opportunity to production participants to act before a problem occurs. This characteristic enables the recognition of production anomalies which can lead to defects or cost increases. Based on proactive maintenance, significant cost savings can be achieved due to absence of unplanned production downtimes.
- Agility – provides for smart factories the opportunity to adapt to production changes with minimal interventions. Robots change their operating tools on their own by ordering tools from the storage which lowers the downtime and increases the profit.

6. THE IMPACT OF SMART FACTORIES ON PRODUCTION PROCESSES

Manufacturers can implement the concept of the smart factory on many ways and to adapt them to present or future demands. The impact of the smart factory concept will be different on each production process. Various manufacturing processes that can be upgraded with modern technologies are shown in table 1. [4]

Table 1. Processes within a smart factory

Process	Sample digitization opportunities
Manufacturing operations	-Additive manufacturing – producing prototypes or low-volume spare parts;

	-Advanced planning and scheduling – using real-time production and inventory data to minimize waste and cycle time; -Cognitive bots and autonomous robots – effectively execute routine processes at minimal cost with high accuracy; -Digital twin – digitizes an operation and moves beyond automation and integration to predictive analyses.
Warehouse operations	-Augmented reality – assists personnel with pick-and-place tasks; -Autonomous robots – execute warehouse operations.
Inventory tracking	-Sensors – track real-time movements and locations of raw materials, work-in-progress and finished goods; -Optimizing inventory on hand and automatically signal for replenishment
Quality	-In-line quality testing using optical-based analytics; -Real-time equipment monitoring to predict potential quality issues.
Maintenance	-Augmented reality assists maintenance operations. -Equipment sensors to drive predictive and cognitive maintenance analytics.
Environmental, health and safety	-Sensors to geofence dangerous equipment from operating in close proximity to personnel; -Sensors on personnel to monitor environmental conditions, lack of movement or other potential threats.

7. CONCLUSION

In this paper, base principles of the fourth industrial revolution are shown. They represent ground for smart factories. Usage of smart factories is a holistic approach which connects events inside the factory with events outside of it. Because of that, in order to achieve a successful result, all factors of the supply chain have to be observed. It is not enough to introduce high technology and connect it to one system. It is necessary to constantly process data coming from the exterior of the factory. Concept of a smart factory is not the final step in the automation evolution. This concept is developing continuously and because of its dynamic nature is applicable to all existing production processes. Investments in smart factories enable manufactures to rise above the competition and to make their business more efficient.

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THE LAST MILE LOGISTICS SOLUTIONS

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Abstract: *In industries such as logistics, it is necessary to follow new technologies and new initiatives to compete in the 4.0 market. Logistic 4.0 is increasingly using modern technologies. According to a survey conducted by Freightos start-up in 2016, 86% of logistics decision makers say technology is the best way to increase efficiency and cost control [4]. The development of transport infrastructure has facilitated the transport of goods at greater distances, but this also increased need for efficient "last mile" deliveries.*

The "last mile" deliveries are one of the key parts of the supply chain and special attention should be paid to timely deliveries. Companies are developing targeted strategies to increase their competitiveness. The "last mile" can be defined as the final step of distributing goods from the transport terminal to the end user. The "last mile" logistics is designed to overcome the challenges created by increasing traffic in urban areas and/or more delivery costs divided by smaller amount of goods that final customer needs.

New technology initiatives are linked to the "last mile" logistics. According to McKinsey's survey of 4700 respondents in Germany, USA, and China, nearly a quarter of consumers are willing to pay more for instant delivery, and this share is likely to increase as younger consumers are more inclined to instant delivery rather than the standard delivery. On the other hand, most consumers still expect free delivery that will be both quick and cheap [8].

E-commerce growth and ever-increasing consumer demand for fast, free, and secure delivery have increased the need for logistics service providers on the "last mile." New business models, innovative strategies, and new technologies are used to reduce costs, increase flexibility, efficiency and delivery speed, and ultimately increase everyone's satisfaction in the chain.

Keywords*: Logistics, the last mile, logistics centers, distribution.*

1. INTRODUCTION

"Last mile" can be defined as the final step of distributing goods from the transport terminal to the end user. The actual reach of the "last mile" can range from a few kilometers to fifty or even a hundred kilometers. Retailers have interest in this kind of logistics because of the growing demand for fully integrated multichannel retailing. This type of delivery is especially popular with online sales. Because of the great competition in the market, service users often have an alternative and for this reason sellers are forced to provide additional value that raises service level, which includes cheap, fast and efficient delivery of products to

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users doorsteps. This way they increase their market share and ensure customer loyalty. In order to understand the benefits and obstacles faced by the distribution of goods in the "last mile", it is necessary to understand the challenges that are present in the “last mile”, how it affects e-commerce, multichannel supply chains and how new-age technology offers new, improved solutions.

Last mile logistics is designed to address the challenges created by increased traffic in urban areas, as well as the complexity of extracting and decomposing large shipments. Delivery in urban areas can be difficult to navigate due to traffic regulations, parking regulations and many other obstacles that lie in urban areas. The problem of environmental pollution is increasing and companies are increasingly turning to solving this problem. One solution is transport without or with reduced CO2 emissions. Because last mile deliveries are one of the key components of the supply chain, companies are developing strategies aimed specifically at successfully meeting the last-mile challenge and delivering goods to the right place and at the right time.

2. LAST MILE LOGISTICS

The flow of goods is increasing every day, so logistics are already looking for future solutions. Complete transport technology is already in the midst of a technological revolution - automated driving, telematics, smart data, virtual data disposition and a whole host of innovative solutions. It is no longer enough to just translate a shipment, the customer wants to have real time information and to know at all times where the shipment is and when it will arrive at its destination. Technology has advanced so much that some products are no longer transported at all, just send the data and the 3D printer creates the product you want.

The consequence of this is that even large logistics organizations can no longer afford to live up to their old glory, but are also forced to work with companies looking for new solutions. It is no longer sufficient to deliver a consignment from point A to point B. Today, delivery truck drivers need to be adept at using new technologies.

Everyone is thinking of crossing the "last mile" even more efficiently, and constantly running various experiments such as the idea of drones. The development of drones requires the adaptation of laws, regulations and rules and there are still a number of questions at the moment, however, this indicates that the future, which has not long ago acted abstractly, is at the door and that many companies will seek to maintain and / or increase their competitiveness with this, or similar, innovative solutions. Digitalization and automation are trends that need to be monitored in the name of increasing a company's competitiveness, so logistics operators need to be flexible and ready for change [1].

The so-called "last mile" has become a big challenge, especially in big cities. In today's age of globalization, the international division of labor is increasing, thus increasing the flow of goods globally. Ecommerce development is increasing demand for direct delivery to the end consumer. Although the industry is more or less ready for it, the pressure is mainly on the availability of resources.

The "last mile" is extremely inefficient, expensive and a generator of pollution. It could be termed as the ultimate frontier of logistics. A cost that pretty much strains supply chains that nowadays are increasingly striving for futuristic ideas, such as drones, flying warehouses, and even self-driving cars. The pace of technology development is that the realization of such a seamless delivery experience is not that far off. The digital age has brought the "last mile" to the fore. Ecommerce and Amazon effect require fast and free shipping or otherwise companies become uncompetitive. For this reason, the industry is again asking how this process can be refined. Today, technology is bringing this process closer to the much-desired perfection [11].

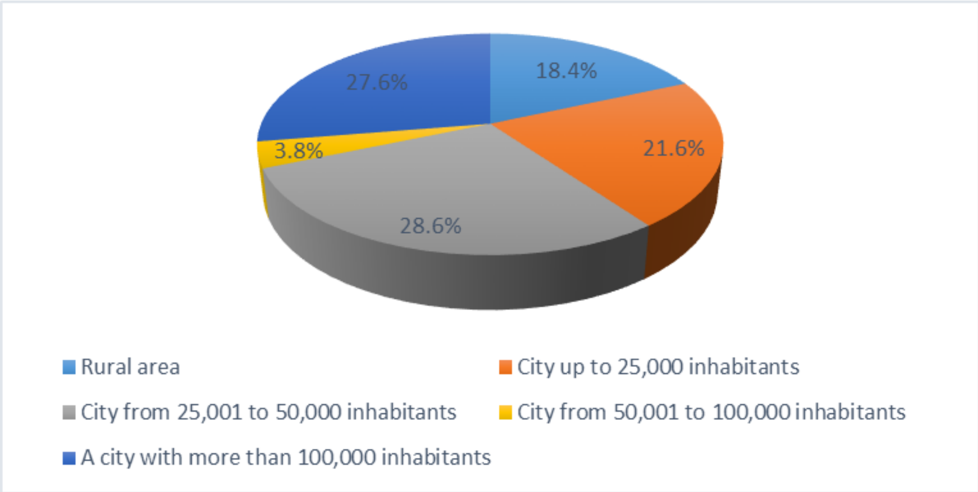
Organizations are increasingly looking at their assets not as physical, but as digital, because the future of the supply chain is smart data, and a somewhat different tool is beginning to be used to harness the power of data: artificial intelligence. Machine learning structures data and leverages predictive logistics capabilities to make smarter decisions that add value to customer service.

3. CUSTOMER DELIVERY REQUESTS

Product delivery is a big challenge for logistics operators, not only because of the often difficult to reach places, but also because of the increasing demands of consumers. For the purposes of this paper, as well as for the needs of interested parties who wish to plan their logistics strategies based on the following results, a survey was conducted on customer requirements for delivery in the Republic of Croatia. Based on 185 respondents from different parts of Croatia, the results of the urban area respondents will be presented, based on which it is possible, if necessary, to adapt "last mile" strategies and logistics solutions.

Most respondents came from cities from 25,001 to 50,000 inhabitants, exactly 28.6%, slightly less from cities with over 100,000 inhabitants, 27.6%. 21.6% of the respondents came from cities of less than 25,000 inhabitants, while 3.8% respondents came from cities from 50,001 to 100,000 inhabitants. The remaining 18.4% of respondents are from rural areas. Considering the urban area, 58.9% of respondents were female, while 41.1% were male.

Graph 1. Interviewee area

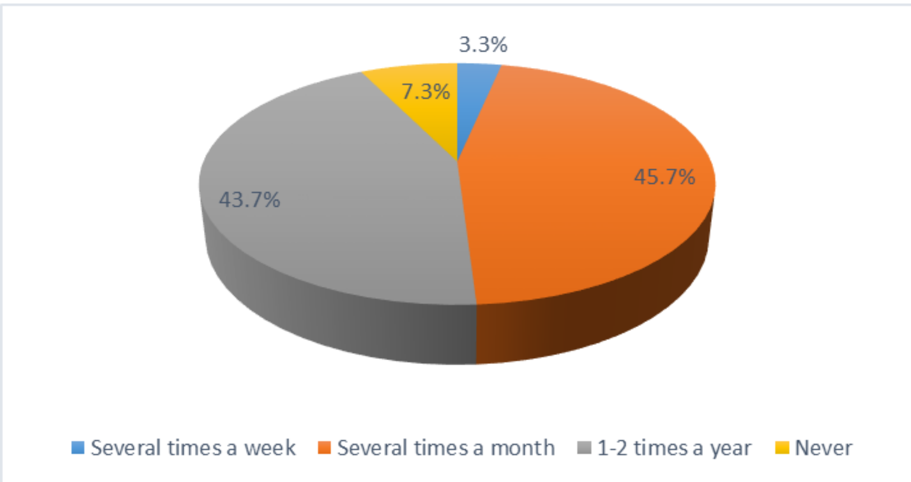


Source: Authors work

The age from 18 to 30 years are 37.1% of the respondents, from 31 to 50 years 45.7% of the respondents, from 51 to 65 years 14.6% of the respondents, while 2.6% of the respondents are older than 66 years.

More than half of the respondents, 54.9% more often buy products online than in the ordinary shop, while Graph 2. shows that almost half of the respondents order products on a monthly basis or more frequently.

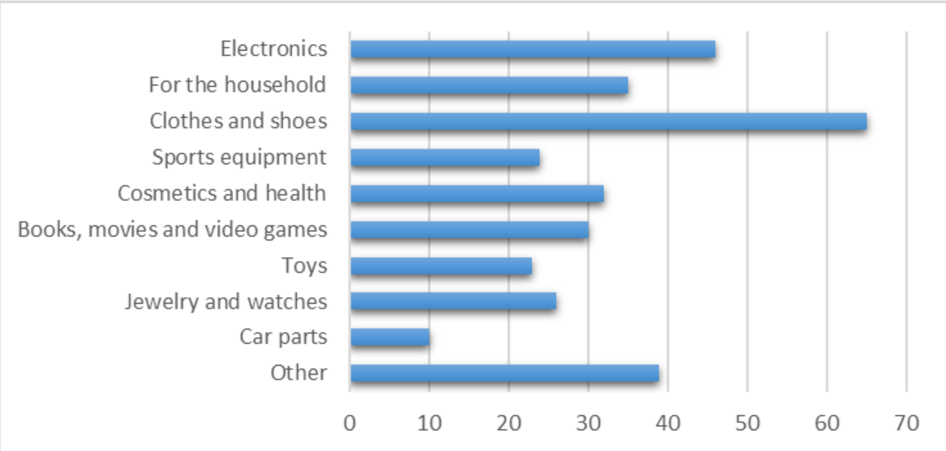
Graph 2. Frequency of online orders



Source: Authors work

When ordering online, respondents cited reliability of delivery as the most important factor when deciding on an order, while the price of products and shipping came second. What is interesting is that they stated that free shipping and flexibility in order picking are more important than the speed of delivery itself. From the above, it can be concluded that consumers will sooner decide to buy products that say "free shipping", so long as it is necessary to wait for delivery, which can serve as a good trick for the marketing services of some companies engaged in online sales. As many as 73.5% of respondents would prefer slower but free shipping than pay for fast delivery, and the same number of respondents would pay for delivery within 24 hours only if it really matters to them. Only 2.6% of respondents would pay regardless of the price for delivery within 24 hours.

Graph 3. The type of goods that respondents buy online



Source: Authors work

Most respondents, as much as 82.8%, consider delivering grocery products to a home address an excellent service they would like to use, and 49% of respondents would pay less than 6 euros for such delivery. 40.4% of respondents are not sure what price they would pay and their decision would depend on the importance and urgency of delivery. The remaining 10.6% of respondents are willing to pay more than 6 euros for such a service.

It is interesting to note that as many as 41.7% of respondents believe that traffic is already congested anyway, so increasing online orders does not necessarily affect traffic congestion, 34.4% of respondents believe that traffic congestion does not increase because not all consumers order at the same time while only 23.8% believe that e-commerce development is increasing traffic congestion.

4. CONCLUSION

In activities such as logistics, it is necessary to keep up to date with new technologies and new initiatives in order to compete in the market. One of these initiatives is "last mile" logistics aimed at delivering the product between the distribution center and the point at which the end consumer will receive it. In order to optimize and adapt to the green logistics standards, it is necessary to invest in transport technology as well as in the initiatives of various companies dealing with innovative package delivery.

Logistics providers are beginning to rely on technology to improve efficiency. Software, web portals and mobile computers provide seamless real time flow of intelligence. The use of technology solutions has helped providers successfully manage time, routes and costs. Technology solutions such as drone deliveries, robotic deliveries, bicycle deliveries, container bikes, and waterway deliveries are just some of the last mile logistics initiatives to reduce fuel consumption and to avoid congestion and other obstacles in urban areas.

Consumers have become extremely demanding, expecting great speed, security and flexibility when choosing different delivery options, pickup and delivery times, and at the same time low delivery costs. Nowadays, the supply chain is changing to meet the need for fast, economical and efficient delivery of goods to the final consumer. Logistics operators are pursuing innovative strategies to reduce costs, improve efficiency and meet the need for fast delivery.

The growth of e-commerce and the growing consumer demands for fast, free and secure delivery have increased the need for "last mile" logistics providers. New business models, innovative strategies and new technologies are used to reduce costs, increase flexibility, efficiency and speed of delivery, and ultimately increase the satisfaction of everyone in the chain.

This article is introduction to the scientific research on how “the last mile” affects supply chain management, logistics and social issues that will be run in the period 2019-2022 in Croatia and the region.

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THE LOGISTICAL APPROACH TO THE DESIGN OF TRANSPORTATION SYSTEMS

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Abstract: *Present time condition of modern production, consumption and predictions of experts of the biggest global companies indicate that the market competition will demand from the participants in supply-chain management abilities which enable instant responses to market requirements. Because of that, intense development of the production is required, especially intense development concerning organization and the automation of complex mechanized transport and warehouse equipment. On the other hand, the basic problem is the fact that investments in new equipment are limited. Transport operations become more and more challenging and complexed so it is expected from the logistical approach to the design of transportation systems to contribute to cost reductions and production efficiency increment. In this paper, an overview of activities and the importance of the logistical approach to the design of transportation systems are given.*

Keywords*: transportation systems, logistics, supply-chain management.*

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1. INTRODUCTION

Transportation systems include machines, devices and equipment with the primary task to execute material transfer and temporary material storage. Transportation system segments are material handling during production, transhipment, order picking, storing goods, packing and palettization. There are no ideal solutions when picking transportation systems for supply-chains. Each transportation system is unique and in order to develop the basic concept to the final form, it is necessary to collect information from all participants in supply-chains. Market demands are high because they require single products with high reliability and quality at the right place at the right time. In order to survive the market race, manufacturers have to be able to instantly respond to various market demands. Even though designers of transportation systems have numerous different possible solutions, they are limited to improve the efficiency of the system without investing in new equipment. Distributive operations become more challenging and complexed and it is expected from the logistic organizations to make an additional contribution to cost reductions. Sharp competition was the reason for the introduction of highly automated production which lead to an intensive development of new equipment in the domain of the technology (manufacturing operations) and transportation-storing systems.

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The intense development of the production conditions a need for adequate solutions concerning transportation and warehouse equipment. That can be determined by analyzing the price structure of a product. It can be conducted that the average share of material handling in the price of the product goes from 10% to 50% [4]. Modern information technologies for planning and decision making, massive concentration of industrial participants and aftermarket suppliers, demands of distributive channels, changes in the globalization, narrowed profits and high demands concerning product quality were the reasons for creating highly restrictive surroundings for economic systems. [1]

The process of solving transportation problems in different areas of economic activities is not often followed with proper information flow and because of that, it often happened that a solved problem was considered again. Because of that, the fundament of a successful economy is the existence of the logistical concept which requires practical knowledge for applying available equipment and information. Main goal is to achieve a stable and uniform usage of all available resources of the existing transportation equipment in order to provide minimal number of positions and material movements.

2. PROBLEMS CONCERNING THE DESIGN OF TRANSPORTATION SYSTEMS

The design process of modern transportation systems in supply-chain management can be divided in several basic phases: [2]

- Introducing with the material i.e., products which are transported and material flows in the supply-chain;
- Logistic research of the transportation problems;
- Access to websites of well-known companies;
- Deciding about the preliminary solution and conducting feasibility study;
- Computer designing and simulating material flows in the system;
- Choosing and acquiring proper hardware and software;
- Installing equipment, probation and employee training.

Listed phases are dependent and overlapping so some activities run parallelly. In the first phase, information about material type is gathered. Data about the available space for placing transportation equipment is of great importance during picking proper equipment. At the end of the first phase based on gathered information, number of possible solutions concerning equipment choice and placement are listed. In the second phase, the logistic research of transportation problems brings together manufacturers and users of transportation equipment.

The logistic strategy is used to reduce supply levels in warehouses, to achieve maximal rationalization in the supply-chain which affects the increase of the efficiency. Logistic strategy has to ensure proper integration of information and logistic activities via logistic supply-chains (suppliers, factories, warehouses and stores) in order to create and deliver required articles or services to the end user.

In fig. 1. basic functions of supply chains are illustrated.

Figure 1. Basic functions of logistic in supply chains [4]

The existence i.e., the absence of logistic strategy in the supply-chains is noticed only when congestions occur. Characteristic indicators of improper and badly implemented logistics in supply-chains are sales reductions because there are no articles in the warehouse, presence of a large number of articles in the warehouse, shipments which do not arrive on time, improper designed warehouses with too little or too big capacity, orders for goods that are not selling good enough, wrong orders from the purchase department etc. In order to avoid mentioned problems, it is important to provide to logistics that its primary goal has to be to research material flows of different types of material and exchanging information through the whole system. The optimization of material flows is of great importance for achieving the required level of the production process. In the third phase, it is necessary to conduct online researches in order to find similar transportation problems and solutions which solved the problem. One of the characteristics of a good engineer is his ability to adjust an existing solution to the problem. Based on collected data, the decision is made about the preliminary solution and conducting feasibility study which is the fourth phase. The preliminary solution does not fully describe the transportation system, but it gives the insight in the technologies and transportation means that will be used for material handling. After that, the layout of the equipment is formed and an analysis is conducted in order to determine how goods will be stored and what will be the capacity of the material flow. One of means for cost reductions is the optimization of material flows. The most efficient way to optimize material flow is by using computer simulations which represents the fifth phase. Modern software for designing transportation systems help engineers in developing efficient systems for short time periods. To achieve optimized material flows, it is necessary to create several simulations models. In these models it is possible to simulate different work conditions of the system and by doing that, it is possible to give answers to various questions which emerge during the design process.

In fig 2. a simulation model of a transportation and warehouse system is shown. By defining different input parameters and by variation of types, numbers and disposition of the equipment, optimized configuration can be achieved for required conditions.

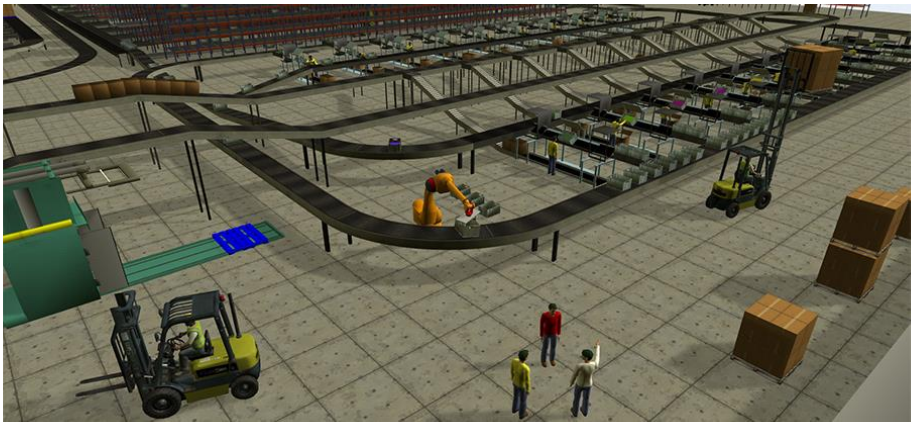

Figure 2. Simulation of the material flow [4]

After conducting simulations and analysis of the behaviour of the proposed transportation system in different conditions, the final decision can be made. It is necessary to form clear specification of the required equipment for the chosen system which is the sixth phase. In the final seventh phase, it is necessary to install the equipment, to conduct probations during which a list of several parameters should be followed in order to determine if the solutions are proper for the existing situation, to train operators and maintenance personnel. [3]

3. PROBLEMS CONCERNING MATERIAL FLOWS IN SUPPLY-CHAIN MANAGEMENT

Problems that occur most often in transportation and storing of products in supply-chains are limited capacities in transportation, storing and production, bottlenecks in material flow and production, long routes of material movement, the appearance of smaller orders with high frequency, excessive time cycles for order picking, excessive time for order processing, large amount of data is processed.

Even though the average share of the space used for material handling is 55% of the overall available space, it often happens that production and storage capacities are filled [4]. Products are often placed in wrong places which slows down work operations. Also, delays are often because products are not delivered fast enough to production or assembling zones. The need for rationalization of material flow is equal for designing new and for rationalization of existing transportation, storing and production systems and it manifests through demands for changes in storing and production capacities, arrangements of processing equipment etc.

In modern systems, often the absence of space for material storing and handling presents a serious problem. Because of that, large amounts of material occur in small places which causes confusion and congestions in the material flow. In those situations, bottlenecks occur which lead to queues. To solve bottlenecks, it is important to analyse and balance production processes in order to ensure optimum work tasks for operators. Concerning storing operations, it is necessary to maximize the usage of available vertical space. [4]

Sometimes, it happens that the actual time cycle if longer that the theoretical calculated time. Operations which are part of the production line take place in different areas of the line and, because of that, the product has to travel long distances and to be in a queue. These phenomena result in an increase in the amount of material contained within the production and its greater unnecessary retention. Optimal solution for mentioned problems is the usage of straight lines in material flows. In order to implement that, it is required to make different arrangements of the production equipment. For transporting large amounts of material, it is necessary to automate transport flows by using conveyors, automated guided vehicles and sorting equipment. It is important to balance operations so that the material flow can be done according to the just-in-time technique. In fig. 3 routes of material flow are shown.

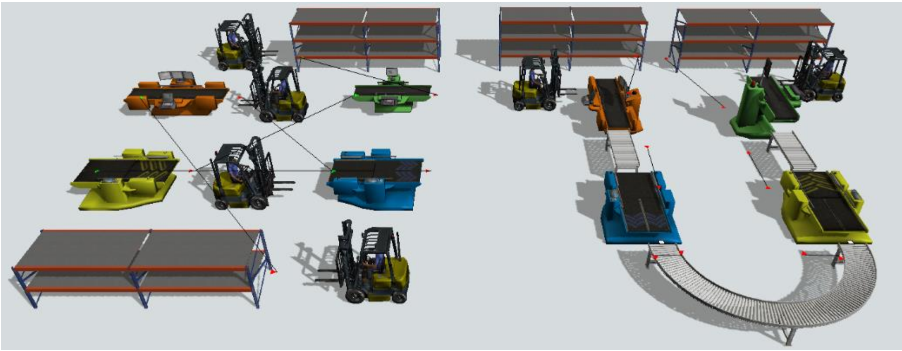

Figure 3. Material flow routes [4]

Often changes in market demands are possible and instead of large orders with a larger individual number of several items, orders with smaller individual number of large number of items happen. Pallet order picking is replaced with order picking in boxes or even single unit order picking which consumes more energy and time. In these cases, order pickers spend large amount of time on movement and searching for the required item. To solve this problem, it is necessary at the design phase to consider how to organize item arrangement in order to adapt to the situation when 20% of articles is used for 80% of overall activities. For enlarging the flexibility of the whole system, modern order picking systems are required – wireless picking system, pick to light, augmented reality and pick to voice. In the spirit of the ergonomic demands, it is necessary to place most picked items on middle parts of shelves and those less picked on upper or lower parts of shelves. By using automated transportation systems, the material flow could be enhanced and the need for human labor would be reduced.

On the other hand, often lists of ordered articles are not arranged on work sheets in such a manner which could provide the shortest distances for order picking. Errors occur and among the ordered articles, articles that were not on work sheets can be found and then more time must be spent by returning them to their positions. For the problems described, the most effective solution is to implement state-of-the-art direct picking techniques, such as pick to light or wireless picking, which, in combination with sorting devices, enables the processing and flow of a large number of items. Alternative methods of picking may also be considered, such as batch picking or zone picking.

In inadequate systems it happens that the required material (item) is not found quickly enough. Order picking paths are inefficient so too much time is wasted. Order picking depends on the printed order list. Some items on order lists can be missing, so they need to be reprinted. There are too many steps to confirm the order. It takes too much time between receiving, accepting and assigning orders, commissioning and confirming the completion of orders. The solution to such problems is to eliminate the need for printing order lists, which is achieved by the aforementioned modern order picking techniques. It is also possible to increase efficiency by simultaneously executing multiple orders, or in the case of a small number of large orders by executing a single order by multiple pickers.

Manual data entry at each point in the process duplicates steps, causes delays, and creates the opportunity for errors. Conventional order picking uses paper-based order lists that may have frequent data entry errors. A lot of time is spent between receiving an order, processing, excluding an item and the final confirmation of the completed work. A large amount of data has to be processed by the picker which can lead to errors. Techniques that overcome these problems are pick to light, pick by voice and bar-code scanning, but the technology that has produced dramatic operational improvements by eliminating manual data entry is certainly RFID - radio frequency identification. RFID is a wireless technology that uses radio waves to gather information. It can be used in different operating conditions and provides high accuracy of the data collected.

4. CONCLUSION

During the design processes of new transportation system or modifications of old ones, it is necessary to choose among various transportation devices and equipment those ones which can perform the transport task quickly and efficiently under the given conditions. It is necessary to precisely describe current working conditions and environment, but also to anticipate potential changes in the future as well as possible problems that may arise as a result. In order to achieve desired results and solve possible problems, it is necessary to ensure that all logistics processes in the supply chains are controlled and managed “paperless”. In complex transportation systems, it is necessary to provide such systems of flow, control and exchange of information that can connect all organizational segments into a single informatics unit.

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CONTAINER TRANSPORT ROUTE OPTIMIZATION APPLICATION

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Abstract: *An efficient and sustainable intermodal transport of containers requires optimization of transportation costs and time, while minimizing the amount of greenhouse gas emissions. For these purposes, within the DBS Gateway Region project, a route optimization application for container transport has been developed. The open source web-application is using the multi-criteria decision making (three criteria: price, time, emissions) in order to compare different available intermodal transport routes from an origin to a destination of cargo flows, considering different types of containers and more potential shippers, and suggesting optimal solutions for the given criteria. The application has been tested for the case study of the container transport between China and Serbia.*

Keywords*: application, container transport, route optimization*

1. INTRODUCTION

Containerization plays a very important role worldwide in the freight transport with a constant tendency of growth. Increased number of business entities involved in the container transport, require continuous coordination and transport management in order to enable an efficient and sustainable intermodal transportation. An efficient intermodal transportation requires optimization of transportation costs and time, while considering the amount of carbon dioxide emissions in order to operate in a sustainable way. [1]

Starting from the idea of containerization, intermodal transport optimization and sustainability, within the project DBS Gateway Region, an open source web application has been developed that enables the multi-criteria analysis of potential intermodal routes using three criteria: minimum transit times, lowest transport costs and minimum emissions during the intermodal transport of containers. Practically, the application can provide companies the ability to make decisions about transport routes, taking into consideration all three optimization criteria, depending on the current importance of each criteria defined through the weight coefficients. [2]

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2. THE APPLICATION

Most of the route optimization approaches are using only one decision-making criteria, usually the transportation cost [3, 4, 5]. Many researchers also considered multi-criteria decision making in route optimization, using mostly transportation costs and time as the main criteria [6, 7, 8].

The developed application enables multi-criteria analysis of potential intermodal routes using three criteria: transport costs, transit times and greenhouse gas emissions during the transport of containers, considering both the maritime and inland transport network. [2]

The application is developed as an open source with the database that will be continuously updated by the stakeholders with the input parameters.

The application enables:

- Simple definition of the weight that each criteria has in each route optimization iteration;
- The efficient analyses of a number of permissible solutions, in terms of more widely adopted heterogeneous criteria, taking into account both the maritime and inland transport network, considering at the same time different modes of transport and different types of containers;
- Generating not only the one optimal solution but the ranking list of the three best potential routes for the given parameters and criteria weights.

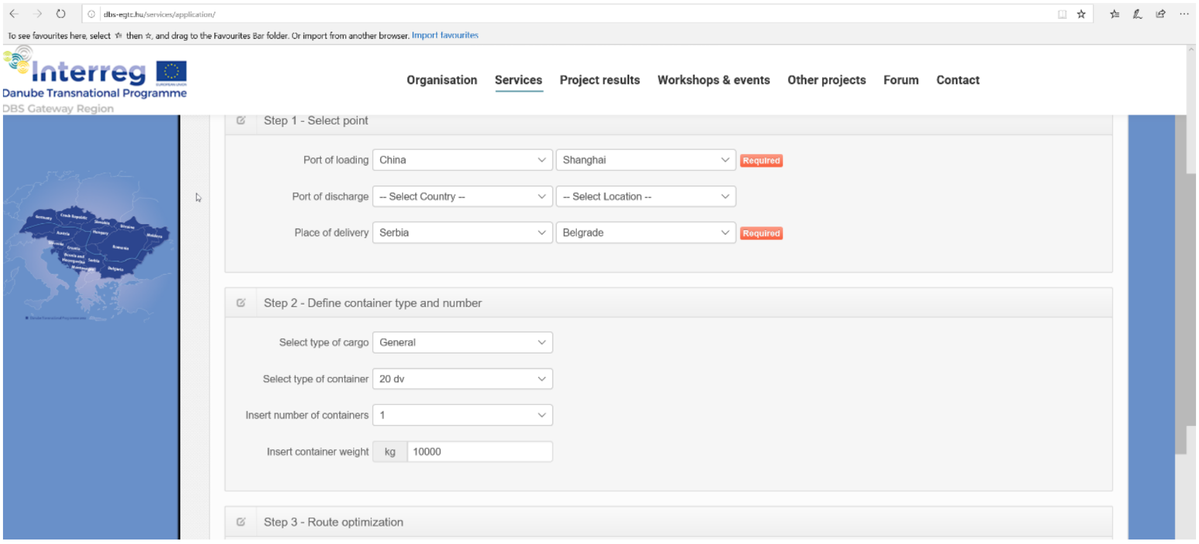

Figure 6. The DBS route optimization open source application

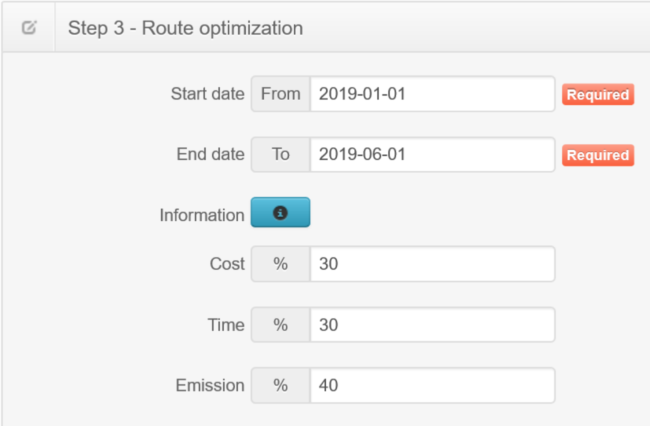

Figure 7. Selection of the weight of the criteria in the route optimization application

3. ROUTE OPTIMIZATION CASE STUDY

3.1 Selected transport routes from China to Serbia from the logistic service providers perspective

The intercontinental container transport chains, in the most cases, consist of the main – maritime transport route section and the first and last transport route section using different modes of transport (road, rail or inland waterway transport - IWT). In the case study, the main objective was to determine the optimal container transport route between China and Serbia, if the starting point in China would be the Port of Shanghai, the end point in Serbia would be Belgrade and the potential transshipment ports: Rijeka, Bar, Koper, Piraeus, and Constanta.

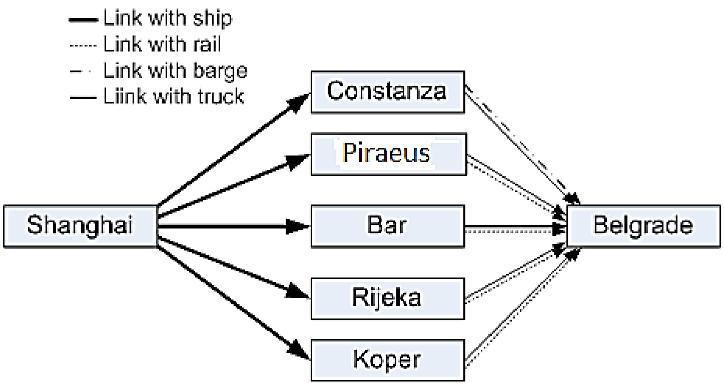

Figure 8. Potential intermodal transport routes from China to Serbia

In the case study, the Port of Shanghai is selected as the world's busiest container port. It is considered that the containers can be transported by sea, from the port of loading to the port of discharging, by the six largest shipping companies (Maersk Line - MSK, Mediterranean Shipping Company - MSC, CMA CGM, Evergreen Line-EMC, China Ocean Shipping Company-COSCO and Hapag-Lioyd). Each of the abovementioned carriers transport containers from the port of Shanghai to the nominated ports.

As Serbia is a landlocked country, the main hubs for importing containers to Serbia are the ports: Rijeka, Bar, Koper, Constanta and Piraeus. Belgrade is selected as the point of delivery as it is the capital city of Serbia and main center of business activities attracting over 30% of total imports of goods to Serbia (according to the National statistical office, 2016). With all considered ports Belgrade is directly connected by different modes of transport (rail, road, IWT). The total transport costs from the Port of Shanghai to Belgrade in this research represent the sum of all transportation costs, including: ocean freight costs from the Port of Shanghai to the ports in Europe (Constanta, Piraeus, Bar, Rijeka and Koper), port charges, manipulation costs and customs formalities at the ports of discharge and transport costs from nominated ports to the terminal in Belgrade using different modes of transport. The transport of containers by rail and barges also includes the costs of container handling at the terminals in Belgrade and local transportation by truck to the consignees (last mile delivery). The total transit time is the time from the moment of departure of the container ship from the port of loading until the moment of arrival of the container to the appropriate destination in Belgrade. It includes the time of shipping of containers at sea, which varies depending on the ship services of different shipping companies (one shipper can arrive at the port of discharge in up to three ways), waiting time in the unloading port and the time of transport of the container from the port of discharge to the end point in Belgrade. Total carbon dioxide emissions are the sum of emissions on every transport section depending on the selected mode of transport. The emissions during container handling in the port of loading and discharging are considered negligible. Based on the data gathered from the great number of logistic service providers, the database for the Danube Black Sea region was created. The database includes the exact transport distances, transportation and handling costs and times for every section provided by the freight forwarders, defined emissions for every mode of transport per tkm. It was used for the creation and testing of the open source web-application.

3.2 Route optimization results for the selected case study

The route optimization was performed for transport of one general cargo TEU (with gross weight 10,000 kg) and six different scenarios depending on the weight of the optimization criteria (see Table 1.).

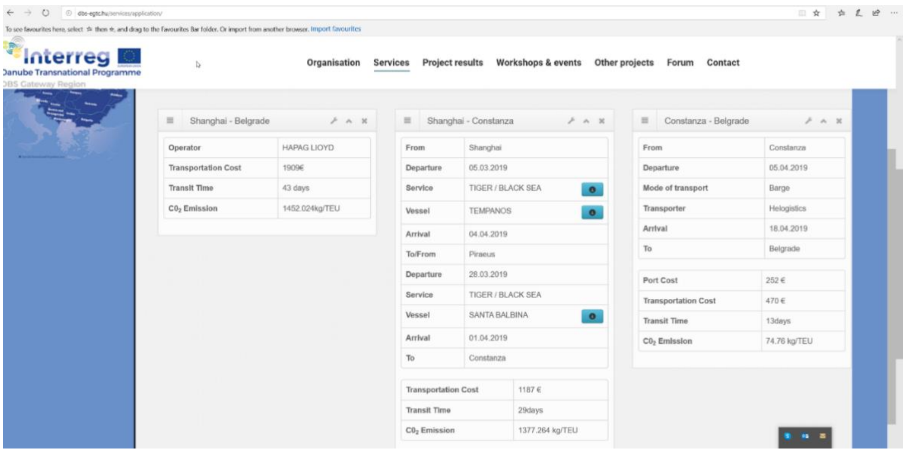

Figure 9. Presentation of the optimization results of the I scenario

All values of transportation costs and times (ocean freight costs, terminal costs, etc.) used for calculation in the following scenarios represent an average values gathered for the year 2018.

Table 6. Route optimization results

Scenario	Criteria	Weight [%]	Total costs [EUR]	Total time [days]	Total emissions of CO_2 [kg/TEU]	Operator	Through the port	Mode of transport - delivery
I	Costs	100	1909	43	1452.024	Hapag - Lloyd	Constanta	IWT
	Time	0						
	Emissions	0						
II	Costs	0	2488	30	3167.5	Hapag - Lloyd	Koper	Rail
	Time	100						
	Emissions	0						
III	Costs	0	1920	48	1405.908	MSC	Constanta	IWT
	Time	0						
	Emissions	100						
IV	Costs	50	2229	31	3160.53	COSCO	Rijeka	Rail
	Time	50						
	Emissions	0						
V	Costs	30	2119	33	1515.558	COSCO	Rijeka	Rail
	Time	30						
	Emissions	40						
VI	Costs	60	1909	43	1452.024	Hapag - Lloyd	Constanta	IWT
	Time	20						
	Emissions	20						

4. CONCLUSIONS

Containerization plays a very important role in the freight transport worldwide with a constant tendency of growth. Although, transportation costs and transit time are two of the most commonly discussed problems related to the container transport optimization, the greenhouse gas emissions and climate change, as one of the biggest challenges of our generation, can no longer be ignored when planning and optimizing container transport routes. Therefore, within the DBS Gateway Region project, an open source web application has been developed that enables the multi-criteria analysis of potential container transport intermodal routes using three criteria: minimum transit times, lowest transport costs and minimum emissions. The application was tested for the six scenarios in the case study of the container transport route optimization between China and Serbia, considering the potential transshipment ports: Rijeka, Bar, Koper, Piraeus, and Constanta. Testing of the application proved the multi criteria approach as well as the application usefulness and effectiveness. The future research should primarily consider update and extension of the database, so that the application can be further tested for the other geographical regions.

ACKNOWLEDGMENT

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SYNERGIES BETWEEN INTELLIGENT INTERACTIONS OF TRANSPORTATION AND ENTERPRISE RESOURCES IN THE AUTONOMOUS FREIGHT TRANSPORT

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Abstract: *The emergence of autonomous mobility will lead to significant changes in the road freight transport. In the modern "data age", companies are increasingly digitizing their resources, taking advantages of potentials of the „smartened" assets. Through cloud-based services the assets are continuously monitored and managed, including also the goods vehicles. These disruptive technologies fundamentally change the demands of freight transport activities. Thus both the operators of the transportation system and the companies in production and service provision are interested in to make the most of the benefits from technology development. This research focuses on exploring, analyzing and evaluating the potentials for interacting with technologies, and on the resulting direct benefits and further synergies. The results of the research will make the process of changing to autonomous vehicles at the companies more smooth and efficient.*

Keywords*: autonomous mobility, freight transport, enterprise resources*

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1. INTRODUCTION

The transport of goods by road is essential and a top priority in the supply chain. Just think that the vast majority of the objects around us are very likely, even for a short while, to have turned around in the cargo compartment of at least one freight road vehicle. The same is true for multimodal transportations, as in the first and last few kilometers, with a few exceptions, it is inevitable that goods will be transported by road. It should also be noted that in spite of the rapid pace of technological development, the increase in environmental awareness, the proliferation and increasing pressure of regulations, restrictions and guidelines, no other transport sub-sector is sufficiently competitive with road transport. [5] Transport is rapidly changing, becoming digital, interconnected and autonomous, with the advancement of vehicle technology and the automation of vehicles, autonomous road freight is appearing. This paper contributes to better understanding of gains of autonomous vehicles in the road freight sector and seeks for possible pathways for the responsible parties.

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2. REVOLUTION IN THE ROAD FREIGHT SECTOR

Alongside self-driving, intelligent vehicles, in freight transportation intelligent cargo also appeared. Those goods or cargo are intelligent that have information about themselves, their environment and their location, and are linked to information services. All this helps companies with logistical and administrative rules for transporting goods, regardless of cargo size. With its benefits, it contributes to achieve a more efficient transport, including more energy efficient transport.

Future vehicle technology requires a sophisticated, widely used vehicle on-board device, which means practically considering the use of an integrated on-board unit capable of handling all intelligent vehicle-specific functionality in a consistent manner. (Fig.1) Establishment of such a system is possible with a single, top-down legislation. Although the tachograph specification is already part of the legal system, on the other hand, the OBU (On Board Unit) tools do not yet have a mature concept for transposition into legal frameworks. It is already clear that the future implementation of such an "integrated OBU" has legal and regulatory barriers rather than technological barriers.

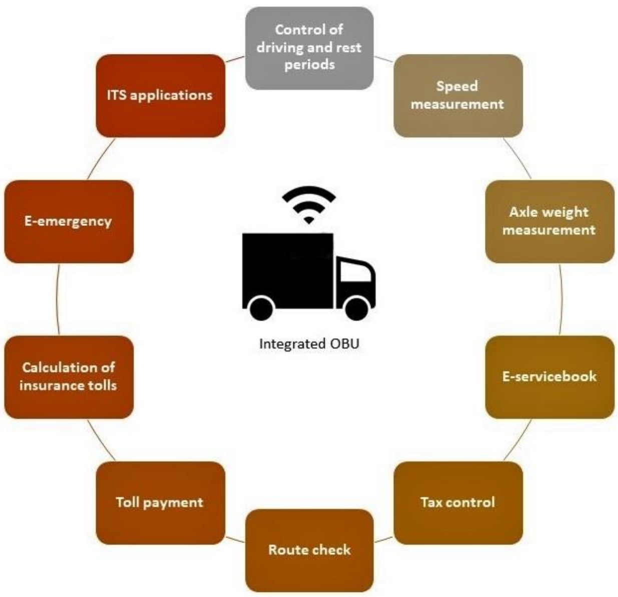

Figure 1 Integrated OBU functions [Own editing]

OBU is an acronym for "On Board Unit" (OBU), which literally means "board unit". Generally speaking, any electronic device can be defined as an OBU that performs some or all of an automated task in a vehicle - driver (vehicle operator) infrastructure relation (eg auto identification, toll payment, driver assistance, vehicle diagnostic services, etc.). With the advancement of technology, on-board devices are being replaced by integrated, smart on-board computers. The on-board units communicate with the central server over a mobile network, allowing real-time tracking and subsequent evaluation of data stored at the headquarters. The use of on-board computers is needed to improve the driver's working conditions and to ensure the traceability of truck performance and to meet the extensive information needs of any transport company. [7]

Real revolutionary innovation and radical change, besides the use of autonomous vehicles, can be brought by the incorporation and use of information technology. This means that in addition to the fact that computer-controlled cars will be on the road; the infrastructure itself, the smart transport network, networked and communicating with each other, contributes to increase the efficiency and safety of mobility. (Fig. 2) The use of such an integrated intelligent transport system can increase the efficiency of passenger and freight transport and contribute to safe and environmentally friendly transport. The system also opens doors to new services and new business models.

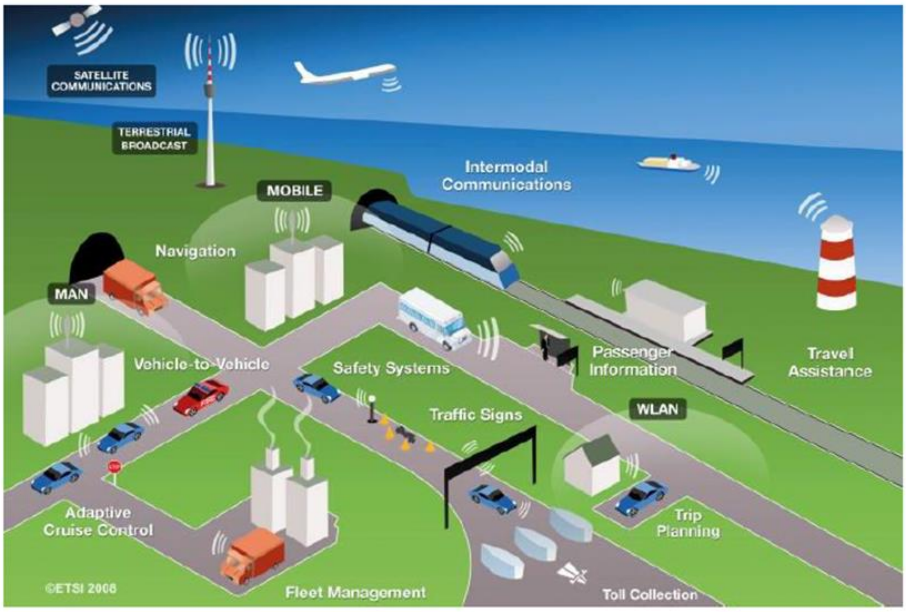

Figure 2 System components of a smart infrastructure [2]

Smart roads and smart cars mutual cooperation means smart transport, for which shared knowledge and a continuous and secure network connection between systems is the key. Intelligent cars are expected to be fully integrated as components of an intelligent transport system and will be key players in sensing and transmitting information. [8]

It is important to mention the concept of IoT, which has become a very important area in relation to the Industry 4.0. The Internet of Things (IoT) concept is that the personal computer is becoming increasingly overshadowed in certain applications and its role and tasks are being replaced by intelligent objects. The Internet of Things also refers to the interconnection of physical objects and devices in a structure similar to the Internet. Smart devices communicate with each other using 5G technology, e.g. the washing machine starts when the electricity is the cheapest, depending on the load of the power supply. In a certain sense auto-identification with RFID, which is widely used in logistics, is considered to be the core of IoT, however, many other encoding makes it possible to identify the devices. [6]

The Connectivity as a Service (CAAS) is based on elements that are part of the IoT linking services, to enable you to take advantage of the benefits of connectivity. The CaaS model provides simple, cost-effective, high-quality, and secure network data connectivity. The data connection network is based on an IoT platform and provides access to the model's features through a cloud-based service. [3]

Another prominent concept of intelligent transport systems is Mobility as a Service (MaaS), where proprietary transport means and modes are increasingly being pushed into the background and service-based, community-based mobility solutions are gaining ground. The trend is driven by the proliferation of new, innovative community mobility services, largely due to the development of the information technology tools and applications described above. Such MaaS services also include different modes of transport sharing, such as community car, bicycle, roller skating. MaaS can improve travel conditions and provide new mobility options for users. Most MaaS services have a positive impact on social values, improve the efficiency of the transport network, and typically favor environmentally conscious solutions. [4]

In the following, we examine the validity of the requirements for the general freight and logistics system described above in terms of the capabilities of the above-mentioned autonomous technology, automated IT system upgrades, and networking of mobile devices.

3. ENTERPRISE INFORMATION TECHNOLOGY AND AUTOMATION DEVELOPMENTS IN THE CONTEXT OF AUTONOMOUS FREIGHT TRANSPORT

Structure of information systems that support logistics processes are closely related to logistics management tasks. In addition to operational tasks, planning is a prerequisite for competitive logistics. During the planning process, the goals, and the frameworks are defined for which the specific processes take place. In order to ensure continuous development, there is a need to measure the real performance of the operation, analysis and feedback of the results obtained, as well as to review and redesign of critical points in the system. The transactional system and the decision support system supporting operational and planning processes are two essential, important and closely related parts of the logistics information system. Below we examine the validity of the requirements for the general freight and logistics system. The opportunities offered by an autonomous technology previously mentioned, in terms of the automated information system development and networking of mobile devices (Table 1). [1]

Table 1. Prerequisites for autonomous road freight transport against the logistics information system of a company [1]

Requirements	Conventional vehicles	Autonomous vehicles	Gains	Challenges
Quality of information	Based on conventional architectures and softwares, easy to process	Based on communication of high level and automated equipments and on application of innovative	More reliable information, up-to-date data management	Investment and higher level operational knowledge are in need

		softwares		
Extent of information	General extent of data interchange	Higher extent of data interchange	Full monitoring and process control	Improvement of informatics system, need for bigger data storage capacity
Location of information	Far from the origin	Close to the origin	Accurate and updated data management	Improvement of information and communication technology solutions
Lead time	Longer	Shorter	Rapid intervention	Holistic infrastructure development is in need
Data security	Normal level security	High level security	Secure, protected communication channels	Need for involving high level IT service provider
Human-machine interaction	Human-human and human-machine interactions	Human-machine and machine-machine interactions	Process automation	Current equipments need upgrading or replacement
Integration to partner systems	Low level	High level	Up-to-date information at all involved parties	Need for cooperative and syncronised developments at all involved parties
Level of digitalization	Paper-based and digital information	Mainly digital information	Reducing data process failures	Time consuming transition
Online accessibility	Only partly online	Mainly online	Cloud-based data management	Emerging risk in abuse of data
Remote monitoring	Low level, minimal number of applied mobile devices	High level, high number of applied mobile devices	No spatial or time limit for access	Internet of Things and mobile data interchange system improvement is in need

In the table, we placed the emphasis on the examination of claims for which the use of innovative technology is a particular degree, clearly identified benefits. We have highlighted the points where the application of autonomous solutions may require reinterpretation or modification in the application of technology.

All of these properties from the point of view of many freight companies exploit the benefits arise from the use of autonomous vehicles concerned.

4. CONCLUSION

Overall, the beneficial effects of using the potential of autonomous vehicles and smart roads for the purposes of freight processes, corporate assets and infrastructure operations safer, more reliable and more efficient. Thanks to this technology, driver errors can be reduced to virtually zero. The traffic load on the road network can be optimized, congestion can be reduced and infrastructure maintenance simplified and streamlined. In connection with the subject area there is a number of points that require further study and research. The integration of autonomous vehicles into the concept of Industry 4.0 is also an open issue, with the vision of automating the entire supply chain from manufacturing to end users, while minimizing human labor requirements.

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