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AUTOMATION OF PROCESSES IN GLOBAL POST SERVICES

Researching the process of implementation of robotics in warehouse and last-mile delivery services in global post companies

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Abstract

The objectives of the thesis were to determine what role robotics plays in global post services operations, how it is being introduced into the sphere of logistics and what consequences it will bring to the market in the future. For reaching these objectives, it was important to analyze how robots will affect warehouse and delivery departments of the post services and what changes they can bring to the particular market area.

Qualitative methods were used in this thesis to provide insight into the implementation of automation in postal industry. Also, the impacts of automation on warehouse and last-mile delivery departments of postal industry were studied in this paper using qualitative methods.

The study showed that the implementation of robotics into postal industry is developing very rapidly. As is presented in the thesis, automation has already been partly implemented in the daily postal service warehousing processes such as sorting and transporting operations. This paper also reviewed the testing of robots in last-mile delivery operations. In addition, the most essential aspects of economic and labor issues that will be brought to postal industry by automation are presented in this study.

It was concluded in the thesis that the final implementation of automation in postal industry will depend mostly on economic issues. Also, it was stated in the study that customers' opinions towards these new technologies will be taken into consideration.

Keywords

automation, postal service, autonomous mobile robots, logistics, warehouse, labor, implementation of robotics

CONTENTS

DEFINITION OF KEY TERMS

Automation – automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labor (Merriam Webster 2019).

Robotic Process Automation (RPA) – the application of technology, which gives employees the opportunity to make the computer software capturing and interpreting existing applications for transactions to be processed, data to be manipulated, responses to be triggered, and communications with other digital systems to be done automatically (The Institute for Robotic Process Automation 2018).

Autonomous Mobile Robots or **AMRs** – robots which can make transportation of items within an open space with no help of people who need to control them. In this research, all machines that are capable of moving between points with no help of human beings, gaining data from everything what is around them using special sensors, and operating inside buildings or on street pavements, not including transport roads, will be called as Autonomous Mobile Robots or AMRs. (United States Postal Service office of inspector general 2018a, 3).

1 INTRODUCTION

Nowadays, robotics is an increasingly common phenomenon in the daily life. People can meet robots literally everywhere: on the street, in a restaurant, in a hotel, in a shopping mall and even at the airport. Robots will also be met when using post services. It has been stated that during the past three decades, many different post services all over the world have been taking machine beings into consideration (United States Postal Service office of inspector general 2018a, 7).

It may not be very likely yet that a robot comes to someone's house with a delivery package**.** However, there are already some companies that provide their customers with such a service. (United States Postal Service office of inspector general 2018c). It seems easy to suggest that this is only the beginning. The idea of deliveries by robots makes postal operators interested in robotics because of its ability to provide customers with even faster and more convenient in-time delivery. These aspects are the main points that customers usually appreciate. Moreover, many people are nowadays either extremely busy and overloaded with work or very lazy and exhausted to go to the closest post office for collecting their parcel. Thus, the implementation of robots in postal operations gives people new opportunities to make their lives a little easier.

Furthermore, if modern warehouse operations are analyzed, robots are employed and included in various types of warehouse activities. The leading distribution centers, such as Alibaba, John Deere and Samsung are currently using different types of machines. (United States Postal Service office of inspector general 2018a, 3). Logically concluding, robotics has many advantages that can generate extra revenue to the companies. Moreover, the automation process makes the average time of delivery shorter, which will result in better customer satisfaction. These aspects will be analyzed in this study.

The objectives of the thesis

The objective of the thesis is to determine what role robotics plays in global post services operations, how it is being introduced into the sphere of logistics and what consequences it will bring to the market in the future. For reaching these objectives,

it is important to analyze how robots will affect warehouse and delivery departments of the post services and what changes they can bring to a particular market area. Moreover, it is necessary to consider the relevant ethical and economic issues in logistics to see how the changes caused by the use of robotics will affect them.

Also, in order to reach the objectives, a number of additional questions will need to be answered in this paper:

- Why does logistics need the automation process?
- Which companies, nowadays, are using robots?
- What types of operations is the robotics responsible for?
- How are the companies going to implement robots into their operations?
- What are the main advantages and disadvantages of robots in logistics?
- What risks do companies take when they bring robots to the market of post operations?
- How will the automation change the sphere of post service in the future?

As a result, the implementation of automation in postal industry must be studied in order to be able to describe the nature and direction of automated processes.

Research methods

The objectives of the study will be reached by means of qualitative method.

The automation process will be examined from different perspectives such as the choice of warehouse location and last-mile delivery destination. This thesis will also examine reports and documentation which will help to fully describe and analyze automation in the postal industry. Moreover, customers' attitude to the process will be discussed in this paper based on information from the previous studies and observation of postal companies. In addition, a number of figures and tables illustrating statistical calculations and results will be presented. Automation in postal industry may be better understood on the basis of numerical information which will provide more specified perspectives of its implementation.

Theoretical framework

The theoretical framework of this study consists of different issues which are connected with automation processes in the logistics sphere. First of all, the processes will be explained from the logistics perspectives, and the need for automated solutions in the sphere of logistics will be defined. Secondly, automation processes in the warehouse and delivery logistics will be studied. Also, various advantages and disadvantages of the implementation will be shown.

2 AUTOMATION OF LOGISTICS

This chapter will cover the most essential concepts that will be presented in this thesis. The most essential terms and issues of the thesis will be defined in this chapter, and it is also important to show the current state of logistics and explain why the sphere needs automation processes and how they can be implemented in warehouse and last-mile delivery departments.

2.1 The need of automation in logistics

There are many different definitions for automation process today. As this study is focused on the market of logistics, only terms that are commonly accepted in the field of logistics are used in the thesis.

The definition of automation which is showed in the chapter of key terms is commonly used on the logistics market nowadays. As can be seen, automation relates not only to machines which can move automatically, but also to processes and systems that are capable of working independently. In other words, human labor can be replaced. However, as this process is only being taken into operation, one may argue that human labor must still be considered as the most important operational tool in logistics. This issue will be discussed later in the paper.

2.1.1 World labor challenge

Nowadays, logistics is facing one of the most significant challenges in its history – labor availability. It has become very complicated for logistics organizations to find high-quality specialists. Also, even if logisticians are well-educated, they are not always well-experienced. At the same time, the growth of e-commerce is gathering speed very fast, so the problem of employees has become much more actual. (Bonkenburg 2016, 4).

In order to better understand the e-commerce growing nowadays, one may review the statistics presented in China Briefing magazine stating that by year 2020 online retailing in China will be valued more than that of The United Kingdom, France, Japan and Germany together (Rauf 2014).

Due to the growth of online retailing, more human labor is needed for one simple reason – online retail usually requires more employees working per item in comparison to traditional retailing. This is because of the fact that a company needs to pick and pack e-goods by hand. The same applies to parcel shipments, because they need to be shipped as individual deliveries to make sure that they will be given directly to purchasers. In addition, the average weight of the parcels has been increased by the fact that online byers now are allowed to purchase larger goods such as furniture and building materials. (Bonkenburg 2016, 4).

According to a recent study that was made by Boston Consulting Group (BCG), it will be the first time in history when countries meet such a vast shortage of employees in mature markets. For example, a shortage of 10 million employees will be faced by Germany by 2030, and a shortage of 40.9 million by Brazil. There are many other countries that were included in this forecast list. Figure 1 below shows the full labor forecast which was made by Boston Consulting Group. (Strack at al. 2014).

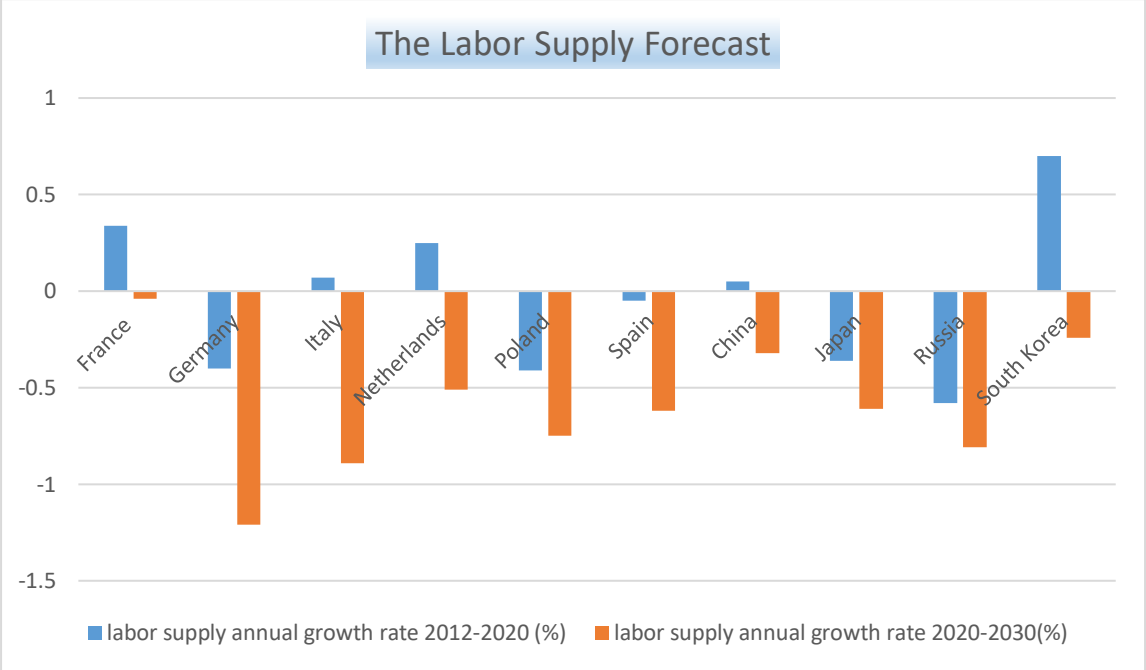

Figure 1. The labor supply forecast (Strack et al. 2014).

Starting from 1948, the growth of the United States economy has been approximately 3% annually. If the situation lasts over the next decade and the rate of productivity is the same, the United States of America will need more than 35 million of employees available on the labor market in 10 years. (Atwater & Jones 2004).

It is very important to take the USA into consideration, because a vast number of European workers has been tending to move to the country since 1980. This can be easily explained by the average level of salary in the USA, which is much higher than in Europe. It can be easily suggested, if there is a lack of workers in the USA, all European countries will have the same problem as well.

Also, as it is shown in Figure 1, most countries in the future will suffer from a lack of available work force. Labor supply is predicted to be problematic, for example, in such countries as Germany, Italy, Poland and Russia (Figure 1). These shortages of labor will bring new challenges to companies.

Moreover, logistics is a field of a difficult occupation, and for people who are over 55 years old it is difficult to operate in the sphere. However, even under these

circumstances, many people are asked to work one or two additional years due to the lack of workers. (Bonkenburg 2016, 4).

Therefore, to overcome the challenge of labor, the employers of the future should either raise the prices for their services or implement automation which will compensate for the costs caused by workers and raising productivity. (Bonkenburg 2016, 4).

Nowadays, robots and employees are working together in transporting goods all over the world with a high-quality service and low costs. Robot technologies have had a rather limited effect on logistics operations. However, now the world of logistics is beginning to introduce robots into warehouses and sorting centers, and even allow them help in the logistics of final-mile delivery. Robots will be assisted by workers who will benefit from the robots' contribution, while buyers will be more satisfied. (Bonkenburg 2016, 3).

2.1.2 Data operation challenges in logistics

Nowadays, logistics companies also need automation for performing their daily business operations connected with customers' information. Such operations as data-driven collection, reviewing, input information, and order processing still take place in a number of logistics organizations. The list of the tasks consists of repetitive and mundane actions which employees must perform from day to day. (Kofax 2015, 3).

At the same time, as Cognizant Center for the Future of Work states, approximately 25-40% of organizations' workflow are being made autonomous (Brown at el. 2015, 7).

It can be easily seen that the workflow of logistics organizations is needed in the automation solution which is still not implicated. The tasks that are considered manual and to be done by people are also often regarded as inefficient and inaccurate – particularly if compared with the predictability of the automated alternatives (Kofax 2015, 3).

For all the reasons that were mentioned in Chapter 2.1.2, Robotic Process Automation can be suggested as a solution for the issues connected with inefficiency, inaccuracy and repetition of human labor.

2.1.3 Robotic Process Automation (RPA)

The robots which are used in RPA are not machines that can sit at tables and using pens and pencils to solve different tasks. Instead, all of them are special software robots which consist of powerful and dynamical flow of machine learning which allow them perform different tasks. Moreover, RPA can complete analogical operations within enterprise systems and in variable computer applications such as MS Microsoft, and across different external sources such as websites, web portals and web platforms, all the same time. (Kofax 2015, 15).

According to KOFAX, Robotic Process Automation can be used in different spheres including logistics and supply chain management (Kofax 2015, 16). Thus, RPA, arguably, should be soon implemented in a majority of organizations in the field of logistics.

2.2 Automation in warehouse logistics

It is easy to assume that warehouses nowadays play an integral role in any supply chain. Earlier in this chapter, the main challenges related to labor were described, and it can be concluded that warehouse logistics needs new innovations and systems which will help organizations to solve the labor issues. The main consequences of implementation of robotics in warehouse logistics will be described below.

The management of warehouse and distribution centers has been changing during the last 30 years. Earlier, people did all tasks, and printed documents played an integral role in business, but nowadays technologies and innovations are increasingly important. Today’s warehouse is full of different robots and other machines. (Honeywell 2014).

2.2.1 Distribution centers

In comparison with the centers of distribution of today, the warehouses of the future, where robotics will be implemented, are completely different buildings (Bonkenburg 2016, 28). It can be easily assumed that the improvements which will be used in the warehouses will change the current understanding of what warehouse is.

Nowadays, many warehouses are equipped with Automated Control Systems (ACS) and Warehouse Management Systems (WMS). These technologies are capable of enhancing performances of the most typical tasks (Honeywell 2014, 3). As a result, the general level of efficiency in warehouses is improved, and transaction costs are reduced (Honeywell 2014, 3). However, it is easy to suggest that companies are searching for more opportunities for success. Warehouse robots will be more appropriate for flexible and fast work, and higher productivity and better quality of performance will be reached by using robots (Bonkenburg 2016, 28).

First of all, according to DHL Report about Implementation of Robotics into Logistics, various operations will be given to specified types of robots so that each of them will be responsible for particular tasks (Bonkenburg 2016, 28). For instance, one robot is responsible for sorting activities, one for transporting goods and one takes care of the packaging process (Bonkenburg 2016, 28). Moreover, workers who usually drive forklifts or tuggers will be replaced with special machines called Power Industrial Vehicles (PIVs) (United States Postal Service office of inspector general 2018a, 8). As Wynright Corporation states on its official website, such machines are able to move mail on and off trucks independently of a factor if it is palletized or individual items (Wynright Corporation).

Secondly, all of the robots will be self-controlled. However, an advanced warehouse management system which is connected with a special planning

software will coordinate them so that all inventory movements and orders will be done at a high-quality level of accuracy. (Bonkenburg 2016, 28).

Another advantage of automation is that general reliability will be increased by reduced number of ‘‘single points of failure’’ in any distribution center (Bonkenburg 2016, 28). Moreover, because of the fact that each robot will be working independently of others, it will be easy to replace one robot with another in the event of operation failure (Bonkenburg 2016, 28). Also, replacement robot will be provided via the main cloud with all necessary information, so it will be able to continue the operation that was started by its predecessor (Bonkenburg 2016, 28). Additionally, FedEx is currently using special “autonomous helpers” which are capable of delivering different tools directly to maintenance workers in order to reduce the average amount of the time which is wasted by employees on walking from one place to another within a warehouse (Murphy 2017).

Therefore, distribution center employees will be granted with responsibilities and duties such as:

- controlling operations;
- organizing flows;
- repairing robots; and
- processing difficult orders.

Moreover, the robots will be trained by workers to perform simple and repetitive tasks while the employees will do more complicated tasks themselves. Thus, warehouses of any size will receive an easier way of productivity – machines which are capable of supporting human labor. (Bonkenburg 2016, 28).

Figure 2 below represents a scheme of the most essential types of robots that will operate in distribution centers.

Figure 2. A scheme of the main types of the robots that will operate in distribution centers (Bonkenburg 2016, 28-29).

One more point is that operational capacity will be scaled and flexed by employees according to changes in demand. It will be a very simple task which will consist of adding more machines if it is necessary, and removing them automatically from the center when demand is down again. Afterwards, the robots will be transferred to other distribution centers where demand is up. This process may be provided by leasing or rental services. As a result, capital investments of organizations on the market will be reduced. (Bonkenburg 2016, 28).

It is one thing to imagine how robotics will work in reality, but it will be a completely different matter to implement them in real-life distribution centers, or indeed, do it successfully (Veridian 2018). In order to take advantage of this process and make business more efficient, managers should follow some very important steps:

- data transparency and quality should be improved;
- disparate systems should be brought together;
- workforce should be re-assured;
- the process should be always measured; and
- co-working with experts should be included in business.

These steps are quite important while implementing the system in and should be considered by organizations' managers (Veridian 2018).

2.2.2 Sorting centers

In comparison with today's sorting centers, the sorting centers of the future, where robots will mostly operate, will be able to run 24 hours per day without any breaks and pauses. Distribution and sorting centers, which will be run by robots, will work equally efficiently during both night and day shifts. An increased number of shipments will be completed on a daily basis owing to more effective and intensive operation. As a consequence, many more customers will be satisfied. Moreover, a great number of logistics costs will be eliminated by utilizing equipment across shifts. All goods will be delivered to the sorting centers by trucks which will be driven autonomously. These trucks will arrive at the territory of the centers according to special timetable, and will be managed by a system which will locate them on the territory of warehouses while they are waiting for loading or unloading. (Bonkenburg 2016, 30).

As soon as trucks reach the dock gate, all goods will be unloaded by a container loading and unloading machine. Afterwards, the goods will be sorted according to their final destination. In addition, if a hazardous good arrives, a specialized robot will handle it, and this item will be sorted separately and safely in a designated area. All the operations will still be controlled by workers of the centers. In spite of the fact that sorting centers will utilize an increasing number of robots, employees will be responsible for all issues connected with managing workflows and making key operational decisions. Also, all goods that must be repackaged or relabeled will be handled by human workers. (Bonkenburg 2016, 30).

When it is time for goods to leave the sorting center, they will be shipped by a loading and unloading robot into trucks which will take them to the next destination. Moreover, the items which are delivered to hard-to-reach places will be loaded into special drones that will transport them to their final destination. Also, items sorted for a local delivery will be placed in mobile parcel robots which will transport them to customers. If an item is ordered by a high-priority customer, it will be loaded into a trunk of a special self-driving car which will deliver it directly to the customer (Bonkenburg 2016, 30).

Figure 3 shows a scheme of the most essential types of robots that will perform in sorting centers.

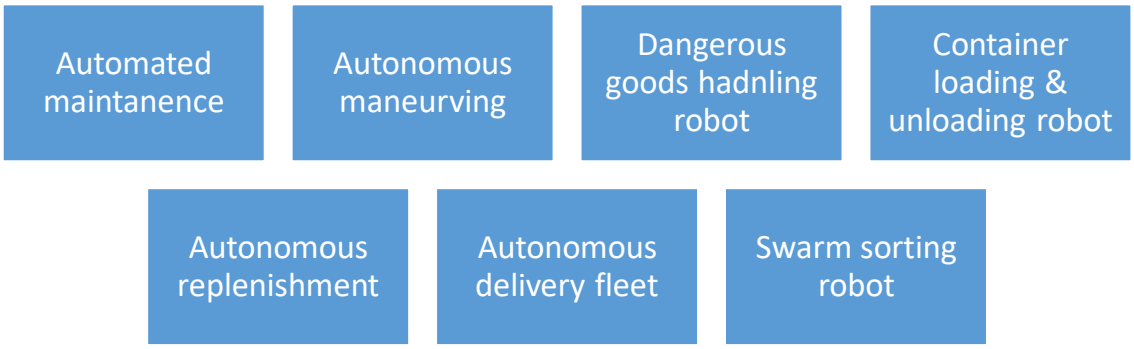

Figure 3. A scheme of the main types of robots that will take part in operations in sorting centers (Bonkenburg 2016, 30-31).

To conclude Chapter 2.2.2, it is easy to see that such centers' privilege is high speed, flexibility and higher productivity. This can be achieved with the use of smart machines, and both customers and companies will benefit from them.

2.3 Automation in last-mile delivery

In Chapter 2.2, automation in warehouses and sorting centers was discussed. It is easy to see the demand for automation in these departments, but robotics will go beyond warehouses. It seems reasonable to assume that parcels will be delivered by robots soon. Customers will receive their goods directly from a robot. Below, some aspects and details of this process will be described.

People can sometimes be afraid of robots or any similar machines. However, DHL says that in the future robots will be included in daily deliveries, and people will increasingly encounter them when receiving their parcels. (Bonkenburg 2016, 32). With relation to this process, certain issues may arise which must be further discussed.

The very first issue concerns the safety of citizens. People should not have to worry that a robot might bump into them when walking on the streets. There must be no victims of using robots in deliveries in real life. As a solution for this issue,

all robots which will operate in densely populated areas will be provided with equipment such as a laser scanner, mapping technology and special sensors (United States Postal Service office of inspector general 2018a, 6). It can be concluded that now it is very important to make the robots as safe for people as possible.

DHL also claims that delivery robots will be able to understand us and our wishes, so they will know if we are satisfied with the delivery or not (Bonkenburg 2016, 32). It can be supposed that it will be quite successful experience for companies who will provide such services: customers will receive new value-added services, organizations will receive happy users.

Receiving an email that your small parcel is ready for collection at a mobile parcel locker which is located outside a store which is nearby could be one more daily activity for those customers who will buy from organizations which will provide with such a service. In the early morning, each of the lockers will be provided with new packages by self-driving trucks which will be also preloaded by a worker even earlier this morning. In that case, only one ease activity is required to be done by a person. (Bonkenburg 2016, 32).

Another advantage of the autonomous deliveries is that large items can also be easily delivered (Bonkenburg 2016, 32). These goods will be delivered to final destinations by people, but they will be equipped with special exoskeletons which will help them to lift and carry heavy goods (Cassel 2019).

Moreover, each carrier will be supplied with a mobile robot helper (United States Postal Service office of inspector general 2018a, 2). This robot will carry several items at once and follow the carriers along their routes (United States Postal Service office of inspector general 2018a, 2). In addition, if the final destination is high in a block of flats, a mobile robot will enter the building and using an elevator it will go to the customer’s apartment and call their mobile phone (Bonkenburg 2016, 32). The customer will open the door, enter a code into the robot and receive the item. As for the deliveries to remote areas, drones will deliver the

items, and all what the customer will need to do is to enter a code into the machine (McNabb 2019).

2.4 Advantages and disadvantages of robotics in logistics

The environment of distribution centers is quite hectic and even chaotic. This is what makes it very different from, for example, manufacturing plants where automation processes have been developed for years. Also, online retail entails high product variability, fast growth and unpredictable changes. All of these factors must be considered when making robots to adapt to new changes. However, it is a new challenge to make machines sufficiently to react to changes. (Wicks 2018).

Many robotics companies are ready to supply warehouses of different organizations with their automated solutions. Robots will be able to decrease the average number of errors during operational time of warehouses. For that reason, many companies whose performance is connected with warehouses are keen on having robots among their employees. (Auptix 2017).

However, logistics operations will require flexibility from robots very soon. Different sizes of products, seasonal conditions and many other aspects – robots will be in need to be developed and to be less manual. Fortunately, nowadays, the market of innovations in logistics is growing with large paces, that means it will be probably able to supply the sphere with robots which will be ready for changes because of their flexibility and endurance. (Wicks 2018).

Reduced labor costs are one more fact that will be brought to companies which will use robotics. Robots are capable of decreasing the average level of the costs by replacing human employees, companies will save money on insurance payments and salary increases. (Benevides 2016).

The main reason why robots cannot completely replace people is their inability to process all the tasks which can be done by employees. Inability to adapt and be

versatile is inherent in robots. Robots are able to perform many functions such as moving large objects and lift heavy items, but a task cannot be changed by robots during the middle of the process automatically, which makes them different from humans. This is due to their construction. Any robot's body consists of different sensors, microchips, data and specific tools which help the machine to operate. Robots are capable of making the best of those equipment which they are supplied with. (Wicks 2018).

Moreover, high-level data science and machine learning make robots to understand how much power they need to use in one situation and how to handle another operation. Also, machine learning gives robots an opportunity to train themselves. They collect new data from every new item they work with. This is an advantage, because if they face new items which have never been met by them before they will not only handle it very well, but also receive all necessary data from it. Moreover, as online shopping nowadays is growing very fast and include much more variations of packages and sizes, the function of robots will be very helpful for the business. (Wicks 2018).

It is also important to highlight some extra advantages that automation will bring to the sphere of logistics.

Firstly, more effective scheduling will be created. Human employees need lunch and other breaks, which means time away from production. However, robots do not require such breaks but can work without any interruptions. Thus, the productivity of an organization will increase. (Auptix 2017).

Secondly, as robots will mostly replace human beings in distribution and sorting centers, employees are less likely to be injured (United States Postal Service office of inspector general 2018a, 17). Additionally, automated machines are provided with special sensors which will save them from bumping into each other or items in a warehouse (Auptix 2017).

In conclusion, in the coming days of worldwide labor crisis (Strack et al. 2014), logistics is in an urgent need of renovations. Automation is one of the multiple ways that will improve sustainability and efficiency of today's logistics. However, it must be carefully analyzed before being finally implemented.

3 ROBOTICS IN WAREHOUSE LOGISTICS OF POSTAL INDUSTRY

It can be easily assumed that nowadays logistics plays an integral role in people's lives. A multitude of organizations operate in the market and accomplish different tasks. However, this study will be focused on the postal industry. Global postal organizations will be examined in this chapter, more specifically, the implementation process of automation in warehouse logistics in postal services will be described here. The most essential types of robots that may operate in warehouses will be presented.

Also, this chapter will provide information generated by such companies as DHL, Posti and United States Postal Service (USPS). These providers are some of the largest postal organizations on the world market.

3.1 AMRs for warehouses and postal sorting facilities

It is easy to suggest, robotics will be implemented very soon in distribution and sorting centers by a majority of postal organizations all over the world. Already, many different robot types are being used in the warehouses of such companies as USPS (Material & Handling Logistics 2001). Steve Banker states that in 2009 KIVA robots were used for the first time by Amazon, and he thinks that it will take approximately 20 years to implement such a type of robot in all logistics organizations (Banker 2016). However, as will be seen in this Chapter, many postal organizations are using such technologies today in their warehouses. Approximately 30000 KIVA robots are being used currently by Amazon (Banker 2016). Unluckily, KIVAs nowadays are not being sold to any other companies, so all the robots are being used inside the company's warehouses (Banker 2016).

However, the global postal industry will be saved by the other companies of the global robot market. It is easy to see that online retailing is growing very fast so postal service providers need to grow at the same pace as e-commerce does. New solutions have been created by companies which are specialized in robot production because they can gain many benefits and much profit from such co-operation with the postal industry. Distribution and sorting centers need new solutions for the processing of multi-line orders and high volumes to be able to help postal organizations to work more efficiently. (Banker 2016).

Different sensors and navigation gadgets are used by Autonomous Mobile Robots (AMRs) to perform all their tasks efficiently (United States Postal Service office of inspector general 2018a, 1). In spite of the fact that robotics system has different physical characteristics, the smartest software platforms and artificial intelligence enable them to operate much more effectively and precisely than people (Banker 2016). AMRs are currently being invested in by various logistics companies and postal services all over the world and they are also used in warehouses and sorting centers. (United States Postal Service office of inspector general 2018a, 3).

One of the most famous postal service providers in the United States of America, USPS, is currently testing the machines. Mails and packages are moved within open space in its sorting centers. Approximately 200 large mail sorting centers are owned by USPS, and 156 million addresses are supplied with their mails and parcels. As the company grows, they are planning to implement Autonomous Mobile Robots in a more of their warehouses soon. (United States Postal Service office of inspector general 2018a, 3).

AMRs are special heavy apparatus, for example, forklifts, tuggers, pickers and delivery robots (United States Postal Service office of inspector general 2018a, 3). A picker is a robot which is able to grab goods and put them in special areas from where these items then will be shipped (Weissman 2018). Tugger robots are capable of automating the process of transportation of large racks to maximize the productivity of a company (Robotic Industries Association 2018).

Below, Table 1 presents the most essential AMR types which can be used in warehouses and sorting centers by postal operators.

Table 1. The main AMRs types which can be used in warehouses and sorting centers by postal operators (United States Postal Service office of inspector general 2018a, 4).

Product	***Company***	***Function***	***Speed***	***Weight***	***Carrying capacity***	***Battery Life***	***Recharge Time***
EffiBOT	Effidence	Follows a picker autonomously around a warehouse	6.9 km/h	129 kg	299 kg	8 hours	4 hours
Open Shuttle	Knapp	Transports one or two totes	6.9 km/h	118 kg	104 kg	4 hours	1 hour
GT10 Tow Tugger	Seegrid	Transports carts around a facility	4.2 km/h	844 kg	4536 kg	8 hours	8 hours
Butler XL	GreyOrange	Lifts racks and carries them to pickers	9 km/h	<200 kg	1600 kg	8 hours	1 hour
Swift	IAM Robotics	Robot arm picks items while moving around	9.7 km/h	295 kg	23 kg	12 hours	7 hours

Table 1 shows the most important qualities of the AMRs. In order to analyze the table and calculate average parameters, an overall understanding of the machines is required.

First of all, the average speed of these robots is 7.3 kilometers per hour. It can be assumed that such a speed is quite appropriate for warehouses and sorting centers because it is fast enough and safe as well. Thus, the machines will avoid dangerous situations while operating in a warehouse. At the same time, the speed is also quite fast to reach a higher productivity level. (Table 1).

The calculation of the average weight these robots can lift is not reasonable, because all these AMRs have different tasks and responsibilities. This also

applies to their own weights. As different operations are done by them, different sizes are needed. (Table 1).

As for a battery and charging time, it is visible from Table 1 that the most advantageous robot is Butler XL which only requires 1 hour for charging while the others require from 4 to 8 hours. Open Shuttle robot also needs only 1 hour for charging, but in comparison to Butler XL, it can only operate for 4 hours before a new charging, while Butler XL is capable of 8-hour operating time. (Table 1).

However, nowadays, the demand on the robots is high not only because of these parameters, but other features are of importance as well (United States Postal Service office of inspector general 2018a, 6).

One of these features is sensors. There are no AMRs without a sensory system. Sensors serve as artificial eyes giving AMRs an abillity to “see” and “feel” everything that surrounds them (United States Postal Service office of inspector general 2018a, 6). Extremely weak magnetic fields can be caught by these sensors, which makes them irreplaceable for traffic detection operations and electronic compasses (Todorov Nikolov 2009, 148). It would be a collapse if robots did not have the sensors (United States Postal Service office of inspector general 2018a, 24). These magnetic sensors are able to catch magnetic waves without physical contact (Todorov Nikolov 2009, 148). For this reason, they have become the most essential tools that are implemented in many industrial electronic processes (Todorov Nikolov 2009, 148). Moreover, in comparison with outdoor robots, machines which operate inside warehouses are supplied with many more sensors, and the most essential reason for that is the number of obstacles in the warehouse environment (United States Postal Service office of inspector general 2018a, 24). Nonetheless, the radius of indoor sensors is much shorter than that of outdoors (United States Postal Service office of inspector general 2018a, 24).

In addition, a composition of various sensors is embedded into the majority of Autonomous Mobile Robots. It is quite useful for the robots to be equipped with

different sensory systems because this enables the collection of an abundance of data. Therefore, the more sensors a single robot has, the more information about environment is obtained by it. As a result, a robot has a better “understanding” of life around itself. Moreover, reserve sensory systems will save a robot if some of its sensors become damaged. (United States Postal Service office of inspector general 2018a, 24).

Another feature is LIDAR technology. LIDAR stands for Light Detection and Ranging (United States Postal Service office of inspector general 2018a, 24). Light pulses are sent towards most directions around a robot, and afterwards, it calculates the distance between itself and the point where the pulse bounced based on the time which was needed for the pulse to make a round trip (United States Postal Service office of inspector general 2018a, 24). However, Danny Bradbury says that the system can be interrupted by ordinary fog, rain and snow, as they will create nonexistent objects (Bradbury 2016). Unfortunately, the system cannot “see” objects, which implies that the robot will not be able to understand how to cope with unknown obstacles it meets on its way (United States Postal Service office of inspector general 2018a, 24).

On the other hand, there is an aspect that makes LIDAR technology less alluring for postal services, the cost of the system, which is approximately $8000 dollars for high resolution 3-dimensional LIDAR. Nevertheless, many postal services purchase machines with less effective LIDAR system which is also quite appropriate for the robots’ tasks and, of course, more profitable for the company. (United States Postal Service office of inspector general 2018a, 24).

Thirdly, an extremely important feature for Autonomous Mobile Robots is the camera technology which creates computer vision (United States Postal Service office of inspector general 2018a, 25). The British Machine Vision Association and Society for Pattern Recognition states on their webpage that computer vision is automatic reception, analyzes and understanding of information on any single image which will be useful for the robot (The British Machine Vision Association and Society for Pattern Recognition).

It is emphasized in this paper that the most interesting point concerning cameras which are embedded into AMRs is how they actually operate in reality. First of all, it is unnecessary for a robot to see the whole object because a camera is able to identify any object simply catching a part of it. Secondly, a machine which is equipped with such a camera is able to distinguish different objects. For instance, if an AMR meets a fire hydrant, it will circumvent the obstacle, but if this robot faces a boy on its way, it will let the boy go first. The cost of such a camera is usually approximately $100. (United States Postal Service office of inspector general 2018a, 25).

In spite of the fact that cameras play an integral role in the operation of AMRs, they cannot provide these robots with a “full-vision’’ picture. Due to their settings, robots are incapable of identifying all objects which exist on the planet (United States Postal Service office of inspector general 2018a, 25). Therefore, there is still a chance that the robot will bump into some obstacles on its way (United States Postal Service office of inspector general 2018a, 25). Furthermore, as Tom Simonite states, if the weather is foggy, or the sun strikes into the robot’s camera, an operation failure may occur (Simonite 2017). As a result, the AMR needs not only a camera but also other components for a “full-vision” picture (United States Postal Service office of inspector general 2018a, 25).

Yet another feature of AMRs is Fleet Management Software which activates robotic co-working (United States Postal Service office of inspector general 2018a, 26). It means that all robots which are located in one sorting center work as a group or a team (United States Postal Service office of inspector general 2018a, 26). South China Morning Post can be taken as an example of a company using such technology (Zheng 2017). All robots which are connected to the system are able to operate at the same time on many tasks (Zheng 2017). Furthermore, there is also a list of roles which are performed by the software (United States Postal Service office of inspector general 2018a, 26):

- Management of traffic coordination (for instance, when more than one AMR meet at one point).

- Distribution of tasks among AMRs.
- Delivery of commands to AMRs to go to their station of charging when battery is low.
- Fulfillment of guidance parameters (for example, where AMRs should stop for picking a good).

Nowadays, such software systems are used by Amazon and Shentong Express in their sorting and distribution centers. In fact, these centers are managed by artificial intellect which is represented by Fleet Management Software. (United States Postal Service office of inspector general 2018a, 26).

In addition, special barcodes which are placed on each platform on the warehouse floor are scanned by AMRs while they are moving, so all necessary data and commands (where and when to move), which are sent by the software system, are collected by the robots. Therefore, they always know what they must do. (United States Postal Service office of inspector general 2018a, 26).

The fourth important feature of AMRs is the mapping and navigation system which is installed even into the simplest versions of the robots. Any Autonomous Mobile Robot is capable of mapping everything that is around it. Moreover, the more complicated an AMR is, the more detailed and complicated its mapping system is. (United States Postal Service office of inspector general 2018a, 27).

Now that the most essential features of warehouse AMRs have been explained, a little description of some of the robot types that were presented earlier will be shown.

First, Knapp’s Open Shuttle will be described shortly. Steve Banker states in his article that Knapp’s Open Shuttles are currently available on the market (Banker 2016). Moreover, many of them are in use now by different postal companies in their warehouses and sorting centers (Banker 2016). The official website of Knapp Corporation claims that a static conveying system can be completely replaced by Knapp’s robots (Knapp 2015). Because of their flexibility, these robots are capable of operating on different types of tasks such as replenishment of work stations and transportation of completed parts for storage (Knapp 2015).

Moreover, as the head of Grene Denmark warehouse, Dennis Pallesen said in an interview that these robots save much time for his company, which allows it to work even more efficiently (Knapp 2015).

Below, Knapp's Open Shuttle's appearance is presented in Figure 4.

Figure 4.Knapp's Open Shuttles (Knapp 2016).

There is another advantage in Knapp's robots. Intelligence and safety of movements are the most important components. They are capable of finding an alternative path if there is an obstacle on their way. Additionally, all this information is processed very fast and extremely safely. (Knapp 2015).

Below, the most essential difference between Open Shuttles and previous robots of that type is shown in Figure 5.

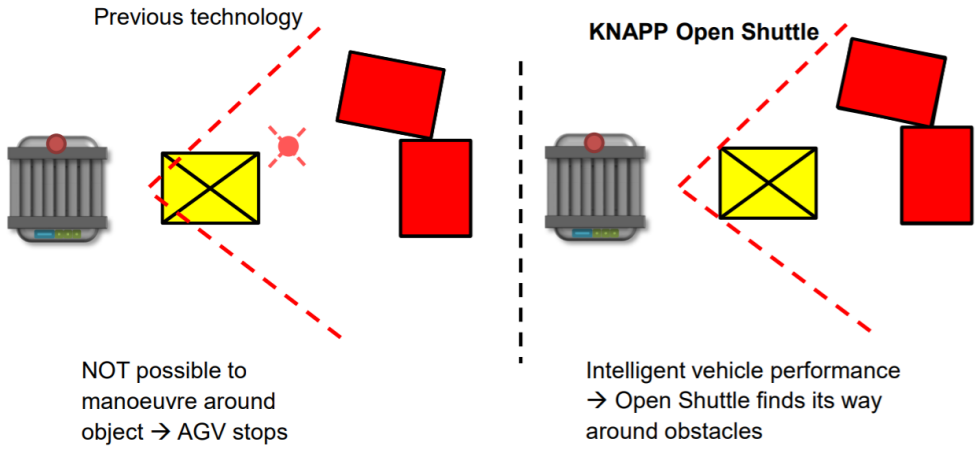

Figure 5. Difference between KNAPP Open Shuttle and previous robots (Knapp 2016).

It can be concluded from the advantages that were mentioned above that such a type of a robot as a Knapp is very suitable for warehouse and sorting center operations and tasks.

Another robot that was mentioned in Table 1 is Swift by I Am Robotics (IAM Robotics). Swift is an autonomous picking machine which has a list of special features. First of all, a number of aisles are moved with a high level of safety and accuracy. This is possible because of integrated obstacle detection technology Swift is equipped with. Moreover, the speed which is used by the robot for picking and transporting items is equal to the speed of human workers when the same operations are done by them. Also, a Swift robot is capable of working both individually and in integration with other robots. (IAM Robotics).

Below, Swift robot's appearance is presented in Figure 6.

Figure 6. Swift robot (IAM Robotics).

One more advantage of a Swift robot is that it is supplied with one of the fastest arm-tools available on the market. Fast and accurate operations are enabled by an industrial arm. In addition, the robot is capable of lifting goods from ground level to the height of seven feet, which makes this machine very useful for high-roof warehouses and sorting centers. (IAM Robotics).

In addition to the industrial arm, this robot is equipped with RapidVision Technology which allows Swift to see the reality in 3D-picture (IAM Robotics). Also, this feature enables the robot to locate any item accurately and safely, which makes the value of the robot to the user even higher (IAM Robotics). It can be easily concluded that Swift robots will be very useful for picking and transporting activities in warehouses and sorting centers equipped with high-rise shelves.

Another advanced autonomous mobile robot which is used in warehouses and sorting centers is called Butler XL and made by GreyOrange. Robotic goods-to-man technology is provided by the robot, which enables automated put-away, inventory storage, refilling and picking of orders in distribution centers. The essential idea of the goods-to-person technology is to make items go automatically to the person who needs them and who will then be able to take these goods for further operations. Therefore, for companies whose business is going to expand, Butler XL robots are the most efficient purchase because they enable the transportation of heavy goods even within multistore warehouses. (GreyOrange).

Below, Butler XL's appearance is shown in Figure 7.

Figure 7. Butler XL (Christina Loh).

In Chapter 3.1, the most essential types of robots which are able to operate in warehouses and sorting centers were presented and analyzed. In the following chapter, real-life cases of using these machines by global post operators will be presented.

3.2 Cases of implementation of AMRs in sorting and distribution centers by global post operators

Some examples of implementation process of Autonomous Mobile Robots into sorting centers will be presented in Chapter 3.2. Postal companies which are currently using these technologies will be introduced. Also, some advantages and drawbacks of these co-operations between postal organizations and AMRs will be analyzed.

3.2.1 Processing and Distribution Center in Brooklyn

In the beginning, one past effort of implementing robots into a distribution center in Brooklyn will be described. The USPS' Processing and Distribution center (P&DC) in Brooklyn is one of the first postal organizations that started using first versions of AMRs. Ten automatic tuggers by Automated Guided Vehicles Products (AGV Products) were bought by the postal service. Special boxes with

letters and parcels have been moved from sorting apparatus to docks by these robots for ten years. (United States Postal Service office of inspector general 2018a, 29).

There were two different types of guiding systems which have been used by the AMRs for a decade. First of all, a Magnet Guidance System (MGS) was used by these robots to move within the sorting center. Secondly, a Laser Guidance System (LGS) was used for making AMRs moving through the P&DC using multiple ways (Banker 2018). Moreover, the ways could be automatically changed if needed (Banker 2018). Thus, special magnets and lasers had been installed on the floor of the sorting center before the robots started operating there. (United States Postal Service office of inspector general 2018a, 29).

In addition to the fact that these robots were quite simple for using, the P&DC found some benefits of using the machines. The average time of transporting the mail trays from sorting machines to docks was divided by two – from 10 hours to less than 4 hours. As a result, the postal service was quite satisfied with the AMRs and even wanted to upgrade these robots. However, it was not done for some private reasons of the postal service. (United States Postal Service office of inspector general 2018a, 29).

It can be supposed that these robot-pilots were quite effective. Unfortunately, there is no accurate information about effectiveness of the robot's time at P&DC in Brooklyn. However, the situation that this postal service finally stopped using these robots shows – as time flows, technologies should be changed, and innovations should be involved. The P&DC had been using the robots until the moment when this organization realized that they need changes.

3.2.2 Pennwood postal service's tuggers

The USPS' Pennwood Place P&DC is located in Pennwood Place nearby Pittsburgh. In 2016, four AMRs were used by the postal service for transportation of mail between sorting machines and loading docks on a regular basis. These AMRs were presented by GT10 Tow Tuggers from Seegrid company. Currently,

approximately 10 machines of this type are being used by the Pennwood Place P&DC. These AMRs are called for gathering in one spot (tuggers parking) by workers who use special devices for this operation. After all of the robots are gathered in one place, each robot receives its own task and goes to operate. (United States Postal Service office of inspector general 2018a, 29).

Unfortunately, these AMRs are followed by some disadvantages (United States Postal Service office of inspector general 2018a, 29).

First of all, the robots seem to be manual, due to the tablet which is used by employees. In fact, these robots are manual. In spite of the fact that the machines are capable of driving themselves, if one of the robots meets any obstacle, all flow of these AMRs will be stuck in a traffic. As a result, all operations will be stopped, and customers will need to wait for their items for indefinite amount of time. (United States Postal Service office of inspector general 2018a, 29).

Secondly, these robots necessarily travel back to their parking area after a single task is done (United States Postal Service office of inspector general 2018a, 29). Then, the robots wait for a new task from an employee (United States Postal Service office of inspector general 2018a, 29). A simple conclusion can be done that the AMRs are not able to keep in mind more than one task. This feature makes customers wait for their deliveries again for indefinite amount of time.

Thirdly, these robots completely depend on wi-fi connection (United States Postal Service office of inspector general 2018a, 29). Therefore, if there are any problems with the connection, all robots will stop operating (United States Postal Service office of inspector general 2018a, 29). As a result, customers will have to wait for their deliveries extra time, that makes them unsatisfied with the service. Also, employees will need to start replacing the robots while wi-fi connection is being fixed, that makes workers mistrustful of these AMRs.

On the other hand, these robots are capable of dragging up to 5 carts behind them, that makes AMRs' work very efficient (United States Postal Service office

of inspector general 2018a, 29). Moreover, these machines are able to learn new routes even without engineers, so they can drive multiple ways doing their tasks. (Seegrid).

Finally, if the robots are still operating at the postal service's warehouse, customers are satisfied with the AMRs' work, and profit is coming to the organization. However, any company which wishes to employ these AMRs should take all the aspects that were mentioned in Chapter 3.2.2 into consideration.

3.2.3 Capitol Heights post office

One of the United States Post Offices (USPO) is located in Capitol Heights city in Maryland. There is also USPO's Network Distribution Center (NDC) which operates for the city. In 2016, four autonomous mobile robots were bought by the USPO's department for operating in the NDC as pallet movers. These Grenzebach AMRs (Grenzebach is a company where the robots are made) are completely different from the robots from Table 1 (23). Special racks are needed for using these robots. The AMR slides under the rack and lifts it under itself. Then, a robot carries this pallet which is placed on the rack from a dock directly to a worker who places the mails into a sorting machine. There is no forklift used by this robot like the other AMRs of this type do. The essential difference which makes these AMRs more attractive for postal services is that the robot's price is $60000-$70000 per machine. In comparison with the AMRs, the other types of robots from Table 1 (23) cost approximately $200000-$250000. This matter of price makes companies be keen on AMRs by Grenzebach more than on the other AMRs. However, there are some aspects about the Grenzebach AMRs, which should be taken into consideration by postal operators. (United States Postal Service office of inspector general 2018a, 30).

Firstly, special racks for lifting pallets are required by this type of AMRs. The robots are not able to work with any other racks, that makes the machines unprofitable for companies which have their own pallets in a good condition. (United States Postal Service office of inspector general 2018a, 30).

Secondly, the price for the robots consists of only the machine bodies. However, a special software system is required for making the robots operate in a warehouse. These AMRs are not able to work while being connected to any other cloud, that makes the machines also unprofitable for organizations which use their own software systems. (United States Postal Service office of inspector general 2018a, 30).

In spite of the all disadvantages, these robots are quite small, that makes them be able to work in hard-to-reach places in a warehouse. (United States Postal Service office of inspector general 2018a, 30).

It can be easily supposed that these robots are very profitable for companies who have no their own software systems for AMRs and a huge number of new racks. As for companies which are about to purchase these AMRs, additional price for the special racks and the software system should be considered. All in all, the USPO has purchased these robots, but the AMRs are not used yet by the department (United States Postal Service office of inspector general 2018a, 30). According to the head of the postal service, the reason is that the racks and the software system have not been bought yet (United States Postal Service office of inspector general, 2018 30). As a result, no conclusion about effectiveness of the robots at the post's NDC can be made.

3.2.4 Cimcorp for Itella

Itella company is a subsidiary of Posti – the largest Finnish postal service. In 2009, all sorting centers of Itella in Finland were invested by Posti Corporation. The direction of this investment was involvement of automation into Itella's sorting centers. Moreover, two new sorting centers in Oulu and Kuopio were built, and two sorting centers in Helsinki and Tampere were renovated. During the next 3 years, these four sorting centers have been equipped with innovative Cimcorp's MultiPicks which made the centers truly modern and automotive. (Cimcorp 2011).

Nowadays, when people are willing to read online newspapers and magazines, the most essential role of postal services is moving towards parcel deliveries. There is also huge pace of growth in online shopping, that makes postal services be even more keen on delivering of goods than before. For these reasons, Itella decided to supply its largest sorting centers with AMRs such as Cimcorp's MultiPicks. (Cimcorp 2011).

In addition, Itella managed to prepare itself for the tough future of the postal market. Competition on this market became in 2012 much tougher than before, so Cimcorp's MultiPicks allowed Itella to take the leading positions. The head of Itella company, Mononen, says that cost efficiency and flexibility to volume changes were improved by implementing Cimcorp's MultiPicks. Mononen also added that nowadays it would be almost impossible for these Itella's sorting centers to stay manual and efficient at the same time. (Cimcorp 2011).

It is necessarily to notice that controllability and efficiency in these sorting centers are also growing. There is no more need for workers to lift heavy racks, because the Cimcorp's system is always ready to operate. As a result, there are less injured employees during operational hours in these sorting centers. Additionally, 24/7 support is given by Cimcorp's company, that allows Itella's sorting centers to work very well and efficiently. Also, if one robot is suddenly out of order, another robot's operational area can be easily widened, that allows to replace the broken robot. As a result, there will not be any loss of effectiveness of sorting center's operations. (Cimcorp 2011).

To summarize the implementation of Cimcorp's MultiPicks, according to Itella company, these AMRs are quite high-effective and high-controllable, that allows Itella's sorting centers also stay efficient (Cimcorp 2011). Moreover, Cimcorp's company supplies warehouses and sorting centers also with the total solution which consists of conveyors, robots, material flow control and systems integration (Cimcorp 2011). As a conclusion, Cimcorp's solutions are multiple and capable of bringing extra efficiency to postal companies' sorting centers.

4 ROBOTICS IN DELIVERY OPERATIONS OF POSTAL INDUSTRY

In Chapter 3, a process of implementing robotics into warehouse logistics in the postal industry was analyzed. Chapter 4 will continue analyzing implementation of robots into postal industry. The most essential types of robots for delivering process will be presented. Also, delivery operations by robotics or with its help at different postal companies will be researched in this Chapter of the thesis.

4.1 AMRs for last-mile delivery in the postal industry

To 2018, robots have not been used for delivering of items directly to customers (United States Postal Service office of inspector general 2018a, 2). It can be explained by several reasons: a fear of robots from customers, a high risk of wrong delivery, probability of a road accident and many other problems. Robots have not been trusted by people during a number of decades, but the end of this era is coming. There is a list with rapid growth of companies which are ready to implement AMRs into post deliveries of parcels. Moreover, some types of AMRs are already used by a number of postal organizations.

There are two ways of autonomous delivery in which robots will be included:

- an accompanied delivery; and
- an independent delivery.

An accompanied delivery is a delivering process in which a carrier is accompanied by an AMR which is in a role of a “helper” robot. (United States Postal Service office of inspector general 2018b, 6). Two ways of such a delivery type are possible. The first way is when a carrier is delivering a good, and a robot is following the person transporting letters and parcels (United States Postal Service office of inspector general 2018a, 2). The second scenario of such a delivery is when a carrier person is supported by an exoskeleton which is capable of lifting very heavy items that would be impossible for a human worker to lift without any equipment (Bonkenburg 2016, 32). The both scenarios of an accompanied delivery let a carrier to complete its deliveries much faster and

without any chance of injury (United States Postal Service office of inspector general 2018a, 2).

The second way of autonomous delivery is independent. Here, parcels are delivered by robots directly to customers without a carrier accompanying these machines. This is a completely innovative way of delivery from postal services. (United States Postal Service office of inspector general 2018b, 5).

In comparison with the AMRs that operate in sorting and distribution centers, this type of robots is now absolutely unpredictable for people. This is the reason why making any decisions about the AMRs' efficiency is not possible now. For the same reason, savings that will be given from using these AMRs are questionable as well. (United States Postal Service office of inspector general 2018a, 2).

Nevertheless, AMRs' independent deliveries should be continued and scaled in the long term. Economic, regulatory and technical progress should be monitored better as well, because the faster the deliveries will be analyzed, the sooner the AMRs will be implemented into most global postal services. (United States Postal Service office of inspector general 2018a, 2).

On the other hand, accompanied automotive deliveries even haven't been started yet. However, this type of deliveries must be started as soon as possible, because of simplicity and effectiveness that will be brought by the service. (United States Postal Service office of inspector general 2018a, 2).

Below, Table 2 presents the most essential types of robots which are used in last-mile delivery operations by postal services.

Table 2. The most essential types of robots for last-mile delivery operations (United States Postal Service office of inspector general 2018a, 5).

Product	Company	Type of operation	Speed	Weight	Carrying capacity	Battery Life	Recharge Time
Post-BOT	Effidence	Follows a carrier	6 km/h	181 kg	150 kg	8 hours	4 hours
Relay	Savioke	Autonomous	2.7 km/h	41 kg	5 kg	5 hours	4 hours
Starship	Starship Technologies	Autonomous	6.4 km/h	27 kg	9 kg	2 hours	45 min
One	TeleRetail	Autonomous	8.1 km/h on sidewalks, 32.2 km/h on roads	27 kg	45 kg	81 km	5 hours
Aida	Unsupervised. AI	Autonomous	Rolls at 32.2 km/h	27 kg	14 kg	9 hours	1 hour

Table 2 depicts the most essential characteristics of these AMRs. In order to understand better functions of the robots, a short analyze of the AMRs' parameters will be made.

First of all, the operational types of these robots should be considered. In comparison to the other types of robots, PostBOT's task is to follow a carrier carrying mail and parcels that must be delivered to customers. Therefore, PostBOTs are representatives of an accompanied type of last-mile delivery. The other robots from Table 2 are autonomous robots which are representatives of an independent way of last-mile delivery. As a result, functions of these robots are completely different: a PostBOT is used as a helper for a carrier; Relay, One, Aida and Starship deliver parcels and mail on their own. (Table 2, 39).

Secondly, the AMRs' speed should be analyzed. As it can be seen from Table 2 (39)**,** the fastest robots are One and Aida. The maximum speed the robots are able to reach is 32.2 km/h on roads (Table 2, 39). As being robots for independent deliveries, the speed is quite useful, because deliveries which are operated by these AMRs will be done much faster, as a result, customers will be more satisfied. On the other hand, such high speed raises a chance of a road accident which can bring harm to both parcels and people around.

As for a PostBot, 6 km/h is quite enough for this type of robot, because its task is to follow a carrier who delivers on foot. It can be easily assumed that a human being cannot reach speed which would be higher than 6 km/h, that makes PostBOT's speed appropriate for accompanying a person. (Table 2, 39).

As for the two other robots, speed levels of Relay and Starship are quite nice for independent deliveries. In spite of the fact that the speeds of Relay and Starship are much lower than the other robots from Table 2 have, these AMRs can be called as the safest types of machines for independent deliveries, because their moderate swiftness produces a much lower chance of a road accident than the chance which is produced by One or Aida. (Table 2, 39).

If weights of these AMRs are analyzed, it will be easily seen that the robots cannot be stolen, because they are enormously heavy even when empty. As for the heavy weight of PostBOTs, it can be justified by the capacity of this robot. (Table 2, 39).

The carrying capacity of the robot by Effidence is almost four times larger than the robot by TeleRetail has. Such a difference in carrying capacity can be explained by the fact that a PostBOT with a carrier deliver significantly a larger number of parcels than the other autonomous robots from Table 2. (Table 2, 39).

Last but not least parameter of these AMRs is a life of their batteries. In comparison to the other types of the robots from Table 2, Aida robot must look most attractive for postal organizations. Aida is capable of operating during 9

hours requiring only 1 hour of charging while the other AMRs are able to work maximally during 5 hours requiring 4 hours for charging. If PostBOT is analyzed, it can be easily assumed that this robot will be convenient to use for postal services as well, because the AMR is capable of 8-hour following its carrier while 4 hours are required by this robot for charging. (Table 2, 39).

All in all, all these AMRs are innovative, and it may be assumed that many postal companies all over the world are interested in using them for delivery operations, that makes the robots valuable enough.

If to take a look at the AMRs features, different sensors, lidars, cameras, mapping technologies and GPS will be identified. However, all these tools were described in Chapter 3. Nevertheless, there is a list of new technologies that the delivery AMRs are going to be equipped with very soon (United States Postal Service office of inspector general 2018a, 28).

For outdoor robots, there is still one problem which is currently actual. AMRs have enough knowledge and technologies to avoid different types of obstacles such as curbs, people and trees. However, developers of these robots have not been creating any technology which would handle stairs yet. Customers are ready to meet the AMRs in front of buildings, because nowadays most buildings have at least five stairs. Nevertheless, innovations are created for making humans lives easier. For this reason, companies need to make the AMRs be capable of climbing stairs. (United States Postal Service office of inspector general 2018a, 28).

However, Aida robots are equipped with a solution which will help the robots to overcome stairs. Legs with wheels are implemented in the robots from Unsupervised. AI. Aida robots are capable of rolling on roads, but if stairs are met by this AMR, this robot will easily switch to legs and overcome this obstacle. (United States Postal Service office of inspector general 2018a, 29).

There is also a company which is currently producing robots' bodies with a special tool which helps robots to climb stairs (Robotics Business Review 2016). This technology is called as stairclimbing treads by Transcend Robotics (Robotics Business Review 2016). This robot costs approximately $2000 and can be attached to most types of the delivery robots from Table 2 (39) (United States Postal Service office of inspector general 2018a, 29).

In addition, there are some other technologies which are installed in some types of delivery robots. For example, there are some AMRs that are capable of travelling within multistory buildings using their wireless connection with elevators' systems in some houses. Therefore, these robots can call an elevator and go to any floor they need. Some robots are capable of recognizing their customer using facial recognition technology. Also, some AMRs can be commanded by voice or gestures. (United States Postal Service office of inspector general 2018a, 29).

In order to summarize all the information that was mentioned in subChapter 4.1, AMRs for delivery operations are being constructed nowadays, and new technologies for them are being created. It can be supposed that in the future, most of daily postal deliveries will be preformed by robots. However, while some of these AMRs are already being used nowadays, some cases of using the robots by global post services will be described.

4.2 Cases of implementation of AMRs in last-mile delivery operations by global post operators

4.2.1 Deutsche Post DHL and PostBOT's collaboration

It is easily to suppose that nowadays one of the most famous postal operators is Deutsche Post DHL (DPDHL). Innovative technologies are always used by this company. As a result, DPDHL's customers are usually satisfied with the company's services. (United States Postal Service office of inspector general 2018a, 33).

In 2017, DPDHL started testing PostBOTs as accompanying robots. Bad Hershfeld city was chosen as a place for the test. The task of the robots is to follow their carriers carrying mail and parcels. These AMRs are capable of carrying six postal trays at the same time, that makes carrier's work much easier than before. Moreover, carriers' hands are not loaded anymore with all the postal mail, so distribution process is also easier now for workers. (Deutsche Post DHL Group 2017).

In Figure 8, PostBOT is shown helping carriers with deliveries in Germany.

Figure 8. A PostBOT during test period in Germany (Deutsche Post DHL Group 2017).

Jurgen Gerdes states in his interview that DPDHL's deliverers work hard every day doing very exhausting tasks. He explains that PostBOTs must reduce the amount of load that is daily on DPDHL's workers. Jurgen Gerdes is also sure that customers will be more satisfied watching these AMRs in operation. (Deutsche Post DHL Group 2017).

DPDHL's PostBOTs have all the requirements which are vital for delivering operations. These AMRs are capable of carrying 150 kilograms that consist of a large number of mail and parcels. Moreover, PostBOTs move always behind a carrier using a track technology which catches worker's movements. Obstacles are always avoided by PostBOT, that allows a carrier to pay more attention to its

task than to an accompanying robot. In addition, any weather conditions are appropriate for operation of this robot. (Deutsche Post DHL Group 2017).

DHL also says that if these robots will be completely implemented into DPDHL's processes, investments in the AMRs will be returned within three years. In order to operate on the market efficiently, such time of return on investments is quite positive. (United States Postal Service office of inspector general 2018a, 33).

In spite of the fact that DPDHL relies on PostBOTs, there are no any results of this test published. The only fact was mentioned in USPS postal report is that DHL have not tried yet to perform any deliveries using this robot farther away than DPDHL office's area in Bad Hershfeld (United States Postal Service office of inspector general 2018a, 34). According to the lack of information about the test results, it cannot be concluded if PostBOTs are efficient and useful for using them in last-mile delivery operations.

4.2.2 Swiss Post's solution for last-mile delivery

At the ending of 2017, Swiss Post has been using AMRs for its last-mile delivering operations (United States Postal Service office of inspector general 2018a, 33). Starship AMRs were chosen for directly-to-customers deliveries by Swiss Post (United States Postal Service office of inspector general 2018a, 33). Swiss Post also states on its official website that they are one of the first companies in Europe which started providing their customers with such a type of deliveries (Buhlmann 2018). This company is trying to become pioneers on the postal market in autonomous deliveries, in order to take leading positions in the future (Buhlmann 2018).

Starship robots have been used by Swiss Post during three months from October in 2017 until January in 2018. Approximately 200 deliveries have been completed by these AMRs. The final distance that was covered by Starship machines is 800 kilometers. In addition, it is important to highlight that no accidents or problems were faced by these robots during the three months. Nevertheless, in spite of the

fact that Starship robots are autonomous machines, they have been accompanied by Swiss Post's workers during the test time. (Buhlmann 2018).

In Figure 9, the robots that have been used by Swiss Post during the test period are presented.

Figure 9. Swiss Post's robots during trial period of autonomous deliveries (Swiss Post).

Andreas Hungerbühler, Managing Director of discountlens.ch, a cooperation partner of Swiss Post for this test, stated that customers are completely satisfied with the result of the deliveries. These robots make last-mile delivery quicker than human beings usually do, because the machines have only one customer. (Buhlmann 2018).

As a conclusion for this test, the most important task of any experiment is satisfaction of customers. According to the information that was provided by Swiss Post, this company managed to reach customers' needs by this test, that means that the robots should be implemented into daily operations.

4.2.3 Australia post and nighttime re-deliveries

Another postal company which decided to try implementing AMRs into a delivering process is Australia Post (Calnan 2017). In 2017, a nighttime re-delivery program was started by Australia Post in order to test AMRs in postal delivery operations (United States Postal Service office of inspector general 2018a, 34). As a place for the test, a neighborhood of Brisbane, New Farm, was chosen (United States Postal Service office of inspector general 2018a, 34). There is no information provided about a type of the AMRs that have been used during this experiment (Calnan 2017). It can be easily supposed, the whole process of such a delivery looks very attractive for customers. If customers miss their daytime delivery, they will be provided with another nighttime re-delivery performing by a robot (United States Postal Service office of inspector general 2018a, 34). An SMS is sent to those customers who missed their daytime delivery that their parcel can be re-delivered again between 6 p.m. and 12 a.m. by a robot (United States Postal Service office of inspector general 2018a, 34). When a robot almost reaches a final destination, the last SMS is sent to a customer, that its parcel is delivered, and as soon as a customer replies to the SMS, that its parcel was delivered, a robot is opened, and a parcel can be collected (United States Postal Service office of inspector general 2018a, 34).

This experiment has been performed during 4 weeks, and 100 parcels have been delivered to customers (Calnan 2017). Moreover, all the customers that were provided with the service said that they are completely satisfied and would recommend the same delivery to their friends, and seventy five percent of the customers said that they would pay additional price for the service, because it is quite convenient for them (United States Postal Service office of inspector general 2018a, 34).

Nevertheless, as no identical deliveries have ever been provided before, AMRs must have been controlled by a human carrier following these robots (United States Postal Service office of inspector general 2018a, 35).

To summarize the re-delivery process, there is a list of advantages and disadvantages of the test. First of all, one robot is only capable of one parcel being delivered at a time, that makes such deliveries inefficient and inflexible (United States Postal Service office of inspector general 2018a, 35). However, most of the customers who were served by a robot concluded that they are completely satisfied and even willing to pay extra money for this re-delivery process. Australia Post stated that there is high possibility of such nighttime re-delivery service being implemented into daily operations of the company within five years (United States Postal Service office of inspector general 2018a, 35).

5 LABOR AND ECONOMIC ISSUES OF AUTOMATION IN THE POSTAL INDUSTRY

According to the paper, implementation of robots into the postal industry is occurring at high speed. AMRs either accompany human workers or replace them. However, there is still a couple of issues that are actual nowadays. Firstly, what companies will do in order to remain human workers in operation in the future. Secondly, how automation will affect economic situation of postal companies. The final stage of implementation of robotics into the postal sphere will depend on these two issues.

5.1 Labor issues in postal services during implementation of robotics

According to Global Employment Institute, approximately one third of all human jobs nowadays can be easily done by robotics (Wisskirchen et al. 2017, 14). Many jobs that require bachelor’s degree also can be performed by machines without any educational diploma (Wisskirchen et al. 2017, 14). In spite of the fact that many professions may disappear in the future at all, some new jobs will be created by implementation of automation (Wisskirchen et al. 2017, 19). However, common requirements for future employees will be changed (Wisskirchen et al. 2017, 19). As Office of Inspector General states in its report, in the postal industry, professions which consist of a set of repetitive tasks will be excluded at all (United States Postal Service office of inspector general 2018a, 16). Current AMRs are already capable of performing almost all the repetitive tasks, as a

consequence, in the future these robots will be able to do all the operations (United States Postal Service office of inspector general 2018a, 16).

As a result of this job issue, if the demand for workers in the postal industry will become lower in the future, organizations' requirements for employees' education and work-experience will be much higher (Wisskirchen et al. 2017, 19). Can be easily assumed that low-qualified employees will need to gain extra degree in some other fields, otherwise they will lose their jobs.

However, a degree in an additional field should be also chosen carefully, because, for example, professions connected with accounting will be eliminated by artificial intelligence as well (Krischke 2015).

Contrarily, employees with good knowledge in math and IT science's fields will be highly-appreciated, because new jobs such as maintenances of AMRs, developers of AMRs and other professions connected with AMRs will appear (Wisskirchen et al. 2017, 20). For example, postal carriers are highly-guaranteed will be excluded from post operations, that means those of the carriers who will know how to work with AMRs or how to fix them will probably keep their work (United States Postal Service office of inspector general 2018a, 17).

At the same time, in order to give more space for Kiva robots' operations, Amazon.com has built several new fulfillment centers (Rusly 2012). As a result, approximately 50000 new employees were hired (United States Postal Service office of inspector general 2018a, 17).

Nye Longman states in his article that robots will replace workers on low-waged positions which include dangerous and "dirty" tasks. Therefore, all the employees who will be replaced by robots will be able to be hired on higher positions such as managers or developers of these "dangerous" departments. Nye Longman also says that the new jobs for these employees will not require any Doctor of Philosophy's qualifications, because these workers will know all processes and machines connected with their previous profession very well. (Longman 2017).

In addition to opening new opportunities for employees, AMRs will also reduce the possibility of being injured for employees, for example, when performing delivery operations, carriers now will be accompanied by robots that will let workers avoid lifting heavy items (United States Postal Service office of inspector general 2018a, 17).

However, such difficult jobs as postal carriers or warehouse loaders are very important for non-career employees, because hard-physical tasks are often done by them (United States Postal Service office of inspector general 2018a, 17). Can be easily assumed that turnover of non-career employees in the postal industry will grow in the future due to the growth of a number of AMRs implemented into daily postal operations.

5.2 Economic issues in postal services during automation

It is easy to suppose that any changes in any industry must be profitable for organizations, otherwise there is no sense in these modifications. However, the average price of AMRs on the market is quite high, that makes companies doubt about the need of automation. For example, large robots' cost such as PostBOTs' one may be as high as $200000. At the same time, there are many smaller AMRs which may cost approximately $10000. However, purchasing such small robots will produce a need in a larger number of them, that will be also unprofitable for postal services. (United States Postal Service office of inspector general 2018a, 15).

Despite these very high prices for AMRs, the average selling price for industrial robots all over the world is currently reducing. Below, Figure 10 shows the average price for industrial robots from 2009 to 2018.

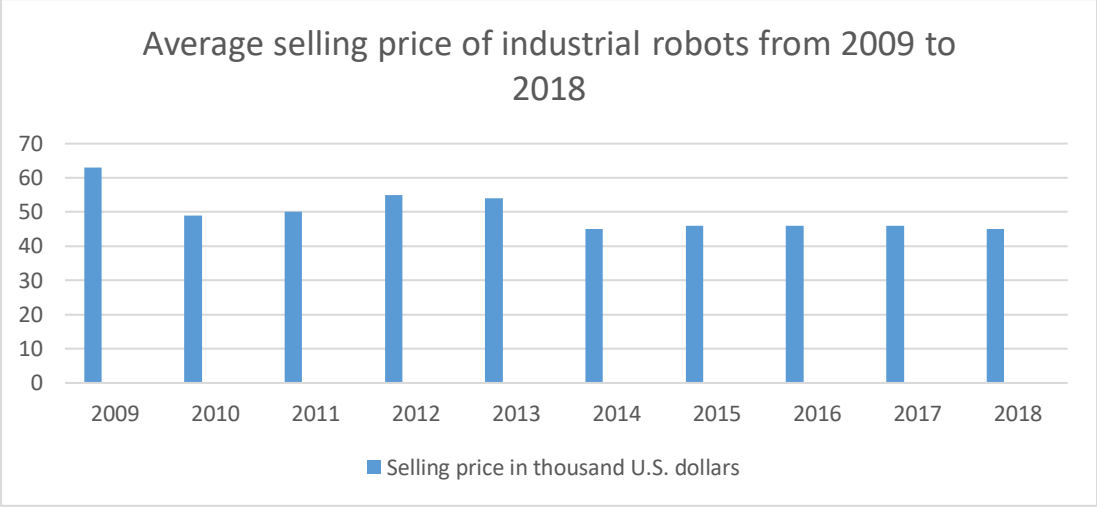

Figure 10. Average selling price of industrial robots from 2009 to 2018 in thousand U.S. dollars (Statista).

As it can be seen from Figure 10, prices for industrial robots do not tend to grow, that gives a chance for postal companies to implement robots into postal operations completely. Moreover, in comparison with human workers, whose work in the USA costs 40$ per hour and in Europe – 20$ per hour, one working hour of a warehouse robot is equal to approximately $8, that makes AMRs much more profitable for postal companies (Wisskirchen et al. 2017, 14).

On the other hand, there are costs per a delivery. For example, the average cost of each delivery by AMRs at Swiss Post is enormously high, that makes these deliveries unprofitable for Swiss Post organization. However, the cost is so high mostly due to the person who follows the AMRs, because local regulations require it from companies. Therefore, there is chance that if the robots will be allowed to work on their own, the average cost per a delivery will be very affordable for Swiss Post. (United States Postal Service office of inspector general 2018a, 15).

One more positive fact that plays for robots is that machines never stay at home due to illness, are never on maternity leave or go on strike. These points make postal companies appreciate AMRs even more, because the average amount of unwanted expenses will be reduced by the “never” factors. (Wisskirchen et al. 2017, 14).

Moreover, warehouse robots are capable of working constantly 24 hours per day and 7 days per week, because, as it was explained in the previous paragraph, these robots are independent of external factors (Frankfurter Allgemeine 2016). Also, as Michael Haag states, accuracy of robots is much higher than human workers do, because machines cannot be stopped by fear or danger (Botthof & Hartmann 2015, 63). In addition, greater standardization and synchronization of work are provided by robots' operations, that, as a consequence, produces a higher level of efficiency and transparency in a company's warehouse (Maschke & Werner 2015, 9). As a result of a high level of standardization, when important decisions are needed to be done, AMRs act according to the standards, that makes them independent of emotional conditions (Wisskirchen et al. 2017, 14).

One more financial advantage of AMRs is that overtime hours' payment is not paid to robots. For example, the USPS postal service in Pennwood Place, which was described in Chapter 3 (31), has managed to reduce the amount of overtime hours by 19 percent during 2017 (United States Postal Service office of inspector general 2018a, 16). As a result, approximately the amount of $281,000 was saved in 2017 (United States Postal Service office of inspector general 2018a, 16). It can be also suggested that in the future robots which accompany carriers during delivery operations will be able to save huge amount of money for postal companies helping carriers be done with all deliveries on time.

As a conclusion for this Chapter, it can be said that there is a couple of issues that must be taken into consideration by postal organizations when implementing automation into all types of postal activities. First of all, it is economic efficiency of these AMRs, and secondly – an ethical issue towards human labor.

CONCLUSION

Nowadays, logistics needs to be renovated, because customers' needs and wishes changes. In the paper, one of such ways of renovation, automation, was analyzed among global post organizations. The most essential aspects and issues of automation in warehouse and last-mile delivery operations of postal services were analyzed.

It can be easily concluded that AMRs are being increasingly purchased by many postal services all over the world (Chapter 3). It shows that automation is already partly implemented into warehouse logistics in postal industry. Also, according to the examples from Chapter 3, post companies are quite satisfied with these robots' results. Extra effectiveness, control and speed are brought to sorting and distribution centers of postal organizations by the AMRs. There is a high possibility that if postal business continues to develop towards this direction, in a couple of years most of warehouses and distribution centers on the postal market will accept implementation of robotics as well.

As for a last-mile delivery issue, it can be suggested that robots will bring a new step of evolution to this sphere. People are capable of many operations, but they are not machines. Humans cannot lift extremely heavy items or transport enormous goods from one place to another one without help of robotics.

Furthermore, autonomous carriers will make removal areas much easier for delivery. At the same time, customers will be able to receive their parcels on time and when it is comfortable for them. In addition, as it was stated in Chapter 3, people will be more satisfied and interested in the new ways of delivery, because it will be absolutely unordinary for them.

On the other hand, nowadays, there are many articles about robotics' revolution. This is the reason why many people can be afraid of machines delivering them their parcels. Moreover, it was mentioned earlier in Chapter 4, that there is still little chance that sometimes robots can become defective. As a consequence, people can be sometimes hit on the streets by robots. However, even if robots do

not bump into passersby but are defective, they still can scare people acting in unordinary ways.

As one more drawback of automation, distribution and sorting centers can also sometimes suffer from robots. For example, if a machine becomes faulty but still continue operating in a wrong way, it can make some harm to items or break a system of sorting order, that will bring additional problems to the centers.

Furthermore, there are several ways of how AMRs' implementation will affect labor situation in postal services. Some of these points are positive for current workers of the postal industry, the others are problematic. Automation will bring unemployment to non-career employees. As it was stated in Chapter 5, when all physical operations will be performed by robots, non-career workers will lose their jobs, because they are usually hired especially for that types of tasks. At the same time, for employees with high-education degree new career opportunities will be opened, because their repetitive tasks will be done by robots. Therefore, these workers will be able to be employed as managers. It can be easily assumed that there will be many contradictions between employees anyway in the future when automation will be completely implemented, because there are always some people who agree with changes and who do not agree.

However, not only labor issues will be taken into consideration when completely implementing robotics into the sphere, but also economic aspects, because automation must be profitable for companies as well.

Robots never become ill, they never have children and never go on strikes. All these points make robots very profitable and attractive for companies, because unwanted expenses will be eliminated when AMRs will be implemented into operations. Also, robots are capable of 24-hours working 7 days per week.

Nevertheless, the average price for industrial robots is still high enough, that makes AMRs unprofitable for many companies. Even if postal organizations buy smaller robots which cost less than huge AMRs with a set of high-quality

features, these companies will need to buy much more machines than they would need purchasing expensive AMRs.

As for costs for deliveries which are provided by AMRs, in the future, if use of carriers is not an obligation, the average cost for a single delivery will be much cheaper, that will make AMRs' deliveries more affordable for customers and postal services.

All in all, as any other innovations, implementation of automation can bring some cones and drawbacks to the whole postal industry. New technologies are often difficult for people to accept. However, all innovations always need time to be approved by people. Finally, robotics will be able to become an integral part of humans' daily life very soon.

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