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AUTOMATION AND INNOVATIONS IN LOGISTIC PROCESSES OF ELECTRONIC COMMERCE

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Many different kinds of automation are saving great amount of time and money in e-commerce. This paper gives an overview of the current applications and future of robots in e-commerce and discusses the various factors that that are important to choosing the best approach in 'last-mile-delivery'. It discusses advantages and disadvantages of autonomous vehicles, questions about safety and reliability and marketing effect. Automation at earlier stages of supply chain, less visible for clients has more impact on delivery process economics.

Keywords: e-commerce, delivery, customer, logistics, costs, robots, time, distance, drone, warehouse

1. Introduction

Nowadays the buyer can choose from a number of possible solutions that meet requirements and preferences in terms of delivery time, form of payment, form of delivery, and prices. Among the most popular solutions there are delivery methods such as: by courier, by post, by parcel services, delivery to automated collection points. Most of them are related to e-commerce. The aim of the paper is to present latest innovative concepts in areas of automation and robotization of logistic processes of electronic commerce.

While the phenomenon of e-commerce is not new, the scale of the process from year to year poses increasing challenges to the logistics industry. Alibaba's "Single Day" promotional campaign brought the company $ 17.79 billion in profits within the first day (the first billion within the first five minutes) and 1.7 million employees sent out 650 million worldwide packages in as little as 24 hours [1]. It's just one example, but the reason is the same for every scale of online trading - producers and traders want to sell directly to the final consumer, bypassing the retailer's chain, while customers appreciate the convenience and time savings.

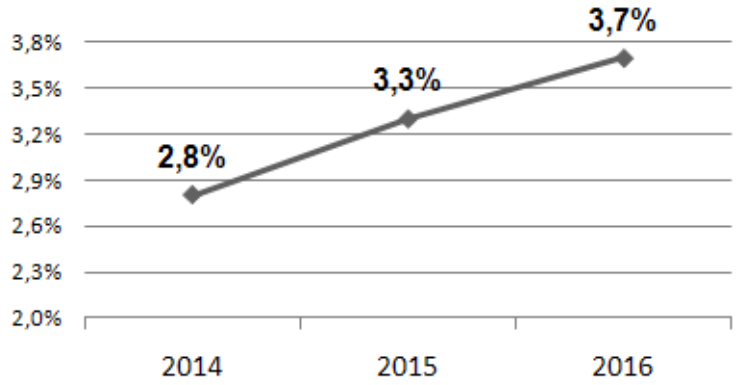

Figure 1. Market share of electronic commerce in whole commerce activity in Poland. *Source*: Retail Research https://www.twenga-solutions.com/pl/insights/e-commerce-polska-2016

The concept of logistics is broadly defined. One of the classic descriptions of this concept is the definition of CLM (The Council of Logistics Management). According to this source, logistics is the part of the supply chain process that plans, implements and controls the efficient flow and storage of goods, services and relevant information from place of manufacture to place of use, to meet customer requirements [2]. This definition does not focus solely on the material flows of products or raw materials but also on the information that is emerging in the process.

Currently, there are many ways of delivering shipments to the customer. Each of these solutions has both advantages and disadvantages. Customer contact to delivery person or technological solution is often final stage of the purchase process, which occurs after the buyer visits the website. Every customer, after analysis and prior experience, and according to their preferences, chooses the right way that will meet his or her requirements appropriately.

Table 1. Structure of customers purchasing goods in Internet

	2012	2013	2014	2015	2016
	Data in %				
Total	30.3	31.6	34.2	36.9	41.9
Gender					
Men	32.4	34.0	35.9	40.0	42.9
Women	28.5	29.5	32.7	34.2	40.9
Age					
16-24	48.8	49.3	52.0	57.9	56.8
25-34	55.3	58.3	59.9	64.3	67.8
35-44	40.6	43.8	48.1	49.0	54.0
45-54	21.3	22.3	26.4	29.5	33.0
55-64	10.0	11.7	13.0	16.0	18.9
65-74	4.0	4.0	6.2	6.2	7.6

Source: own work based on Information society in Poland. Statistical data 2012-2016, GUS

Throughout the supply chain, global as well as domestic, the biggest problem is the 'last mile' problem. It is to deliver the product from store or distribution center to the final destination. Malcolm Gladwell described it in 1999 in one of his articles: "Right now, billions of dollars are being spent on so-called ‘last-mile delivery systems’". It is, due to its very specific delivery needs, considered as the most expensive part of the supply chain. The last-mile part accounts, depending on several factors/characteristics, for 13% up to 75% of the total supply chain costs [3].

Many companies are not even trying to compete with the price of supply services that have been free for many customers in many industries for several years. Instead - the focus was on the so-called. VAS - Value Added Services. We can observe more and more types and technologies of supply in the market, which are not only cost-effective but also fast, convenient or even exciting, creating added value for the recipient.

2. Robots in last-mile delivery

The most spectacular and most controversial of automated delivery vehicles are Unmanned Aerial Vehicles (UAVs) known as drones

Less than 4 years ago, Domino's Pizza, the UK's first company, has announced the first tests to deliver a package wrapped in a special thermo-insulating bag via the DomiCopter dock. In December 2016, Jeff Bezos, the CEO of Amazon, one of the world's largest e-commerce retailers, announced on Twitter the first successful delivery. The entire operation (from the moment of placing the order to delivery to the customer) took 13 minutes.

In November 2016, the Czech online shop Mall (also operating in Poland, Slovakia, Hungary, Slovenia and Croatia) reported the successful completion of a pilot program using the drones "DJI Matrice 100 quadcopter"). The pilot program consisted of transporting the package at a distance of 2 kilometers and was the first such operation in Central and Eastern Europe, which took 2 minutes. Unpacking of the packaging was done using a remote control. According to information provided by the Mall online store, these tests were conducted in cooperation with the staff of the Center for Artificial Intelligence at the Faculty of Electrical Engineering of the Czech Technical University in Prague. The total capacity of the transport device allows the transport of unit packages up to 2 kilograms at a maximum distance of 60 km.

Figure 2. Drone "DJI Matrice 100 quadcopter" tested by Mall online store
Source: https://www.rockawaycapital.com/en/2016/11/mall-cz-successfully-tests-drone-delivery-package-delivered-in-three-minutes/

Within three years, Amazon developed his Prime Air project. The project is linked to the creation of a future delivery system from Amazon, designed to deliver orders to Amazon customers up to 30 minutes [4, 5].

Figure 3. Amazon Prime Air prototype. *Source*: https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011

Prime Air has the potential to expand the range of services offered. Introducing Prime Air will take some time, but Amazon will introduce it once it receives support from state regulators.

Due to the increasing popularity of unmanned aerial vehicles, on 7 September 2016 legal regulations entered into force, which regulated the movement of unmanned aircraft over Poland. The most important provisions of the regulation include the limitation of the ability to fly over built up areas using drones weighing more than 0.6 kg (with a minimum distance of 100 meters from buildings and 30 meters from people and vehicles). For devices whose own weight does not exceed 0.6 kg, it is possible to fly almost without restrictions (including built-up areas).

The most important advantages of using unmanned aircraft in e-commerce logistics include:

- Ability to deliver orders in a very short period of time (less than 60 minutes from the time of placing the order to delivery of the order to the buyer),
- The ability to provide services on a continuous basis - 24 hours a day / 7 days a week,
- Significant cost reductions on the part of the buyer as well as the seller related to the need to execute the order through an intermediary,
- Measurable benefits to health and the environment associated with the reduction of emissions from vehicles used in the delivery process,
- Delivery on difficult terrain like mountains or jungle, not restricted to road infrastructure.

The disadvantages of using unmanned aircraft in e-commerce logistics include:

- "Childhood Diseases" related to new technology and the lack of use of large-scale equipment (e.g. No systems developed to prevent airborne collisions),
- The high cost of training the personnel responsible for steering unmanned aerial vehicles,
- The need to adapt the equipment and delivery methods to local legal requirements,
- Complex logistics of using the drones to deliver to many different types of destinations including homes, apartment buildings and commercial properties,
- Problems with inclement weather conditions such as ,snow, heavy rain, strong winds.

Rakuten, Japan’s No. 1 online shopping site conducted drone-delivery service by delivering player golf balls and refreshment on a golf-course. This considerably small service allowed to collect test data, which was utilized during building new drone. “Tenku” has a number of performance enhancements including water-

resistant parachute to slow the speed of the fall in an emergency, image recognition technology for landing, and offers a greater level of safety than conventional drones [6].

However from economics perspective drone delivery is not perfect solution. Economics of “last mile delivery” depend on two factors: route density and drop size. Making many deliveries at various locations at a single route results with low single delivery cost. Drones perform poorly on these economic aspects. Current prototypes can deliver one package in time, and have to fly back to base for recharging batteries and new load.

Comparing this to a delivery truck from UPS makes an average of 120 stops a day to deliver hundreds or thousands of packages. Delivering packages in a city with many packages delivered on every block is very cost effective. Rural delivery routes to widely dispersed addresses are the most expensive due to the time and vehicle expenses required to complete for each deliver.

Reduction of just one mile per driver per day over one year can save UPS up to $50 million. UPS is aware of that fact. To reduce costs and create effectiveness on rural delivery roads they plan to incorporate drones into day-to-day truck operations. The drone docks on the roof of the truck, a driver loads parcel into cage beneath the drone and sends it to a destination. The drone is fully autonomous, doesn’t require a pilot so meanwhile driver continues along the route to make other deliveries. Returning drone is pulled down to the vehicle with a robotic arm and docked, so it can recharge itself through a physical connection with truck battery [7].

Another aspect is important in terms of drone economy. Aircraft moving forward or hovering in the air constantly have to fight gravity, when it accelerates also a resistance of inertia and air must be taken into account. The flight time of a drone is limited by its weight and the energy stored in its battery. Optimizing battery weight is important for drones because battery consumes a large portion of drone’s carrying capacity, meaning that increasing its battery size to extend flight time significantly reduces the capacity available for packages. Balancing payload weight, battery weight, and flight time are important considerations when attempting to minimize the cost or the delivery time for drone deliveries. An energy consumption model helps balance the two by providing the energy consumed by the drone as a function of its weight [8].

Drones can successfully be used on hard to reach, rural areas but in cities, ground-based delivery services are a more practical solution. Unlike drones, delivery robots can travel at low speeds on pedestrian and bike lanes and are targeted uncrowded suburban areas or campuses. They require recharge every few hours. At the same time, delivery robots have a shorter range when compared with drones. Roadblocks such as ramps, steps, and curbs may be problems for some.

And since robots are designed to share the sidewalk with pedestrians, there may be limitations as to their numbers. They may also not be able to operate in crowded areas.

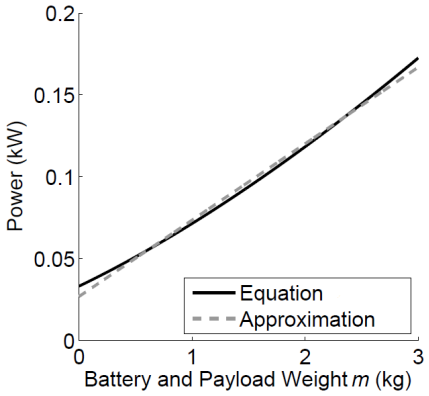

Figure 4. Power consumed by a multirotor drone assuming 6 rotors, a fluid density of 1.204 kg/m3, a rotor disc area of 0.2m2, and a frame weight 1.5 kg. *Source*: Dorling K., Heinrichs J., Messier G.G.,Magierowski S.Vehicle Routing Problems for Drone Delivery

The first example of, quite futuristic on-ground delivery robot, is the Starship. This is a British-Estonian concept of using small, self-propelled 'toy cars' to ship consignments. Vehicles are equipped with a number of sensors to ensure traffic safety and theft protection. The robot manages a distance of 5 km in 30 minutes, carrying loads of up to 20 kilograms. The whole route can be monitored by smartphone and even modified in real time. The whole project is already in advanced stages of implementation. By November 2016, the robots totaled a distance of 20000 km. In January this year the company announced its $ 17.2 million R & D budget.

Figure 4. Starhip robot. *Source*: https://www.starship.xyz/press/images/

Another company creating delivery robots is SideWalk which has already conducted pilot projects partnering DHL in Lithuania, with plans to expand to Germany and Denmark. SideWalk provides instant (about 15 min) first-mile, last-mile city delivery. Theirs robots require recharge once every 7 hours, can carry a load 23 kg, and travel 10 km. SideWalk robot can drive mostly on its own, using integrated navigation and obstacle avoidance software, but it's also overseen by human operators in the office to ensure all times safety. The estimated cost of delivery by a SideWalk robot is about $3.40 [9].

Delivery robots use GPS, sensors, and cameras for navigation, stopping for an obstacle or pedestrian in its path. Some models can travel up and down curbs and small stairs. Robot drive autonomously 99 percent of the time in a carefully mapped local area. Another key advantage of delivery robots is relatively low cost. Since delivery robots are earthbound, the technology required to monitor and operate them can be less sophisticated than drones, thus reducing costs.

To speed up delivery and eliminate shipping costs, consumers may prefer to pick up an online order at the store. Retailers offer this option today, dependent on inventory availability. If drones and robots or driverless vehicles become adopted by individuals, consumers may be able to send their own drone, robot or driverless vehicle to pick up an order from the store.

3. Automation in warehouses

Technological innovations are not only the use of robots for mailing and delivery but full automation of warehouse processes from computer modeling to robotic applications, or further development of existing technologies such as replacing conventional scanners for mobile devices.

In 2012, Amazon acquired Kiva Systems, which was involved in the production of warehouse robots, robots that automate the picking and packing process At the end of 2014, Amazon started using 15,000 Kiva robots in 10 warehouses and 30,000 robots were used in 13 of the company's magazines.

Amazon logistics centre in Poland is the first distribution centre in Europe using sophisticated robotics system. Robots use barcodes and other identifiers to find shelves containing product, next move the entire shelf to the to the shipping queue where the necessary products are ; and after some time put shelves back in the right place. Algorithm used in this system allow robots to choose the shortest way from its localization to needed shelf, it also help to put the most often used shelf nearer to packing zone [10].

The Kiva robot is a square structure with wheels, a height of 40 cm and weighs about 130 kilograms. It moves at a speed of about 7.5 km / h and is able to carry loads of about 280 kilograms. Thanks to the Amazon robots there is the

possibility not only to shorten ordering time but also to save space in the room. In fully automated warehouse, where operating robots are much smaller than traditional forklifts spaces between the shelves can be narrower and more space could be used to store things. In magazines where engaged robots, you can place 50 percent more goods compared to where people work [11].

Efficient completion is minimizing the time needed for order preparation, it also fluent on decreasing the amount of order mistakes. Another issue is the fact that products have to be clearly labeled. They often have to be packaged and stored in different ways so the robots can deal with them. In some cases, this may mean completely replacing all of the shelving in your warehouse.

Robots have cut operating costs by about 20 percent ($ 22 million). According to Deutsche Bank experts, if Amazon uses robots on all 110 magazines, it will save the company about $ 2.5 billion. Although the installation of robots in each warehouse will cost $ 15-20 million, a one-time savings will be about 800 million [11].

Figure 5. Maasvlakte II at the Port of Rotterdam. *Source*: https://www.joc.com/port-news/european-ports/port-rotterdam/europe%E2%80%99s-pioneering-automated-terminals-face-challenging-year-ahead_20160204.html

Automation at much larger scale can be applied in ports. At peak efficiency, a single crane can remove about 40 of containers per hour and for each one they unload, companies moving containerized cargo are charged a terminal handling fee of around $300.

The container cranes at Maasvlakte 2 in the port of Rotterdam are unmanned and practically fully automated. For instance ships are loaded and unloaded by automatic cranes. Remote process operators, working from at the office monitors control a crane movements. A crane lifts a container and loads it onto an automated vehicle which transports containers to the storage area. They are also unmanned and fully automated. They even know when their battery is almost empty, then

drive to the battery swap station where a robot equips itself with a new battery. “Ports are the ideal testing grounds for robots. It is a controlled area with lots of space.” says Markus Kueckelhaus from DHL [12].

4. Conclusion

The advantages of robots are evident. They eliminate tasks that are dangerous, don’t mind doing work that is dull or repetitive, and are more efficient, more accurate and stronger than people could ever be.

Table 2. Advantages and disadvantages of robots in supply chain

	Advantages	Disadvantages
Drones	Fast delivery Operate in hard to reach areas	Expensive Weather dependent Legal issues
Delivery robots	Low cost Easy to operate and monitor	Parcels could be stolen or vandalized
Warehouse robots	Efficient use of storage space Warehouse can continuously work 24/7	High initial cost Special labels for products are required Higher level of maintenance needed
All kinds of automation	Less workers needed Faster supply chain	Requires educated personnel with high salaries who monitors and maintains robots Possible software malfunction Hackers threat

If the goal is to be considered as an innovative company, the company may want to push the edge of technology and product acceptance to create delivery drones and autonomous vehicles. In contrast, if the company is more cautious and desires the perception of dependable package delivery, then the new systems may face more internal requirements before release. In both cases, regardless of consumer preferences, robots will be further applied on earlier stages of delivery process. The last mile robots will be used mostly in limited areas of logistics such as rural delivery for air drones and short distances in cities for on ground solutions.

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