THE BENEFITS OF USING DRONES WITHIN LAST-MILE DELIVERY ACTIVITIES IN THE SMART SUPPLY CHAIN

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Abstract: *The aim of this paper is to consider the term of the last-mile delivery, as well as problems that may arise and their solutions. Last-mile delivery is the last step in the supply chain to deliver the goods to the end-user. This is the most important step in achieving customer requirements. There are different ways of realizing the last-mile delivery, such as conventional shopping, "click and collect", application of pick-up points and locker stations, home delivery, and in-car delivery. Last-mile delivery can be exposed to many challenges and problems that include outdated technology, COVID-19 regulations, increased CO_2 emissions, poor logistical visibility, etc. The use of autonomous drones is an attractive and modern way of solving the last-mile delivery problems. This paper discusses the use of drones as significant during the COVID-19 pandemic to deliver the necessary drugs and vaccines to some vulnerable areas.*

Keywords*: supply chain, LMD, drones, trends.*

1. INTRODUCTION

Market globalization and the use of new information and communication technologies have resulted in a constant need to increase the speed of goods flow throughout the supply chain (SC). Within the same, special attention is paid to the segment of delivery of goods to the final consumer. As a result, new solutions, business strategies, and concepts are created in order to overcome all possible obstacles and, at the same time, satisfy and meet the requirements of end-users in the most efficient way possible. All of the above speaks to the fact that more than ever, the emphasis and focus are placed on the end-user, that is, the pursuit of a high degree of customer satisfaction (Venus, 2019). In today's business environment, which is prone to rapid changes, legal persons and citizens require delivery in a short time to their home or company address, which can cause great challenges for their suppliers. In the SC, customers appear as the first point which

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generates delivery demands, and the last point in the chain, which evaluates the quality of the delivery service.
The successful realization of the service depends on a number of factors that occur from the very beginning of the realization of the service to the so-called last mile. Above all, high-level organization, cooperation, and synergy between all participants in the SC are required (Ewedairo, 2019; Borghetti et al., 2022).

The aim of this paper is to consider the concept of "last-mile delivery" (LMD) as a new type of service in the SC and the importance of that part of the delivery, as well as problems that may arise and their solutions. The concept of the LMD, its implementation, and potential problems will be discussed in the first section of the paper. The second part of the paper focuses on one of the LMD solutions, and it concerns the use of drones. The third part of the paper singles out some of the most common trends in this area.

2. THE TERM OF THE LMD IN THE SUPPLY CHAIN

The LMD in the SC refers to the distance it takes to deliver the product or service to the end-user, whether it is a direct delivery from a supplier, a distribution center, or any other entity in the SC. The transport of goods from point A to point B is something that existed in the earliest forms of developed society, while to this day, the number of these methods has only further developed. A large number of factors affect how, in what quantities, when, and from which place the goods will be transported to their final destination. What significantly influences the successful realization of this process is the successful realization of its individual segments, which can be called miles by one name (Ewedairo, 2019; Borghetti et al., 2022).

The last-mile represents the last step of the SC that needs to be carried out so that the goods undisturbed come from the sender to the recipient. LMD refers to the last distance that the delivery passes from the distribution center to the "home threshold" of the consumer. It is representative of the last step in the delivery process and represents the most critical section of the SC. Consequently, it is the most expensive (Ewedairo, 2019; Venus, 2019).

In addition to the LMD, which is mostly used to describe problems in the realization of delivery in the SC, there is also the first and middle mile. **The first mile** refers to the distance from the warehouse, i.e., from the center of the retail to the next hub, from where the goods will be carried on. The characteristic of this type of mile is that it has a different meaning for each of the participants in the SC. In the case of retail trade, the first mile would refer to the delivery of goods from local distribution centers to stores, while in the case of wholesale trade, the first mile would refer to the transport of goods from the manufacturer's factory to the distribution center. **The middle mile** means the distance at which the goods are supplied from the warehouses of distribution centers to the classic shops and retail facilities. End users come to these facilities in order to buy products. Figure 1 graphically shows the above types of miles, as well as their critical points (Ewedario, 2019).

Figure 1. Miles in the logistics (Ewedario, 2019)

2.1 Options for LMD logistical fulfillment

In the literature, numerous methods and options for achieving the LMD can be found. For the purposes of this paper, six options for the realization of the LMD have been singled out. It should be emphasized that this is not the final set of options, but only some of the most common and best-established examples. The first option involves **conventional shopping**. This means that the customer goes to the retail store in order to buy the product and he is responsible for the last part of the transport. The user can fulfill the LMD with own passenger car, bus, bicycle, on foot, etc. The next options include e-commerce. The second option is called **"Click and Collect,"** and it means that the user electronically orders the goods. This is an essential difference compared to the first option, which reduces the time of purchase. However, the similarity is reflected in the fact that the user also goes to retail stores to pick up the goods. Upgrading the previous option is the introduction of **pick-up points,** and this is the third option. The consumer orders the goods online and picks them up at those points that can be spread all over the country. The points are often placed within a walking distance from the user's home in urban areas, e.g. at supermarket entrances (Halldórsson & Wehner, 2020).

The fourth option involves the use of **locker stations,** which operate similarly to pick-up points. The main difference, as well as the advantage, is the independence of the time of picking up the goods from the working hours of the store. **Home delivery** is a frequent way to fulfill the LMD, which is the fifth option. It expanded during the COVID-19 pandemic. In this case, there is no private transport of goods. Delivery time must be coordinated between the customer and the logistics service provider. The latest among these options is **in-car delivery**—the sixth option. The end-user orders goods online and needs to park his car in a certain urban area during a defined time interval. The logistics provider locates the car and accesses the trunk in order to deliver the shipment. The user is responsible for the further transport of the goods (Halldórsson & Wehner, 2020; Ewedario, 2019).

2.2 LMD problems

The fact is that the LMD is the most critical part of the SC, which can be burdened with many problems and challenges. Table 1 presents the most common problems that may occur during the completion of the LMD (Correia et. al., 2021; Borghetti et al., 2022).

Table 1. The most common LMD problems (Correia et. al., 2021; Borghetti et al., 2022)

LMD problems	Brief description of the problem
Traditional routing models	Last-mile cost-effectiveness is linked to routing tools and strategies. Problems such as bad weather, congestion, and sudden road closures cannot be identified by "manual" routing methods.
Poor logistical visibility	It is necessary to establish synchronization between the provider's system and the system for tracking procurement and inventory. Otherwise, it may be difficult to track the location of the delivery truck.
COVID-19	Problems with the delivery and collection of shipments may be conditioned by regulations on social distancing.
Scaling delivery operations	It refers to the inability of companies to find a delivery manager during peak periods when their own funds are already engaged.
Firmly logistics processes	Processes are performed according to a predefined procedure, which means that there is no possibility to change the location and delivery time in progress.
Increasing CO_2 emissions	Heavy environmental pollution comes from transport. For this reason, it is expected of suppliers to replace existing and introduce new shipment delivery technologies.

3. AN EXAMPLE OF SOLVING THE LMD PROBLEMS

In the field of logistics, many researchers are facing the challenges of the LMD. The closer the product gets to the end-user, the higher the unit transport costs. In that part, the costs reach their peak at the completion of the LMD. The expansion of e-commerce, due to the COVID-19 pandemic, is leading to increased congestion, which encourages city authorities to strictly regulate traffic in urban areas. In addition, environmental and social issues should be taken into account, which largely dictate the way the LMD is conducted. One of the possible solutions is the use of modern technological solutions for Industry 4.0, such as drones (Borghetti et al., 2022; Sigari & Biberthaler, 2021). Figure 2 illustrates an example of an SC where a drone was used in the LMD.

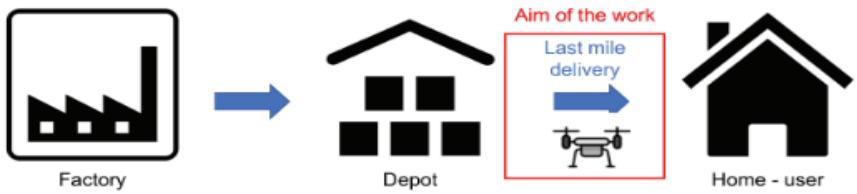

Figure 2. A schematic view of using drones within LMD (Borghetti et al., 2022)

Today, unlike in previous years when they were most often used only for military purposes, drones are increasingly attracting the attention and interest of logistics companies that provide goods delivery services. However, the use of drones in logistics processes and activities is still low. Continuous growth in the usage of drones is expected in the future. The current assessment includes the use of 20,000 drones for delivery. According to Gartner, more than a million drones are expected to be used in 2026 to deliver goods to retail facilities (Osakwe et. al., 2022). Since each SC is oriented towards meeting the requirements of end-users, commercial drones will be connected to mobile applications, which will be user-friendly. In this way, they can track the ordered goods, which reduces the delivery risk (Osakwe et. al., 2022; Borghetti et al., 2022).

DHL Express, a leader in international express delivery, and Ehang, a leading manufacturer of autonomous drones, have entered into a strategic partnership to achieve regular fully automated drone delivery. This endeavor came to life in 2019 in response to the challenges of the LMD in China's urban areas. The route is exclusively designed for DHL customers and covers a distance of 8 km between the DHL service center in Liaobu, Dongguan, and the customer's home. The use of drones for delivery overcomes complex road conditions; i.e., it can effectively avoid the congestion that is characteristic of urban areas (Osakwe et. al., 2022; Saraceni, 2021). This regular DHL service reduces delivery time in one direction from 40 minutes to just 8 minutes. Also, cost savings of up to 80% per delivery are achieved, with reduced energy consumption and carbon dioxide emissions compared to road transport. The Ehang Falcon drone has vertical takeoff and landing capabilities and provides high GPS accuracy, visual identification, intelligent flight route planning, and real-time network connection. It can transport up to 5 kg of goods per flight (Saraceni, 2021). The drones take off and land from the top of an intelligent locker, which is specially equipped for autonomous loading and unloading of delivery, as shown in Figure 3.

Figure 3. The drone takes off from the DHL intelligent locker (Saraceni, 2021)

The global impact of the COVID-19 pandemic has initiated an improvement in the SC like never before. The use of drones has become necessary for the transport of medical supplies because the delivery time between hospitals and clinical laboratories can be significantly reduced. In sub-Saharan Africa, during the pandemic, the delivery of necessary medicines and vaccines begins to work by using drones. It was necessary to ensure the availability of medical facilities in the shortest possible time, given that the infrastructure in that area was less developed. Also, with the use of drones, it is possible to provide tumor patients with the necessary chemotherapy drugs so they do not have to leave their homes (Sigari & Biberthaler, 2021; Saraceni, 2021).

From the aspect of ecology, research was conducted on the differences between the use of drones and delivery trucks in the LMD. Within a 4km radius, battery-powered drones have been found to consume less energy per package than delivery trucks. Given that road transport is responsible for 1/5 of harmful gas emissions on a global level, it is pointed out that drones deliver faster and with less impact on the environment. Like any new technology that is gradually being introduced, it encounters certain restrictions in replacing road vehicles (Stolaroff et al., 2018; Osakwe et al., 2022). The first restriction refers to the (non) acceptance of the use of drones by end-users for conducting the LMD (Osakwe et. al., 2022). The second restriction implies the existence of much larger storage capacities due to the limited range. Package size can also be a problem. Regulations related to the use of drones for commercial purposes include the obligation to register, possess a work permit, and carry liability insurance of up to 880,000 euros. It should be emphasized that regulations may vary from country to country. These regulations lead to a cost increase compared to other ways of completing the LMD (Stolaroff et al., 2018).

4. SOME ACTUAL TRENDS WITHIN THE LMD

With the raising of awareness about the importance of the degree of satisfaction of the end-user, certain trends appear in order to make that degree as high as possible. The first place is certainly the growth of electronic commerce, especially in the context of the COVID-19 pandemic. Due to limited movement and reduced contact between people, the only way to buy certain products was through the Internet and online ordering. This entails the requirements of users regarding the shortest possible delivery time, and most often on the same day.

4.1 E-commerce

E-commerce is the purchase and sale of goods, services, information, or products that take place with the significant use of modern information and communication technologies. The advantages of this method of purchase are: reduction of costs in various business segments; savings in in-service time because it responds faster to customer requests and achieves greater flexibility in customer supply; improving contact with consumers; improving business through increased revenue and access to new markets; increased labor productivity; and reduced commitment of business resources (Venus, 2019; Osakwe et al., 2022; Stolaroff et al., 2018).

4.2 Short delivery time

In the beginning, with the advent of e-commerce, the **delivery time** was approximately 5 days. However, later, that time decreased more and more, until today, when there is a delivery on the same day. The increase in this trend is a consequence of the fact that customers know exactly what they want and they wish to have the ordered product in their hands in the shortest possible time. It is also known that the shorter the delivery time, the higher the price. This fact is in favor of e-commerce companies because they are given the opportunity to make more profit and earn more on this trend. In general, customers want their LMD to "fit into life"—this includes offering a variety of options, including choosing the right delivery days, pick-up and packing cabinets, and more. According to research, more than 80% of customers today are willing to pay more for faster delivery, and meeting these expectations is the biggest challenge in LMD. One of the challenges of this trend is to ensure optimal use of vehicle capacity. As same-day deliveries generally involve small packages, the chances of fully utilizing vehicle capacity are becoming a problem, causing difficulties for logistics companies to make significant savings. Companies do not have that luxury, in terms of time, to wait for all orders that would ensure 100% utilization of vehicle capacity (Aćimović et al., 2020; Osakwe et al., 2022).

4.3 Crowdsourcing

Crowdsourcing is a trend that involves engaging a crowd or group of people for a common goal, hence the name "crowdsourcing". The common goal is mainly to introduce some innovation, problem-solving, or just greater efficiency. Crowdsourcing is driven by new technologies, social networks, and media. It can be applied and developed in various industries. Crowdsourcing is actually collecting information or opinions from a large group of people who send their data via social networks, the Internet, or applications on smartphones. Thanks to the Internet and social networks, organizations and companies are now closer to all stakeholders. Crowdsourcing the delivery of ordered products has marked a significant turnaround in LMD. Crowdsourcing logistics uses crowd workers to deliver the ordered item to the consumer as the cost of e-commerce providers themselves, providing LMD, is exceptionally high. Usually, crowd workers are a group of local and non-professional drivers who are willing to temporarily work for delivery companies and provide their assets (for example, their vehicles) to perform the parcel delivery. Crowdsourcing as a LMD concept is borrowed from sharing economy models like ride-hailing taxis (Uber and Lyft) (Correia et. al., 2021; Borghetti et al., 2022).

4.4 Consumer experience

The most important factor in the LMD process is the **experience and impression of the consumer** because it depends on whether the customer will remain loyal to the service provider or product. However, the expectation of every customer, online or not, is to have the best purchase experience and maximum satisfaction with their needs. All this must be a priority for logistics companies and their retail partners. The experience and opinions of already existing users of a certain product greatly influence the final decision of new customers on whether to buy something or not. As for the LMD process, consumer experience is the number one factor that drives innovation in this industry. Consumers have high expectations of the online shopping process itself. This refers to the ease and

smooth flow of the purchase. The high satisfaction of end-users is reflected in their higher consumption as well as more frequent purchases. Such customers will better accept new ways of service. Apropos, a high-quality LMD service is the key to developing long-term relationships (Halldorsson & Wehner, 2020; Borghetti et al., 2022).

5. CONCLUSION

LMD problems are related to challenges that companies have to face from the moment an order is generated to the moment it is delivered to end customers. It has been shown that the use of modern software solutions and information and communication technologies can significantly contribute to the elimination and reduction of problems that occur during delivery to the end-user. Some of them are optimal route planning, organization, and engagement of human resources; determining the availability of stock levels; means of transport; insufficient efficiency and speed in delivery; and similarly. The LMD in the SC is becoming a special type of service, which is becoming increasingly important due to financial, environmental, and other issues. At the same time, it represents the last phase of the SC and the last step in the delivery process to the end customer.

One of the most modern solutions to LMD is the use of unmanned aerial vehicles or drones. The use of this technology at a higher percentage worldwide would lead to a significant reduction in environmental pollution, reduce the need for manual work, and increase the speed, reliability, and accuracy of delivery. However, in addition to numerous advantages, there are several disadvantages, such as the inability of drones to access all locations due to different legal regulations or unfavorable weather conditions, and it is not possible to deliver heavy deliveries. Although this type of delivery in trade is not very common in the world, the use of drones for these purposes is expected to increase. This would further contribute to certain trends emerging in the field of LMD, such as the rise of e-commerce, home delivery, and same-day deliveries, which are of particular importance during a pandemic. In the end, the method of realization of delivery depends on the users themselves, specifically on their expectations and needs. Therefore, the focus is on them, and they strive to achieve the highest possible degree of customer satisfaction.

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