10.26411/83-1734-2015-2-55-6-23

The Use of Drones and Autonomous Vehicles in Logistics and Delivery

Ian Nurgaliev
The International University of Logistics and Transport in Wroclaw, Poland

Youssef Eskander
The International University of Logistics and Transport in Wroclaw, Poland

Supervisor:
Karolina Lis PhD
The International University of Logistics and Transport in Wroclaw, Poland

Abstract
The logistics and delivery industry is facing challenges such as high transportation costs, difficulty in meeting customer demands, and environmental concerns. However, the integration of drone and autonomous vehicle technology can address these challenges by reducing transportation costs, increasing speed and reliability of delivery, and improving efficiency. The use of drones and autonomous vehicles can bring significant benefits such as increased efficiency, cost savings, improved safety, increased accessibility, and real-time tracking. Despite the potential benefits, there are still regulatory, technical, and financial barriers to overcome before a widespread adoption of these technologies. The use of drones and autonomous vehicles in the logistics and delivery industry is rapidly growing, with companies like Amazon, UPS, DHL actively experimenting with the use of these technologies. However, there are several challenges and limitations that must be overcome before they can be widely adopted, such as safety and regulatory requirements, weather and environmental conditions, battery life and range, navigation, and public perception.

Keywords: logistics and delivery, drones and autonomous vehicles, efficiency, cost savings, challenges and limitations.

1. INTRODUCTION

Logistics and shipping are critical elements of a supply chain, and the methods used to move goods from warehouses and distribution centres to customers have a significant impact on the efficiency, cost, and security of these operations. Traditional logistics and delivery methods typically use ground vehicles such as trucks and vans driven by human drivers. However, as technology advances, drones and unmanned aerial vehicles (UAVs) are emerging as new logistics and delivery methods that offer many potential advantages over traditional methods. This article compares traditional logistics and delivery methods to drone logistics and delivery, examines the pros and cons of each approach, and discusses the potential implications for the logistics and delivery industry. Traditional logistics and delivery methods have used ground vehicles such as trucks and vans driven by human drivers. These vehicles transport goods from warehouses or distribution centres to customers. The main drawback of traditional methods is limited access. Ground vehicles can only reach certain locations, such as those with roads and infrastructure. It may be difficult or impossible for ground vehicles to access remote or hard-to-reach areas. In addition, conventional ground vehicles are subject to traffic and road conditions, and delays may occur due to traffic jams and accidents. This can lead to longer delivery times and higher prices. Additionally, conventional land vehicles are operated by human drivers and are susceptible to human error and can cause accidents, posing a hazard to both drivers and the general public.

Drone logistics and delivery, on the other hand, rely on autonomous unmanned aerial vehicles (UAVs) or drones that can fly anywhere regardless of the terrain or infrastructure. A major advantage of drone logistics and delivery is improved accessibility. Drones can reach areas that are difficult or impossible for ground vehicles to access, hard-to-reach locations. This may improve our delivery service to customers in these regions. Additionally, drones can arrive to destination faster than ground vehicles and are not affected by traffic and road conditions. This shortens delivery times and increases customer satisfaction. Drone logistics also improves safety by reducing the risk of accidents caused by human error, as they are operated by autonomous systems and do not require a human pilot. In addition, they consume less energy than ground vehicles, thus reducing labour and fuel costs. Real-time tracking is another benefit for better visibility and control of the shipping process. This allows logistics companies to optimize routes, reduce delivery times, and improve the overall efficiency of their operations.

However, it is important to note that drone logistics and delivery is still a relatively new technology and it may take some time before it is widely adopted and fully integrated into the logistics and delivery industry. This technology faces several challenges, including regulatory, safety and reliability. Also, they are not suitable for all products or deliveries, and there may be restrictions on the weight and size of packages that can be delivered by drone[1].

Traditional logistics and delivery methods and drone logistics and delivery each have their advantages and disadvantages. Traditional methods have proven their worth for decades, but drone logistics and delivery offer new opportunities for increased efficiency, reduced costs and safety. As technology advances and regulations evolve, the use of drones in logistics and delivery operations may increase in the future.

2. THE METHODOLOGY OF THE RESEARCH

The purpose of this article is to examine the use of drones and autonomous vehicles in logistics and their potential impact on the industry. The research question for this study is:

How do drones and autonomous vehicles impact logistics operations and efficiency? It is hypothesized that the integration of these technologies into the logistics industry could increase efficiency and reduce costs. The research methodology includes case study analysis of companies currently using drones and autonomous vehicles in their logistics operations, desk research, and a review of relevant academic literature on the topic.

3. DRONES AND AUTONOMOUS VEHICLES IN LOGISTICS: A SOLUTION TO CHALLENGES

Logistics and delivery have traditionally been complex and costly processes with many challenges and limitations. Some of the main problems faced by traditional methods are:

1. High transportation costs due to fuel prices and labour expenses.

[1] M. C. Lucic, O. Bouhamed, H. Ghazzai, A. Khanfor, Y. Massoud, *Leveraging UAVs to Enable Dynamic and Smart Aerial Infrastructure for ITS and Smart Cities: An Overview,* „Drones" 7(2) (2023), p. 79.

2. Difficulty in meeting increasing customer demands for fast and reliable delivery.
3. Inefficiency and delays caused by traffic congestion and road infrastructure.
4. Environmental concerns related to emissions from transportation vehicles.

However, recent advances in drone and self-driving technology have the potential to address these challenges. Drones and self-driving cars can:

1. Reduce transportation costs by eliminating the need for human labour and optimizing routes
2. Increase speed and reliability of delivery by bypassing traffic and accessing hard-to-reach areas
3. Improve efficiency and reduce delays by communicating with other drones and vehicles to optimize routes and traffic flow
4. Mitigate environmental concerns by reducing emissions and fuel consumption[2].

As such, many companies and organizations have started to explore the use of drones and autonomous vehicles for logistics and delivery. However, there are still many regulatory, technical and financial barriers to overcome before widespread adoption.

Additionally, the use of drones and autonomous vehicles in logistics and delivery can also bring other benefits such as:

1. Real-time tracking and monitoring of shipments, which can improve transparency and accountability
2. Increased accessibility and flexibility in delivery, as drones and autonomous vehicles can operate in areas that are hard to reach by traditional vehicles
3. Increased safety and reduced risk of accidents, as drones and autonomous vehicles can operate in hazardous or dangerous environments without endangering human lives.

However, it should be noted that the integration of drones and self-driving vehicles in logistics and delivery is still in its infancy, and a lot of research and development is needed before these technologies can be used at scale[3].

In addition, integrating these technologies into existing logistics and delivery infrastructure also presents challenges such as the development of new regulations,

---

[2] S. Mohammed Hashem M. Mehany, G. Bashettiyavar, *Claims and Project Performance between Traditional and Alternative Project Delivery Methods*, "Journal of Legal Affairs and Dispute Resolution in Engeenering and Construction" 10(3) (2018).

[3] Ibid.

the need for new logistics management software, and the integration of these technologies into existing delivery networks. Overall, the use of drones and autonomous vehicles in logistics and delivery is an exciting and rapidly developing field that has the potential to significantly improve the efficiency, safety and sustainability of logistics and delivery operations.

4. THE BENEFITS OF USING DRONES AND AUTONOMOUS VEHICLES

4.1 Drones and Autonomous Vehicles in Logistics: Improved Efficiency, Cost Savings, and Safety

Drones and self-driving vehicles have the potential to revolutionize the logistics and delivery industry by offering benefits such as increased efficiency, reduced costs, improved security, improved accessibility and flexibility, and real-time tracking. These technologies can perform a variety of tasks and can be easily reprogrammed or upgraded as needed, making them highly adaptable to the ever-changing needs of the logistics and delivery industry. This answer details the specific benefits that drones and self- driving vehicles bring to the logistics and delivery industry[4].

The use of drones and self-driving vehicles in the logistics and delivery industry could bring many important benefits such as:

1. Increased efficiency
2. Cost savings
3. Improved safety
4. Increased accessibility
5. Increased flexibility
6. Real-time tracking

These technologies have the potential to revolutionize the logistics and delivery industry, making it more efficient, cost-effective and safer for both employees and customers[5].

---

[4] Sik Chang Y., Jung Lee H., Optimal delivery routing with wider drone-delivery areas along a shorter truck-route, "Expert Systems with Applications" 104 (2018), pp. 307-317.

[5] Henderson C. E., Warner M., *Commercial prospects: the benefits and drawbacks of drone logistics*, ReedSmith site https://www.reedsmith.com/en/perspectives/global-air-freight/2022/01/commercial-drone-delivery-a-solution-to-lastmile-logistics

4.2 Comparison between Traditional and New Methods

Traditional logistics and delivery methods typically use ground vehicles such as trucks and vans driven by human drivers. These vehicles are used to transport goods from warehouses or distribution centres to customers. The main drawbacks of traditional methods are:

1. Limited accessibility: Traditional ground vehicles can only reach certain areas, such as those with well-maintained roads and infrastructure. Remote or hard--to-reach locations may be difficult or impossible for ground vehicles to access.
2. Limited speed: Traditional ground vehicles are limited by traffic and road conditions, and may face delays due to congestion, accidents, or other factors. This can lead to longer delivery times and increased costs.
3. Increased risk of accidents: Traditional ground vehicles are operated by human drivers, who are subject to human error and can cause accidents. This poses a risk to both the driver and the general public[6].

Drone logistics and delivery, on the other hand, rely on autonomous unmanned aerial vehicles (UAVs) or drones that can fly anywhere regardless of terrain or infrastructure. The main advantages of drone logistics and delivery are:

1. Increased accessibility: Drones can reach areas that are difficult or impossible for ground vehicles to access, such as remote or hard-to-reach locations. This can lead to improved delivery services for customers in these areas.
2. Increased speed: Drones can fly faster than ground vehicles and are not subject to traffic or road conditions. This can lead to faster delivery times and improved customer satisfaction.
3. Improved safety: Drones are operated by autonomous systems and do not require human pilots, which can reduce the risk of accidents caused by human error.
4. Reduced labour and fuel costs: Drones do not require human pilots, which can reduce labour costs, and they also consume less energy than ground vehicles, reducing fuel costs.
5. Real-time tracking: Drones can be integrated with real-time tracking systems, which can allow for greater visibility and control over the delivery process. This can help logistics companies to optimize their routes, reduce delivery times and improve the overall efficiency of their operations.

[6] Moshref-Javadi M., Hemmati A., Winkenbach M., *A truck and drones model for last-mile delivery: A mathematical model and heuristic approach*, "Applied Mathematical Modeling" 80(2020), pp. 290-318, https://www.sciencedirect.com/science/article/abs/pii/S0307904X19306936

The rise of commercial drone deliveries has the potential to revolutionize the delivery supply chain, particularly in meeting last-mile consumer use cases and B2B needs. Although the number of commercial drone deliveries is still relatively small, it has been growing rapidly, with more than 2,000 deliveries occurring every day worldwide in early 2022. Drones are also environmentally friendly, with CO_2 emissions lower than those of electric cars and vans, and significantly lower than those of gasoline-powered vehicles. However, labour costs associated with drone delivery currently represent up to 95% of the total cost, which is not yet competitive with electric cars and vans. For drones to become truly cost competitive, operators will need to shift their focus from observing airspace to operating drones, and the number of drones per operator will need to increase significantly. Once these innovations are in place, regulations will need to evolve, enabling larger numbers of drones per operator, and the potential cost advantage of drone delivery will begin to grow. Given the potential cost and sustainability benefits of drone deliveries, companies would do well to build a clear strategy for their use, considering factors such as which products can feasibly be delivered by drone, which regions will have the greatest demand, and how drones can help contribute to the company's sustainability goals. As companies reach full drone delivery capabilities, they will begin to see expanded benefits in their delivery strategies.

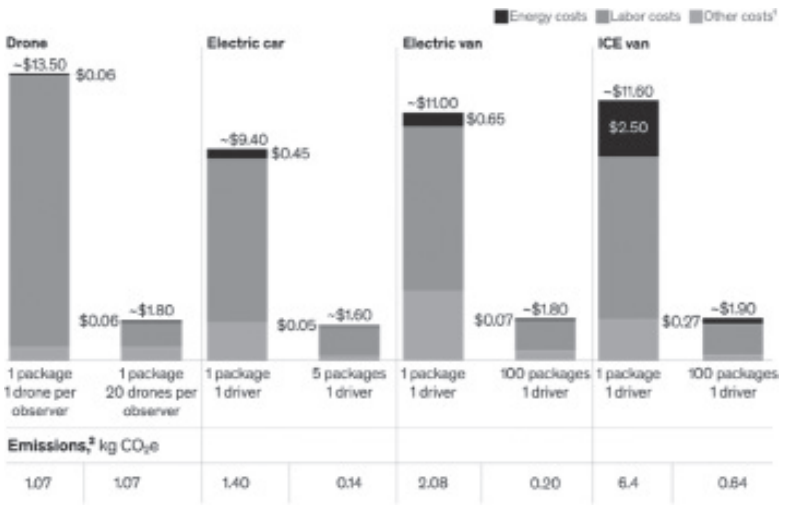

Fig. 1 Comparison of delivery costs and CO_2 emissions of three modes of transport
Source: https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/drones-take-to-the-sky-potentially-disrupting-last-mile-delivery

In the article, there is a graph chart that illustrates the unit delivery costs and emissions for a five-mile delivery of a 216-cubic inch package (six inches per side). The graph compares the delivery costs and CO_2 emissions of three modes of transportation: an electric car delivering five packages, a drone delivering one package with 20 drones per one observer, and an internal combustion engine (ICE) van delivering 100 packages in a milk-run format with one driver.

According to the chart, the drone delivery has a unit cost of 1.8 US dollars per one package, while an ICE van delivering 100 packages in a milk-run format with one driver has a unit cost of 1.9 US dollars. In terms of CO_2 emissions, the drone delivery produces significantly lower emissions than both the electric car and the ICE van. This graph highlights the potential cost advantage and environmental benefits of using drones for last-mile deliveries[7].

Overall, drone logistics and delivery can offer many advantages over traditional methods, including: improved accessibility, speed, security, and cost savings. However, it is important to note that drone logistics and delivery is still a relatively new technology and it may take some time before it is widely adopted and fully integrated into the logistics and delivery industry[8].

5. REAL-WORLD APPLICATIONS AND USE CASES OF DRONES AND AUTONOMOUS VEHICLES

Drones and self-driving cars are growing in popularity in the logistics and delivery industry. Companies like Amazon, UPS, DHL, Domino's Pizza, Alphabet's Project Wing, Alphabet's Waymo, Uber Elevate, Flirtey, Zipline and Matternet are just a few examples of organizations using these technologies in their operations[9].

For example, Amazon pioneered experiments in using drones for package delivery, developing its own autonomous drone called Prime Air to deliver packages to customers within 30 minutes. These drones are electric, can fly at 400 feet, and carry loads under 5 pounds, equipped with advanced navigation systems, sensors and cameras to safely navigate and operate in complex environments. Amazon

---

7 Andrea Cornell, Benedikt kloss, Dj presser, Robin Riedel, *Drones take to the sky, potentially disrupting last-mile delivery, (2023).*

8 Ibid.

9 Frachtenberg E. *Practical Drone Delivery*, „Computer" 52 (2019), pp. 53–57.

has been testing Prime Air drones in the US, UK and other countries for several years. The company has worked to obtain the necessary certifications and approvals from the Federal Aviation Administration (FAA) and other regulatory bodies to operate the drone commercially. In December 2019, Amazon received FAA Part 135 standard certification, enabling commercial drone flights beyond the operator's line of sight. This certification is an important milestone for Amazon, allowing them to conduct more test flights and more flights to customers' homes. Amazon is also experimenting with different drone designs and technologies to improve its capabilities. For example, they are testing the use of hybrid electric propulsion systems that can extend flight times, but also the use of multiple small drones working together. Like Amazon, UPS is also testing the use of drones for package delivery and other purposes. They are experimenting with using drones to deliver packages in rural areas where traditional delivery methods are inefficient and costly. The company is also testing using drones to inspect infrastructure such as pipelines and power lines that are difficult and dangerous for human workers to access. In 2016, UPS announced it had completed its first revenue-generating drone delivery to a rural residential customer in Florida. The company has partnered with his CyPhy Works to use Hexacopter drones for deliveries. To further extend its drone delivery efforts, UPS has created a drone delivery division called UPS Flight Forward. The department is certified to FAA Part 135 standards, allowing for out-of-sight operations. This certification will allow UPS to operate the drones commercially and make more test flights and flights to customers' homes. UPS is also partnering with various hospitals to test using drones for deliveries in urban environments to deliver medical samples and supplies. The company is also working on developing its own drones, and in 2019 announced testing of his UPS-owned HorseFly drone, which can transport up to 10 pounds of cargo[10].

DHL is actively experimenting with using drones for package delivery and other purposes. The company uses drones to deliver medicines to remote areas in Africa and the Pacific Islands. In these regions, traditional shipping methods can be inefficient and costly. DHL is also testing the use of drones for parcel delivery in urban areas. In 2016, DHL launched a pilot program in Germany called Parcelcopter, using drones to deliver packages on the island of Uist. The test was successful, showing that the drone can deliver parcels in a timely manner and with great accuracy. In 2018, DHL launched a pilot service to deliver medicines by drone to a telemedicine

[10] C. Guglielmo, *Turns out Amazon, Touting Drone Delivery, Does Sell lots of Products that Weigh Less than 5 Pounds*, Forbes, https://www.forbes.com/sites/connieguglielmo/2013/12/02/turns-out-amazon-touting-drone-delivery-does-sell-lots-ofproducts-that-weigh-less-than-5-pounds/?sh=4854bfee455e

centre on Nordtrandish Moor, Germany. Successful trials have shown that drones can safely and efficiently deliver medical supplies to remote locations. DHL is also working on larger drones that can carry heavier loads over longer distances. The company is experimenting with different drone designs and technologies to improve drone capabilities such as: testing the use of hybrid electric propulsion systems that can extend flight times, and testing the use of multiple small drones that can work together to provide a single package[11].

Domino's Pizza is testing the use of drones for pizza delivery in several countries, including the US, New Zealand and the UK. Alphabet's Projects division is testing the use of drones to deliver parcels in rural areas and deliver goods to disaster areas. Alphabet's Waymo, a self-driving technology company, is testing self-driving vehicles to transport goods. Uber Elevate is developing a drone delivery program for urban areas. Flirtey has partnered with his 7-Eleven to deliver convenience store merchandise to customers in Nevada. Zipline has delivered medical supplies and vaccines to remote areas of Africa and the United States. Matternet has tested the use of drones to deliver parcels in urban areas and transport medical samples in hospitals[12].

All of these companies and organizations use drones and self-driving cars for a variety of tasks, including: parcel delivery, inventory management, last mile delivery. They also work on developing regulation and security protocols for these technologies and explore new ways to use them in the logistics and delivery industry. Drones and self-driving cars are expected to become even more popular in the future due to rapid technological progress. Additionally, the increased use of drones and self-driving vehicles will help the logistics and delivery industry improve efficiency and reduce costs, increase the speed and accuracy of deliveries, and improve employee and customer safety. Additionally, drones and self-driving vehicles can help address the challenges of delivering goods to remote and hard-to-reach areas such as remote islands and mountainous areas, improving accessibility and connectivity for those living in those areas[13].

---

11 Hambling D., *DHL Partners With Dronamics For Middle-Mile Drone Service*, Forbes, https://www.forbes.com/sites/davidhambling/2021/08/17/dhl-partners-with-dronamics-for-middle-mile-drone-service/?sh=6f10eed8362d

12 Frachtenberg, E. *Op. cit.*

13 Lahoti N., *Drones - A Leap Into the Logistics of Tomorrow*, mytruckpulse blog, 2019, https://mytruckpulse.com/blog/drones-in-logistics.html

6. CHALLENGES AND LIMITATIONS

Drones and self-driving vehicles have the potential to significantly improve logistics and delivery operations by reducing costs, increasing efficiency, and enabling faster and more flexible delivery options. However, there are some challenges and limitations that must be overcome before this technology can be widely deployed. Some of the main challenges are:

- Safety and regulations: Drones and autonomous vehicles must be able to operate safely in crowded urban areas and comply with regulatory requirements.
- Weather and environmental conditions: Drones and autonomous vehicles must be able to operate in a variety of weather conditions and environments.
- Battery life and range: Drones and autonomous vehicles must have sufficient battery life and range to complete deliveries.
- Navigation and mapping: Drones and autonomous vehicles must be able to navigate and map complex environments in real time.
- Data security and privacy: Drones and autonomous vehicles must be able to protect sensitive data and maintain privacy.
- Cost: The cost of drones and autonomous vehicles must be reduced to make the technology more accessible and affordable for businesses.
- Control and maintenance: To maintain reliability, safety, and compliance the drones and vehicles need to be controlled and maintained properly.

6.1 Regulatory Challenges for Drones and Autonomous Vehicles in Logistics

One of the biggest challenges for companies such as Amazon, DHL, and UPS is the lack of clear regulations and guidelines regarding the use of drones and self-driving vehicles in logistics and delivery. Governments around the world are working to establish rules and guidelines to safely operate these vehicles, and this lack of clarity could make it difficult for companies to make the most of this technology. The Federal Aviation Administration (FAA) in the United States is currently working to regulate the use of drones in US airspace. The FAA has proposed a number of rules and guidelines for drone operations, including drone height, speed, and weight limits, as well as drone registration and tracking requirements. In Europe, the European Union (EU) has also proposed a set of regulations for drone use, including drone height, speed and weight limits, as well as drone registration and tracking requirements. Additionally, the EU has proposed various safety

requirements for drones, such as using geofencing technology to prevent drones from flying in restricted areas. However, these regulations are still being enacted and it may take time for governments around the world to establish clear rules and guidelines for the use of drones and autonomous vehicles in logistics and delivery. This lack of clarity can make it difficult for organizations to take full advantage of this technology. Organizations may not know how to comply or what is allowed under applicable regulations[14].

6.2 Battery and Navigation Challenges

Another big challenge is the technical hurdles in implementing drones and self-driving cars. These vehicles rely on complex systems such as sensors, batteries and navigation systems to move goods safely and effectively, and developing and maintaining these systems can be difficult and costly. The battery challenge is the trade-off between the weight of the battery and the amount of energy it can store and the cost of the battery. A lighter battery can store less energy and a heavier battery can store more energy. This means that drones and self-driving vehicles must be designed to balance battery weight with the energy requirements of the intended range. Commercial drones have an average flight time of about 25-30 minutes and a range of about 2-4 miles. However, drone and autonomous vehicle technology is evolving rapidly, and new developments in battery technology, lithium-sulphur batteries, have the potential to extend battery life and range.

6.3 Overcoming Public Perception Challenges

Public perception is also a major obstacle for companies looking to use drones and self-driving vehicles for logistics and delivery. Many people are still sceptical of the technology and may be concerned about issues such as security and privacy. The general public fears that drones and self-driving cars will cause accidents and crashes, especially in congested urban areas. You may have concerns about what it might cause. You may also be concerned about the privacy implications of drones and self-driving cars. Especially when this technology is used for surveillance and tracking. Additionally, there is recognition that the proliferation of drones and self-driving cars could result in job losses, especially in the transportation and logistics industry. People may be concerned that the proliferation of drones and self-driving cars could replace human workers and lead to widespread unemployment.

[14] H. Eskandaripour, B. Enkhsaikhan, 2023. *Last-Mile Drone Delivery: Past, Present, and Future*, „Drones" 7(2) (2023), p. 77.

This may further adversely affect public perception of the technology. Companies looking to use drones and self-driving vehicles for logistics and delivery should consider this common perception and address these concerns through education and engagement[15].

6.4 Summary of Challenges and Limitations

To sum up, the use of drones and autonomous vehicles in logistics and delivery will revolutionize the way goods are transported and delivered by reducing costs, increasing efficiency and enabling faster and more flexible delivery options. It has potential. However, there are some challenges and limitations that must be overcome before this technology can be widely adopted. Safety and regulations, weather and environmental conditions, battery life and range, navigation and mapping, data security and privacy, cost, control and maintenance are some of the key challenges that need to be addressed. One of the biggest challenges for companies such as Amazon, DHL, and UPS is the lack of clear regulations and guidelines regarding the use of drones and self-driving vehicles in logistics and delivery. Governments around the world are working to establish rules and guidelines to safely operate these vehicles, and this lack of clarity could make it difficult for companies to make the most of this technology. there is. Commercial drones have an average flight time of about 25-30 minutes and a range of about 2-4 miles. However, drone and autonomous vehicle technology is evolving rapidly, and new developments in battery technology, lithium-sulphur batteries, have the potential to extend battery life and range. Public perception is also a major obstacle for companies looking to use drones and self-driving vehicles for logistics and delivery. The public may have concerns about security, privacy, and unemployment, which could negatively impact adoption of this technology. The potential benefits of drones and self-driving vehicles in logistics and delivery are big, although there are significant challenges and limitations that must be overcome for the technology to become widespread[16].

7. CONCLUSION

Logistics and delivery are an important part of the supply chain, and the methods used to move goods have a significant impact on efficiency, cost, and safety. Traditional logistics and delivery methods use land vehicles such as trucks and vans,

[15] Ibid.

[16] Ibid.

have limited access, can experience delays due to traffic and road conditions, and are operated by human drivers, resulting in accidents. Drone logistics and delivery, on the other hand, require autonomous unmanned aerial vehicles (UAVs) or drones that can fly anywhere, improve accessibility, reduce delivery times, improve safety, and reduce labour and fuel costs. use. However, drone logistics and delivery are still a relatively new technology and face challenges such as regulation, security, reliability and package size limitations. The use of drones in logistics and delivery operations is expected to increase in the future as technology advances and regulations evolve. The logistics and delivery industry has traditionally faced many challenges and constraints, such as high transportation costs, difficulty meeting customer demands, and environmental concerns. However, advances in drone and self-driving vehicle technology may help meet these challenges by reducing transportation costs, increasing the speed and reliability of deliveries, and improving efficiency and reducing delays. Despite their potential benefits, regulatory, technical, and financial barriers must be overcome before these technologies are widely adopted. Additionally, research and development are required to make these technologies available at scale, but integrating them into the existing logistics and delivery infrastructure presents additional challenges. Overall, the use of drones and self-driving vehicles in logistics and delivery is an exciting and rapidly developing field that has the potential to significantly improve the efficiency, safety and sustainability of logistics and delivery operations. The use of drones and self-driving vehicles in the logistics and delivery industry can bring significant benefits such as increased efficiency, reduced costs, improved security, improved accessibility, and real-time tracking. These technologies have the potential to revolutionize the industry by making it more efficient, cheaper and safer for employees and customers. Compared to traditional methods, drone logistics and delivery offer greater accessibility, increased speed, increased safety, reduced labour and fuel costs, and real-time tracking. These technologies continue to evolve and improve and may play an increasingly important role in the logistics and delivery industry in the future.

The use of drones and autonomous vehicles in the logistics and delivery industry is growing rapidly. Companies such as Amazon, UPS, and DHL are actively experimenting with using these technologies for tasks such as parcel delivery, inventory management, and last-mile delivery. Companies like UPS are also focusing on using drones for parcel delivery in rural areas where traditional methods can be inefficient. These companies are working to obtain the necessary certifications and regulatory approvals to operate the drones commercially, experimenting with different drone designs and technologies to improve functionality and efficiency. Overall, the use

of drones and self-driving vehicles in the logistics and delivery industry has the potential to significantly increase efficiency, reduce costs, and improve safety for businesses and customers. Drones and self-driving vehicles have the potential to revolutionize logistics and delivery operations, but there are some challenges and limitations that must be overcome before they are widely adopted. These include safety and regulatory requirements, weather and environmental conditions, battery life and range, navigation and mapping, data security and privacy, cost, control and maintenance. One of the biggest challenges is the lack of clear regulations and guidelines regarding the use of drones and self-driving vehicles in logistics and delivery. Governments around the world are in the process of establishing rules and guidelines for safe operation. Additionally, technical hurdles such as sensor, battery, and navigation system development and maintenance can be costly and difficult to overcome.

REFERENCES

[1] Frachtenberg E. *Practical Drone Delivery*, „Computer" 52 (2019), pp. 53–57.

[2] Eskandaripour H., Enkhsaikhan B., 2023. *Last-Mile Drone Delivery: Past, Present, and Future*, „Drones" 7(2) (2023), 77.

[3] Lucic M. C., Bouhamed O., Ghazzai H., Khanfor A., Massoud Y., *Leveraging UAVs to Enable Dynamic and Smart Aerial Infrastructure for ITS and Smart Cities: An Overview,* „Drones" 7(2) (2023), 79.

[4] Hambling D., *DHL Partners With Dronamics For Middle-Mile Drone Service*, Forbes, https://www.forbes.com/sites/davidhambling/2021/08/17/dhl-partners-with-dronamics-for-middle-mile-drone-service/?sh=6f10eed8362d

[5] Guglielmo C., *Turns out Amazon, Touting Drone Delivery, Does Sell lots of Products that Weigh Less than 5 Pounds*, Forbes, https://www.forbes.com/sites/connieguglielmo/2013/12/02/turns-out-amazon-touting-drone-delivery-does-sell-lots-ofproducts-that-weigh-less-than-5-pounds/?sh=4854bfee455e

[6] Lahoti N., *Drones - A Leap Into the Logistics of Tomorrow*, mytruckpulse blog, 2019, https://mytruckpulse.com/blog/drones-in-logistics.html

[7] Henderson C. E., Warner M., *Commercial prospects: the benefits and drawbacks of drone logistics*, ReedSmith site https://www.reedsmith.com/en/perspectives/global-air-freight/2022/01/commercial-drone-delivery-a-solution-to-lastmile-logistics

[8] Sik Chang Y., Jung Lee H., Optimal delivery routing with wider drone-delivery areas along a shorter truck-route, "Expert Systems with Applications" 104 (2018), pp. 307-317, https://www.sciencedirect.com/science/article/abs/pii/S0957417418301775

[9] Moshref-Javadi M., Hemmati A., Winkenbach M., *A truck and drones model for last-mile delivery: A mathematical model and heuristic approach*, "Applied Mathematical Modeling" 80(2020), pp. 290-318, https://www.sciencedirect.com/science/article/abs/pii/S0307904X19306936

[10] Mohammed S. Hashem M. Mehany, Bashettiyavar G., *Claims and Project Performance between Traditional and Alternative Project Delivery Methods*, "Journal of Legal Affairs and Dispute Resolution in Engeenering and Construction" 10(3) (2018), https://www.researchgate.net/profile/Mohammed-Hashem-M-Mehany/publication/326745396_Claims_and_Project_Performance_between_Traditional_

[11] Andrea Cornell, Benedikt kloss, Dj presser, Robin Riedel, *Drones take to the sky, potentially disrupting last-mile delivery, (2023),* https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/drones-take-to-the-sky-potentially-disrupting-last-mile-delivery

Ian Nurgaliev
The International University
of Logistics and Transport in Wroclaw, Poland
nurgalievyan@gmail.com

Youssef Eskander
The International University
of Logistics and Transport in Wroclaw, Poland
youssifwageh@gmail.com

Karolina Lis
The International University
of Logistics and Transport in Wroclaw, Poland
lis.karolina.e@gmail.com
https://orcid.org/0000-0002-4432-8628