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DRONE LAST MILE DELIVERY: AN ASSESSMENT OF THE VIABLE MARKET AND SECURITY POTENTIAL OF DRONE DELIVERY

Abstract

Purpose: the paper includes a review of the literature in the field of drones, drone technology, possible implementation in the field of the last mile concept, legislation, suitability of technology in the field of security, weather conditions, social acceptance and later focuses on checking the possible implementation of drones according to the set parameters.

Methodology: for the purposes of research and obtaining answers to the posed research question and hypotheses, we used the method of literature review in the selected field, panel data analysis, conducted interviews with experts in the field of delivery drones in the Republic of Slovenia, and conducted secondary research.

Results: the results show an assessment of the possible implementation of drones based on the analysis of the obtained data and interviews. We determined a realistic assessment of the potential of delivery drones, in which we included several vital aspects necessary for implementation.

Conclusion: it was found that the current technology is not yet fully adequate, and significant technological improvements are also needed. It is also necessary to plan integrated urban spatial solutions that will enable safe and efficient delivery in the supply chain. Namely, delivery with drones is currently ineffective due to flight safety, harmful sound emissions and the inability to fly in bad weather conditions. Based on a literature review and a survey among large logistics companies, it was found that there are still many barriers to implementation due to legal norms and regulations, which are currently very constructive. It is unlikely, however, that parcel delivery will take off in an urban environment soon, as there are still many unknowns. With proper planning and use of suburban consolidation centres, e-vans, e-cars and bicycles are currently economically viable for last mile delivery.

Keywords: Drones, last mile, urban logistics, parcel delivery

1. Introduction

In recent years, we have witnessed rapid urbanisation and development. The result is an above-average load on the urban environment, excessive pollution, road congestion, and reduced mobility efficiency. The current use of conventional drives is among the main contributors to carbon dioxide emissions, which increase the greenhouse effect to the greatest extent and represent a severe impact on natural systems (IPCC, 2014). It is known that the possibility of unrestricted use of the World Wide Web is changing the habits of retailers and offers new challenges and opportunities to transform consumers' shopping habits (Wolfinbarger & Gilly, 2003). The way of understanding the concept of supply chains is changing, and due to the above-average increase in sales, new transport problems are also appearing. Currently, the most important problem of transport logistics is the delivery of the first and last mile (Airborne Drones, 2017). Logistics as an industry represents an essential segment of the economy, as it generates between 10 and 12% of the gross domestic product in developed countries, which also applies to Slovenia. The contract logistics market is one of the fastest-growing industries, with expected annual growth of up to 15%. The economic importance of logistics is also reflected in data on the share of its costs in the sales value of goods. According to research, it averages around 8-10%, and in some industries, even up to 30%. The importance of logistics is therefore growing unstoppably, and its usefulness is expanding into various fields (Svašek, 2007). The industry's consistent growth and continuous development mainly present new logistical challenges for sustainable logistics, transport, and delivery of goods to city centres (Basu & Muylle, 2002). Kellerman et al. (2020) focus on the economic benefits of using drones for delivery, while the social and environmental impact of drones is under-reported in most scientific literature. Indeed, many types of research are focused only on the use of different delivery models or the economic efficiency of implementation (Di Puglia Pugliese et al., 2020; Marinelli et al., 2018). However, it is necessary to realise that drones are becoming one of the most researched and potentially useful technologies of the 21st century (Kellerman et al., 2020).

The delivery of packages with the help of unmanned aircraft has proven to be potentially promising in the concept of last-mile delivery. The use of drones represents a faster, cheaper, and more environmentally friendly solution compared to traditional delivery methods (Yoo et al., 2018). According to Deloitte Touche Tohmatsu Limited (2015), the use of drones and unmanned vehicles will play a significant role in the supply chain in the future. Chaturvedi et al. (2016) predict that 80% of deliveries will soon be made by driverless vehicles.

From the point of view of logistics, the delivery itself causes disturbances even at the place where the goods are delivered. Delivery traffic often requires more space due to loading and unloading, storage and packaging (Dablanc, 2007). The concept of the last mile in connection with drones will become a trend soon, as the demand for delivery increases. This is how delivery with drones is becoming interesting, as more people want home delivery of packages. Doole et al. (2020) estimate that the number of packages increased in 2018 and 2019 by more than 10% each year. This growth in the number of packages is a global trend and is primarily due to the increasing popularity of e-commerce (Yoo & Chankov, 2018). With the growing number of online shoppers, parcel delivery is also increasing, as most goods purchased online are delivered directly to customers (Aurambout et al., 2019).

The use of unmanned aerial vehicles in transport and their potential application benefits in this field have sparked a genuine research fervour focused on the strategic and operational challenges associated with unmanned aircraft. Thus, it can be seen that most of these studies investigate versions of the travelling salesman problem and the vehicle routing problem.

The implementation of drones in urban areas is becoming more and more likely. The goal is to direct the current road transport of goods into the air. According to some concepts, cities will build consolidation centres in the suburbs. Their purpose is to consolidate or combine packages and prepare them for delivery within the urban city environment. A smartphone and GPS application will allow the user to order and track a drone delivery to a specific location where they can also pick up the shipment. Therefore, delivery by drone presents many advantages from the point of view of the retailer as well as the consumer. New technology also presents new logistical challenges. With the possible implementation of delivery by drones, delivery times will be shortened due to the use of airspace. In addition, there is less chance of the cargo being damaged during transport and manipulation (Airborne Drones, 2017). According to Lovelace Jr. (2016), drones rep-

resent excellent potential for cost savings. In 2025, 80% of food deliveries are expected to be carried out by drones and driverless vehicles, and delivery costs are expected to decrease by up to 50% (Aysev et al., 2017; Bouton et al., 2017).

In the field of drone development, the number of public and private research laboratories has also increased in recent years. They are developing human-friendly and accessible drones that can fly autonomously indoors, outdoors, and near people and urban areas. Current development is aimed at miniaturisation and cost reduction of sophisticated electronic components (microprocessors, sensors, batteries, wireless communication units, control) and increasing transport capacity. Improvements allow companies to prototype and commercialise drones (Floreano & Wood, 2015). In addition, there is much interest in the field of electromagnetic spectrum sensing (infrastructure maintenance inspections, extensive environmental impact assessment). The air project is successfully aimed at the use of drones for the delivery of commercial products. Some applications may cross boundaries; air and water quality samples can be collected for laboratory analysis or assessed on-site with onboard sensors (Gallacher, 2016).

The use of drones is based on sophisticated technology that is successfully developing and already offers advanced solutions today. Currently, technology research is focused on (Cohn et al., 2017):

- flight autonomy. Drones can already operate entirely autonomously without the help of the user. In the next five years, the responsiveness of the system and the dynamic guidance of the flight without the use of hands (handoff) should be further improved;
- battery capacity. The rapid development of batteries represents an added value in using drones. The quality of lithium-ion batteries is improving every year by 5 to 8%, and their lifespan is expected to double by 2025. The improvements will allow the drones to fly for more than an hour without recharging;
- technology of detection and prevention (Detect and avoid). The development of the mentioned technologies is currently in a phase of rapid development. In the future, these systems will prevent drones from colliding and steer them away from obstacles;
- integrated air traffic management (ATM) systems. Due to the potential risk of collision, drone flights are currently permitted below the altitude reserved for commercial aircraft. Thus, development is focused on recognition and communication with air traffic control systems;
- location technology. Drones must recognise their location even in a possible anomaly and GPS failure. Densely populated urban areas and remote locations present a problem in terms of inactivity or displaying the wrong location. Therefore, future integration of air traffic and location recognition systems with drones is necessary.

Nowadays, the professional use of drones is already present in the field of geography and geodesy because, with the help of drones, we can obtain high-quality and high-resolution images from the air. In agriculture, they can be used to monitor the quality of plant products. Construction companies use them to monitor construction progress, and in mining, we can use drones to obtain accurate volumetric data on excavations. Drones are also becoming a fixture in the energy and infrastructure industry, as they can be used to inspect pipelines, roads, and cables in inaccessible areas (Floreano & Wood, 2015).

When we talk about transport with the help of drones, today, they already offer safe landing and take-off near buildings and people in urban areas. The mentioned feature represents a novelty in package delivery, and the road infrastructure we know today will no longer be needed to deliver goods. In the future, drones will enable fast and efficient delivery of goods anywhere and anytime. The concept of e-business and Industry 4.0 will come to life with the implementation of drones. In the future, the use of drones will represent a critical supporting element in the development of underdeveloped countries. By using drones, we can already improve the quality of services in congested urban areas and remote uninhabited areas where the use of classic transport is reduced or impossible. Drones enable rapid delivery of medical supplies, food, and medicine to inaccessible areas. Firefighters, the police, and the military are also aware of the benefits of using it (Floreano & Wood, 2015). The retail giant

Amazon was the first company on the global market in 2013 to introduce a drone, Prime Air, whose purpose is to deliver packages and reduce delivery times in major cities to 30 minutes. The company started a revolution in package delivery as competing companies also began to realise the advantages and opportunities offered by the implementation of drones (BBC NEWS, 2013). As a result, the DHL company prepared a pilot program to introduce drones for package delivery purposes (Figure 1), followed by the Google company with the "Wing" project and UPS, which is engaged in research into the movement of packages between distribution centres and airports.

1.1 Drone operations

There are several models of dealing with the Drone Delivery System. For example, Marinelli et al. (2018) consider a delivery system where drones, in conjunction with trucks (Figure 1), fly from a truck to a location and return to the truck after dropping off a package. Thus, from the point of view of such treatment, we are talking about the emotional problem of the travelling salesman. Also, the author claims that such a method is currently the most effective delivery for drones.

Figure 1 Delivery system with drones, in conjunction with trucks – City of Celje

Source: Authors

In the scientific literature, establishing a specific node – hub where goods are delivered and further distributed by drones is often mentioned (Goodchild & Toy, 2018). The so-called hives have the characteristic of a back-storage. Aurambout et al. (2019) believe that such a hinterland must have a relatively large number of addresses in its vicinity to be economically competitive. Doole et al. (2020) define a system where vans deliver goods to a hub (Figure 2), and from this hub, the goods are delivered to the destination. Murray & Chu (2015) believe that the size of such a hinterland largely depends on the distance that drones can fly on a battery charge. Such a system of back-end centres can also be combined with traditional delivery trucks, where the trucks still deliver to houses convenient for the route, while the drones serve other locations.

Figure 2 The goods are delivered to the destination from the hub – the City of Celje

Source: Authors

1.2 Public acceptance, security and privacy

There are empirical public opinion surveys that examine various issues related to drones. Faulkner Rogers (2013) examines public approval of using drones with weapons. Reason Wong & Mulligan (2016) highlights privacy concerns and the use of drones for surveillance purposes by law enforcement agencies. Research has shown that acceptance for most drone use in the European Union is high. This is especially true for research and security. The acceptance of drones for package delivery is much lower, with 49% of people perceiving it as a good or good thing and 21% as a bad or horrible thing (Kennisinstituut Voor Mobiliteitsbeleid, 2017). However, Clothier et al. (2015) expect that the general attitude towards the adoption of drones will change a lot in the future, as there is a lack of public knowledge about the safety and interference issues, as well as the added benefits. Nentwich & Horváth (2018) believe that restrictions on the use of drones will be determined by society. Also, privacy will play an essential role in the adoption of drones. Namely, the problem is represented by recreational drones, which represent a potential threat in the field of privacy as they are equipped with a camera. Lidynia et al. (2017) note that privacy is an essential criterion at this stage.

Improper use or even abuse can endanger lives. We can apply the principles of security and security analysis to any device or system we use or the organisation that makes it (products or manufacturers) and identify the risk. Lavaliee (2019) believes that the future large-scale integration of unmanned systems into the airspace may cause problems:

- in the field of general safety (if they are not used appropriately and cause damage);
- in the field of privacy and personal data protection (because it can be used for photography, recording, data collection...);
- in the area of liability and insurance of third parties (in case of accidents); and,
- in the field of environmental issues (e.g. noise). Therefore, at the level of integration of drones into the airspace, we must take into account the necessary legal, political and technical provisions.

It is also necessary to face dangers such as (Lavaliee, 2019):

- Danger during take-off and landing;
- Risk of failure of critical components;
- Risk of collision;
- Danger due to excessive exposure to noise;
- The risk of the illegal invasion of privacy;
- Fire hazard.

In addition, there are other possibilities for damage that can be caused by remote aircraft systems, namely (Macnish, 2019):

- Civic inactivity: Individuals may become afraid to express their dissatisfaction with a system and participate publicly in rallies, demonstrations, and petitions if they suspect or know that their photo will be stored in police files;
- Social "sorting": Stereotyping, stigmatisation, discrimination; it is entirely possible that certain social groups and communities would be more under control, observed, as the stigma of "criminals" would cling to them;
- Imbalance in the distribution of costs: Someone may also bear the high costs of state control more than anyone else. This would further contribute to the socio-cultural division of society;
- Paternalism: State paternalism means that someone as a "parent" takes care of you and protects you - but for your own good;
- Social fatalism: Paternalism can lead to the "surrender to fate" of individuals because they would realise that since they are protected by the state, they cannot do anything or influence anything themselves;
- Behavioural Uniformity: Individuals in such a controlled system will not want to expose themselves, or do anything that would cause them to "stand out" to attract attention;
- Reduction of trust: It is often said that if you are not doing anything wrong, you do not need to hide anything - when being monitored;
- Fear of surveillance: With increased surveillance comes more fear (of exposing even non-criminal acts).

1.3 Drone regulations

The European Aviation Safety Agency handles the regulation of the aviation sector in the EU. It is responsible for the operations of various aircraft in the EU; EASA is responsible for aircraft over 150 kg and under 150 kg, previously the responsibility of individual member states (Molina & Montagud, 2018). Rijksoverheid (2021) divides all drone flights into three different categories. Thus, there is a category of low, medium, and high risk. We refer to these categories as EASA (2019) open, specified, and certified categories.

EASA (2019) has also published a brochure with recommendations for the management of drones. These are as follows:

- Possession of suitable insurance;
- Check the drone before the actual flight;
- Check the restrictions of the individual areas where the drone will be operated;
- Keep the drone in line of sight at all times;
- Maintain a suitable distance between the drone, people, animals and other aircraft;
- If the drone is flown near people, its speed should be reduced, keep it horizontal - distance to them, but never less than 5 meters;
- Operating the drone in accordance with the restrictions issued by the manufacturer; follow the manufacturer's instructions;
- Urgently notify the national aviation organisation if the drone is involved in an accident with serious or fatal consequences, or if the accident affected the flight crew;
- Do not make changes to the drone that are not supported by the manufacturer;
- The drone must not fly more than 150 m above the ground;
- The drone must not be flown near airports, helipads and other pilot areas, about aircraft, as well as not in areas where it could endanger public safety, or about areas where prisons, military bases, power plants, etc. are located;
- The drone must not fly over large groups of people;
- The drone may not record videos, take photos, or record sound of individuals without their prior permission;

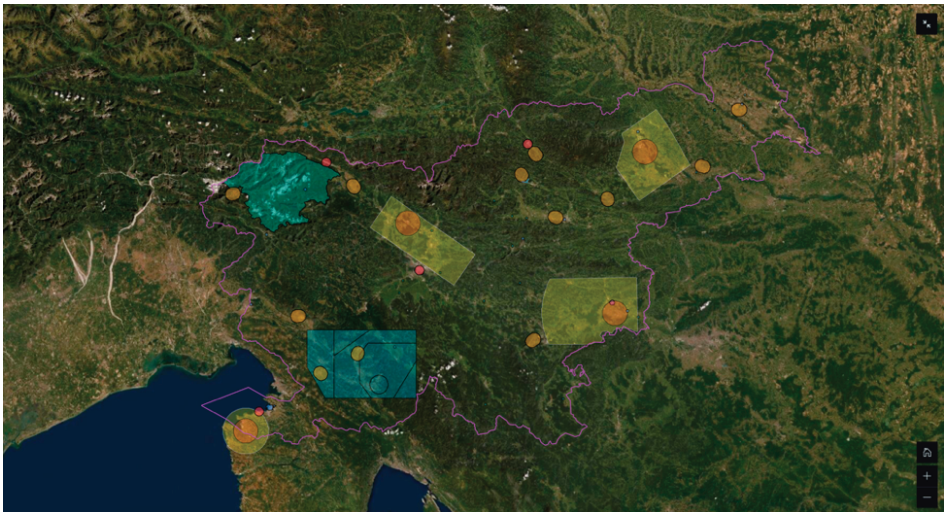
- If we fly a drone over land or property of individuals, we must take into account a distance of at least 20 m; if less, we must have their permission;
- Respect for the privacy of individuals;
- The drone must not carry dangerous substances or objects;
- Plan your flight;
- Check the restrictions of individual areas and get to know the area where you want to fly;
- Check weather conditions;
- Verify the electronic identification and geo-awareness system.

All regulations in the Republic of Slovenia derive from the adopted legal acts of the European Union Aviation Safety Agency (EASA). Commission Implementing Regulation (EU) 2015/947 sets out the rules and procedures for the operation of unmanned aircraft and is directly applicable in all EU member states. In addition to the regulation, the Slovenian Regulation on the Implementation of the Implementing Regulation of the Commission (EU) on Rules and Procedures for the Management of Unmanned Aircraft (Official Gazette of the Republic of Slovenia No. 195/20) and the Delegated Regulation of the Commission (EU) 2019 also apply to unmanned aircraft (drones) /945 of 12 March 2019 on unmanned aircraft systems and operators of unmanned aircraft systems from third countries (C/2019/1821) (EASA, 2019).

It is important to point out that member states must establish a register of unmanned certified aircraft and a register of operators. The register must be digital and interoperable, and the competent authorities of the member states are obliged to give each other access to the register (CAA, 2022).

Figure 3 shows a map of zones (CAA, 2022) with limited low-flying or no-fly zones. Orange dots represent no-fly zones, while yellow areas represent low-fly zones. The green area represents the national park, where flying is also restricted, and the marked blue zone represents the zone where military activities occur. Flying is prohibited during specific periods. The map also contains red zones where flying is wholly prohibited due to industrial facilities of national importance.

Figure 3 Drone flight zones in Slovenia



Source: CAA (2022)

2. Methods

The goal of this research is to determine to what extent drones will be useful from the point of view of the concept of the last mile in the Republic of Slovenia. Thus, we will build a theoretical framework, look for solutions and make proposals related to the introduction of drones, examine the compliance of the introduction regarding legislative regulations and whether delivery in the urban area can be im-

plemented. By creating a multi-factor model and interviewing experts and delivery companies, this research provides detailed insight into what factors are most limiting to drone delivery. These factors will then be presented and used to assess the feasibility of the implementation. We will also present their potential in the coming years.

The main research question is: *To what extent will delivery drones be introduced as part of the last mile delivery traffic in the Republic of Slovenia in the coming decade?*

We also set the following hypotheses:

H1: *The use of drones has great potential for use in the last mile concept.*

H2: *Companies and experts perceive opportunities for the implementation of drones.*

2.1 Estimation of delivery drone potential

Based on the collected theoretical data, we will determine the possibility of implementing drones in connection with the concept of the last mile. Thus, it is necessary to justify the expediency of the implementation of drones in relation to the number of delivered packages in the Republic of Slovenia. Weight, weather conditions, flight zones, and possible prohibitions must be included when determining performance and rating. Thus, with the help of the literature and subsequent calculations, we will present the obtained results.

2.2 Qualitative approach – the future of drone delivery in Slovenia

According to Steen (2016), an analysis of innovation and industrial change should be based on a combination of retrospective data. Thus, interviews with companies are a suitable method for data collection. Furthermore, Nentwich & Horváth (2018) recommend combining the views of companies and experts when reviewing drone implementation scenarios. Thus, we included companies experimenting with drones in Slovenia and experts with knowledge in the field of delivery drones in the analysis.

In the field of companies, we included Pošta Slovenije and ElevonX in the interview. Both companies are pioneers in the field of drone delivery in Slovenia. In the field of science and research, we included the Professor of Sustainable Logistics and Assistant Professor of Sustainable logistics and transport in the interview. All interviews were conducted in person at companies and the University of Maribor.

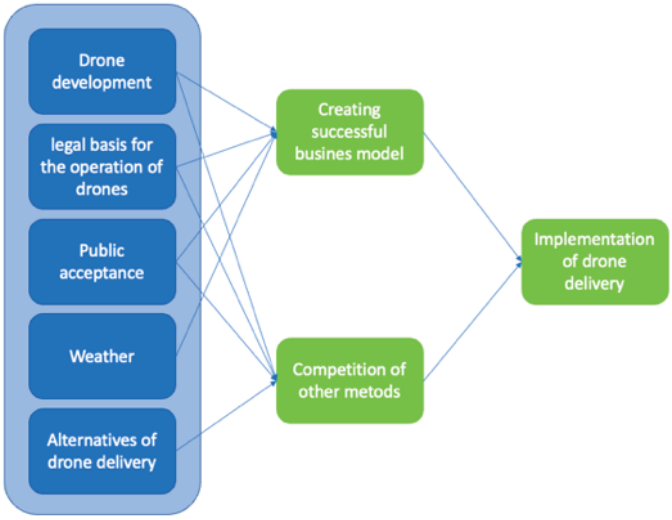
The questions in the interviews were semi-structured. Also, the order of the questions was adjusted due to the interview. The questions we asked followed in the existing order:

- Have you already done research on the use of drones in the last mile area?
- What is your position in the company or University?
- Have you supervised studies by students conducting drone research in this area?
- How does your work relate to the use of drones?
- Do you actively follow the developments in the field of delivery drones?
- What are the main limitations that may limit the potential of drones in last mile delivery?
- What international developments do you see in the field of drone delivery?
- Justify how the safety of drones can be improved to be suitable for delivery in urban areas?
- How do you expect people's acceptance to develop if a regular drone service were introduced?
- What do you expect from the future of drones as delivery vehicles?
- Do you think drone delivery has economic potential?
- Is development going faster or slower than you expected a few years ago?
- In what environment would delivery drones currently be appropriate?
- In what environment do you expect the first drone delivery networks?
- When do you expect drone delivery to be economically feasible?
- According to the current legislation, establishing delivery networks with drones is impossible. Do you expect that there will be more room for the use of drones in the future?

2.3 Building the conceptual model

When building the conceptual model (Figure 4), we took theoretical knowledge into account. Within these categories, the theoretical framework identified several aspects that could play a role in delivery. By creating a multi-aspect framework, it is possible to see the effect of these defined aspects on the total number of possible drone deliveries in the Republic of Slovenia.

Figure 4 Multi-Factor Model



Source: Authors

3. Analysis

3.1 Estimation of drone potential in Slovenia

The parcel transfer market is a segment of the postal services market where the reception, routing, transport, and delivery of parcels are carried out. The essential function of the parcel service is the transfer of goods between the sender and the addressee, which may or may not have a considerable value. Parcel shipments are up to 31.5 kg, the contents of which are goods. In addition, as a universal service, the transfer of packages up to 10 kilograms in domestic traffic and up to 20 kg for packages arriving from other EU member states is carried out (AKOS, 2020).

There were 15.4 million shipments on the domestic parcel market in 2019, which is a 6.2% increase compared to the previous year. The number of packages has been steadily increasing since 2015, growing by 50% from 2015 to 2019, and the cumulative package growth from 2011 to 2019 was 64.5% (AKOS, 2020).

3.2 Weight

Drones operating in urban areas have an estimated payload of around 2.2 kilograms (Doole et al., 2020). Weight is summarised based on data from Amazon Prime Air (Lovelace, 2016). According to Doole et al. (2020), 86% of packages are lighter than 2.2 kilograms. If such a weight is given to a standardised commodity, it can be adjusted to this demand. Based on the obtained data (AKOS, 2020), we can assume that 13.24 million (86% of 15.4 million) packages would be eligible for drone delivery by weight in the Republic of Slovenia.

3.3 Weather

Doole et al. (2020) believe that weather conditions also mention the problem of drone delivery. The Kennisinstituut Voor Mobiliteitsbeleid (2017) identifies three different weather aspects that play an essential role. These conditions are precipitation, extreme temperatures, and wind. According to Bergsma (2021), weather condi-

tions have been found to affect the potential of drone delivery services. In Table 1, we obtained statistical data on weather conditions in the Republic of Slovenia.

Table 1 Weather data according to the possibility of flight restrictions

Weather factor 2021	Days	Percentage
Temperature < 0	69	18.9%
Rain	149	40.8%
Wind speed > 8 m/s	42	11.5%

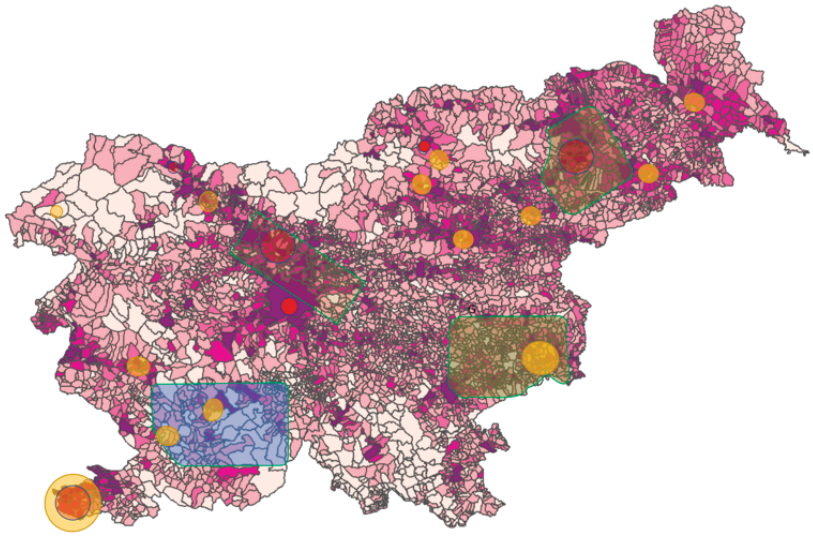
Source: Arso Meteo (2022)

Based on the obtained results, we found that drones could fly in the Republic of Slovenia on 28.8% of the days of the year, according to weather conditions. Thus, it can be argued that weather conditions significantly limit the potential of drone deliveries.

3.4 Limitations by no-fly zones

According to data (SiStat, 2022), there are currently 2,865,000 registered addresses in the Republic of Slovenia. We mapped these addresses (Figure 5) with the help of ArcGis and found that 31% of prohibited and low fly areas of all addresses in urban areas lie in prohibited areas or partial flight bans. Of these, 23% (prohibited areas) are addresses where drone delivery is impossible. On the other hand, we also note that 82% of addresses in rural areas are suitable for drone delivery.

Figure 5 Display of flight restriction zones based on pact delivery addresses



Source: Authors

3.5 The future of drone delivery in Slovenia – expert view

Pošta Slovenije conducted the first test flight with an unmanned aircraft in cooperation with the Slovenian company OneDrone, which is the first Slovenian operator of unmanned aircraft of the highest category and enables the implementation of aerial operations in the most demanding conditions. The start-up company ElevonX, a manufacturer of unmanned aerial vehicles or complete systems, also participated. The start-up developed the ElevonX SkyEye modular unmanned aerial system and brought it to series production. Pošta Slovenije

performed the first test flights with unmanned aerial vehicles. In this way, it is preparing for when it can deliver urgently needed shipments to places where conventional vehicles cannot deliver them so quickly and efficiently. Given the current trends in delivery, we are no longer far from being able to make deliveries with drones in logistics instead of test flights. Furthermore, we want to be actively involved in creating regulations governing the flying and management of drones in Slovenia, with the explicit goal of finding new business opportunities.

The interviewed companies highlighted several different aspects that need to be improved. They highlighted the problem of GPS distortion due to physical obstacles in the field. The drone's stability when landing due to the package is also a problem. They also highlighted the problem of technology that enables safe and dynamic flying. The interviewees also believe that drone operations will not be as limited in the future as they are today. Thus, they believe that delivery by drones will become a reality soon.

The interviewed companies believe that technology has enabled delivery by drones for a long time. However, the current regulations governing airspace pose a problem. Currently, there is not much room for manoeuvring in the European area for mass production deliveries.

They also highlighted the potential of using drones in delivery for various purposes. They believe that the initial deliveries will be aimed at the delivery of laboratory samples from remote areas, the delivery of medical devices, the delivery of goods from ships to land, and later, with intelligent regulations, the delivery of online purchases to end customers can also be expected.

Also, the companies' experts note that the public's reaction is positive. They think that the public generally supports the first test delivery that they carried out. However, they pointed out that in conversations with the public, they noticed specific issues related to safety and noise. Thus, they believe development and research should improve safety and reduce noise emissions.

Interviewees believe it will take quite some time before the first working drone networks can become a reality. Therefore, we were interested in where the interviewees see opportunities for a successful business model with delivery drones. Interviewees conclude that it will take at least a few years before a drone network can be operational. This is how companies generally see the potential for these services. Therefore, they believe that investing in drone experiments will yield positive results. However, they state that delivery by van or bicycle is already a very efficient system, and the cost of operating drones is still higher than existing methods. Hence, drone delivery is unlikely to be adopted for simple package delivery anytime soon.

According to the interviewees, it becomes clear that the development of drones is still in its early stages. Thus, we cannot confidently say that the public will agree with the implementation. Also, there will still be many steps to be taken technologically. However, due to possible improvements in this area, this aspect is probably not a significant limitation in the development of drones. It was also noted that currently, the most critical obstacles in the field of legislation are the ones that prevent commercial drone delivery services from flying. New legislation was introduced in the Republic of Slovenia in January 2021, but even with these new rules, the legislation will probably continue to inhibit the development of drones.

It should be noted that drones are currently more expensive to operate compared to other delivery methods, such as vans or bicycles. Therefore, we believe that the first implementations of drones are limited to niche functions where high-priority, high-value products need to be delivered. We also consider the widespread use of drones to deliver food and packages an unlikely scenario.

4. Results

In the following section, based on the obtained theory and results, we will answer the research question: *To what extent will delivery drones be introduced as part of the last mile delivery traffic in the Republic of Slovenia in the coming decade?*

We will answer this question with a combination of the results of tests and calculations, which were created based on an analysis and review of the literature. It is clear from the theoretical work that several factors will shape the implementation of drones for commercial delivery purposes in the next decade. At this point, it is necessary to highlight three key factors. These are legislative barriers, technological capacity, and social acceptance of the presented technology. Based on the literature review, it was determined that the key to implementation is positive acceptance by society. We find it easier for society to adopt drones for medical emergencies than for commercial delivery purposes. We also note that many improvements are needed for technological capabilities, as there are still quite a

few problems in the field of sensors, battery capacity, and the behaviour of devices in terrible weather conditions. We also note that legislative obstacles due to the new regulations are still partially undefined and point to the ambiguity of the very possibility of implementing drones in everyday life. The results indicate that several factors related to delivery drones must change before this technology becomes a reality. Efforts by the European Union to harmonise drone regulations in member states may significantly increase the potential number of packages suitable for drone delivery.

One of the significant limitations of the implementation of drones in the delivery system is weather conditions, which harm the implementation. Namely, due to the geographical location of the Republic of Slovenia, we can claim from the obtained results that at least part of the year, which is quite rainy, represents a problem in the implementation of drones. This particularly highlights the reliability of future drone delivery. An essential aspect of why weather reliability should be considered is because one of the primary motivators for potential drone delivery companies is the maximum efficiency and predictability that delivery companies strive for. Until there are technological improvements related to weather conditions, drones will not be able to meet the criteria of good economic use, and it is unlikely that these companies will use drones on a large scale. Therefore, technological improvements in weather resistance would be crucial to adopting drones for delivery. Doole et al. (2020) expect that in the future, drone technology will be so advanced that the number of days a drone could not operate due to weather conditions would be zero.

It is also necessary to highlight the areas of flight that currently limit delivery in certain areas. In this case, patience is also required for technological improvements because otherwise, the legislation will remain restrictive, and flying will be limited. The analysis shows that urban areas are likely to be particularly affected by the prohibition zones. This can pose an additional problem for the implementation and potential of drones when a drone network requires a high population density in its environment to be effective. Aurambout et al. (2019) and Doole et al. (2020) expect that, from the point of view of implementation, technical perfection and legal regulation will be a condition before the introduction of drones becomes economically justified. With this in mind, it is clear that extending the current no-fly zones for low-risk drones to delivery drones would preclude widespread use. It is also necessary to highlight that the number of addresses not part of these zones is quite large. However, in this case, the drone networks are fragmented, which would significantly limit their effectiveness when we talk about the last mile of delivery. If the legislation is not adapted to support such operations, Slovenian airspace is not suitable for delivery by drones. However, as new drone regulations are constantly changing and upgrading based on market demands, these no-fly zones can also change significantly. How this plays out will significantly impact the potential of delivery drones over the next decade. Despite the limitations caused by the mentioned aspects, the calculation still showed that almost 82% of all packages delivered by the six major delivery companies would currently be suitable for delivery by drones.

In the following section, we will check the hypotheses we have set for the research purposes.

H1: *The use of drones has great potential for use in the last mile concept.*

Based on the theoretical work, we notice that more and more authors highlight the economic potential of last-mile delivery with drones. We find that drones will lead to a reduction in time and cost in the last mile. However, several technological barriers currently limit the potential. Based on the interviews, it is also becoming apparent that widespread adoption is, at best, a distant future scenario, although drone deliveries are already being tested today. As found in the analysis, current drone technology and legislation still severely limit the implementation of drones for commercial delivery purposes. While these factors do not prevent all drone delivery operations, they still prevent widespread use for now. Based on the results, it is likely that the role of these limiting factors will diminish with further development of technology and legislation.

We note that in delivery, niche roles in high-value functions such as healthcare are likely to be introduced. Such niche features could work as a blueprint for drone delivery operations in other areas. However, the execution depends on whether drones are more competitive than other current delivery methods. The results of this research show less potential for drones concerning the concept of the last mile than the literature described in the theoretical framework. One reason is that many researchers envision specific technological improvements to

drones that are not currently on the market. Thus, it is uncertain whether this predicted technology development will occur. Also, additional developments in drone security could significantly increase the cost of operating drones, making them much more challenging to operate, especially when we talk about the last mile concept. The interviews made it possible to detect concerns about implementing this technology in cities. Namely, city centres are very unsuitable for the operation of drones, as there is currently no suitable infrastructure for safe and efficient package disposal. In countries with poorer infrastructure, competition from other delivery methods is likely less of a factor, and the potential for drones may be more significant.

H2: *Companies and experts perceive opportunities for the implementation of drones.*

Interest in the field of drone delivery in Slovenia is on the rise. Based on interviews with experts and companies, we found that a competitive environment is being created, but currently, such delivery is only in the test phase. The interviewees believe that much time will pass, and many more tests will be needed for the idea to be implemented in reality. The surveyed companies highlighted several different aspects that need to be improved. They pointed out the problem of GPS distortion, the current instability of the drone when landing due to the package, the problem of technology that enables safe and dynamic flying, and the problem of legislation and public perception.

Nevertheless, experts and companies in the Republic of Slovenia believe that the operation of drones in the future will not be as limited as it is today. Thus, they believe that drone delivery will soon become a reality. Experts highlighted the potential of using drones in delivery for various purposes. They believe that the initial deliveries will be aimed at the delivery of laboratory samples from remote areas, the delivery of medical devices, the delivery of goods from ships to land, and later, with intelligent regulation, the delivery of online purchases to end customers can also be expected. It is also necessary to highlight the investment in drone experiments, yielding positive results. We also note that delivery by van or bicycle is already very efficient in urban environments, but the cost of operating drones is still higher than existing methods. Therefore, it is unlikely that drone delivery will be adopted for simple package delivery any time soon.

5. Conclusion

Setting up a drone delivery system in urban areas raises many questions. They are related to privacy, security, environmental risks and the direct impact of drones in connection with urban delivery and transportation. The industry was the first to recognise the possibilities of using drones in civil airspace, and ideas about the transportation of shipments emerged. In addition to transportation, the industry has recognised other advantages in the form of activities that were recently performed only by manned aircraft. Thus, we can claim that the industry is aware of the importance of the exposed technology, but full implementation will require a lot of invested energy, both in the technical and legal fields. Namely, as we have already pointed out, there are quite a few obstacles to the implementation in the full sense. This is also related to privacy, security, other environmental requirements, and legislation. Over the past ten years, the number of noise restrictions has doubled as part of the restriction (Antoine & Kroo, 2002). Commercial use of drones is restricted in much of the world, but the U.S. The Federal Administration and the European Aviation Safety Agency are developing regulations to enable greater commercial use (EASA, 2019). There are also issues related to infrastructure. The widespread adoption of drones to replace the current delivery of parcels in cities could also affect the complete transformation of the energy system in the future. Thus, upon possible introduction, the entire demand for current derivatives, which are implemented for the purposes of current transport use, would change. However, the current energy system is also unsuitable and unsustainable for possible mass use (Stolaroff et al., 2018).

In addition, we found that the implementation of drone delivery will also strongly depend on the terrain, geographical location, weather and weather influences. The Republic of Slovenia has strong geographical and weather diversity, so conducting research in smaller areas, e.g., according to regions would be advisable. We have also found that there are no studies regarding the adoption of drone technology in the Republic of Slovenia, so we propose to carry out a study with surveys among the general population in the Republic of Slovenia in the future to find out whether the public will agree with the implementation.

Understanding these issues forces decision-makers and the public to face integrated energy and environmental solutions today, which in the future will deliver the first package to our doorstep with the help of a drone.

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