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Developing Small-Cargo Flows in Cities Using Unmanned Aerial Vehicles

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Abstract: Modern technology allows for the simplification of a number of functions in industry and business. Many companies have achieved a high level of robotisation and automation in the use of services, including companies operating in the transport sector, where smart systems help to control load planning, the issuing of documents, the tracking and transportation of shipments, etc. Drones can be exploited as smart assistants in delivering cargo in cities. Since it is a new technology capable of working autonomously, it presents various legal, psychological, and physical challenges. This article presents an analysis of the scientific literature on the development of small-cargo flows using drones and a research methodology on the development of the use of drones, presenting a model which helps to address the issue of cargo delivery in cities.

Keywords: cargo flows; drones; development; model

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1. Introduction

Integrating UAVs into urban freight logistics offers benefits such as traffic relief, faster deliveries, cost efficiency, environmental sustainability, improved accessibility, and enhanced safety, ultimately contributing to more efficient and sustainable urban freight transportation systems. Electric vertical take-off and landing vehicles (eVTOL) are expected to be the key drivers for urban air mobility (UAM) scenarios by satisfying on-demand air travel needs in the short or medium term [1].

Unmanned aerial vehicles (UAVs) deliver goods with fewer emissions than traditional delivery vehicles, thus contributing to environmental sustainability in cities. By reducing dependence on fossil fuel-powered vehicles, the use of UAVs contributes to reducing air pollution and its associated health risks.

It should be noted that the development of urban freight flows using unmanned aerial vehicles (UAVs) is important for several reasons. UAVs can bypass congested roads, reducing traffic congestion in cities, especially during peak hours. This reduces traffic-related delays and disruptions and ensures smoother freight transport. Unmanned aerial vehicles (UAVs) can deliver goods faster than traditional ground-based transport modes. This is particularly advantageous for the delivery of urgent consignments such as medical supplies and organs, where speed is a crucial criterion.

The donation–transplant network's complexity lies in the need to reconcile standardised processes and high levels of urgency and uncertainty due to organs' perishability and location. Both punctuality and reliability of air transportation services are crucial to ensure the safe outcome of a transplant [2].

UAVs can reduce delivery costs by optimising the routes and requiring minimal human intervention. This results in cost savings for businesses and consumers and makes delivery more affordable. UAVs can also reach areas that are difficult for conventional vehicles to reach, including densely populated urban areas and remote locations.

This enhances accessibility to goods and services, particularly for residents in underserved areas. UAVs operate above ground traffic, reducing the risk of accidents and collisions on busy city streets. This enhances the overall road safety and minimises the potential for accidents involving delivery vehicles.

Relevance. According to statistical data, cargo flows are constantly increasing, which leads to higher flows of freight vehicles not only in urban areas but also in rural areas. Heavy vehicular traffic in cities is one of the major reasons behind the search for new technologies. An excessive number of cars in cities causes traffic congestion, which puts a strain on urban logistics, leading to economic and environmental problems [3]. The number of people living in cities is growing rapidly [4], making it difficult to satisfy consumer needs. Logistic companies are implementing digitised solutions in their operations, but, regardless, there are obstacles that hinder this progress.

The delivery of goods to the end user is known as the last mile [5]. It is usually the most expensive and cost-intensive segment in the transport chain [6]. Giant companies, such as Amazon, DHL, or Jingdong, have been solving these problems using unmanned aerial vehicles (UAVs) for last-mile deliveries to the final destination [7].

Good market research and the right application of drones in logistics would allow this new technology to become indispensable [8]. Currently, UAV infrastructure has many obstacles that make the implementation of this new transport system still complicated and requiring new solutions.

The following main research problem of freight transport can be distinguished: the lack of the capacity to properly identify the characteristics of urban freight transport in urban transport systems. This affects their ability to make effective decisions to support the implementation of sustainable transport policies such as urban freight models. Local authorities do not take a systemic approach to urban freight transport. This results in a lack of clearly defined policy objectives or corresponding performance indicators. There is a lack of comprehensive research on how urban freight patterns are applied to improve the implementation of measures. As a result, a reliable link between the policy objectives supported by sustainable urban transport models and the means of policy implementation can hardly be established [9].

Topological analyses based on complex networks help to better understand the characteristics of these networks and the characteristics of their dynamic behaviours. This can help to study phenomena such as robustness, resilience, or propagation processes [10]. To reduce all logistics costs, companies are now changing to an air mode, but it is necessary to clarify which shipments should be sent by said air mode. Several other parameters such as shipment value, shipment volume, product type, and reliability of the shipping method should be considered while choosing the shipping method. Before choosing between air and sea shipping methods, it is necessary to carefully calculate and compare the costs [11].

According to Comi et al. [12], the long-term effects of transport–land use interactions can be considered using LUTI-type modelling, mainly in the development of localisation models for urban distribution centres and large shopping centres.

Comi et al. [13] stated that it could be useful to have an overview of a city's similarities or differences in terms of freight transport. According to Comi et al. [13], this type of framework can serve as a useful ex ante assessment guideline to identify the different classes of factors for each sustainability goal noted. It should also allow planners to check whether the experimental results in a city are consistent with the results obtained in the city through the goals defined for other cities. Nuzzolo et al. [14] propose a travel chain-ordering model to simulate retailer restocking in an urban-metropolitan area. It is part of a general modelling framework developed by the authors to simulate urban freight demand, taking into account demand and logistics subsystems. Nuzzolo et al. [14] proposed that the logistics subsystem of the modelling system could be divided into two parts: the first one, which defines the order of the travel chain, and the second, which takes into account the choice of stopping places. Nuzzolo et al. [14] focused on the specification and calibration of a travel chain-booking model using data collected in the city centre of

Rome. Also, Nuzzolo et al. [15] analysed agent-based modelling (ABS) for load distribution modelling as a challenge and an opportunity for future developments in this research field. According to Nuzzolo et al. [15], different stakeholders are involved in urban load distribution, and ABS allows for considering many types of agents, each with its own specific objective function, behaviour, specific characteristics, needs, and aspirations. As stated by Nuzzolo et al. [15] using this modelling approach, an agent that acts to achieve one (or more) goals, guided by certain criteria, interacting with other representatives and learning from their own experience, represents the interested party. Nuzzolo et al. [15] found, in their review of articles, that the impact of a wide set of urban logistics measures can be assessed and that research methods in this area are improving, often coupling agent-based simulation with another model (e.g., vehicle routing).

Nuzzolo et al. [16] mentioned that this paper focuses on models for estimating vehicle O-D matrices by an item/quantity approach. Considering the complexity of representing the restocking phenomenon, estimating the vehicle OD matrix from a given quantity or delivery O-D matrix is quite difficult, and only the literature reports some applications for test cases. Nuzzolo et al. [16]'s proposed modelling framework overcomes these limitations by specifying the number of pre-trip stops for restocking and sequential delivery location selection. Nuzzolo et al. [16] also considered that restockers may behave differently in relation to trip characteristics.

The main problem of the topic is the fact that insufficient attention is paid to the use of UAVs for transporting small cargo in cities. The aim of the paper is to analyse the current and continuously evolving situation of UAV adaptation, define the possibilities of their use in cities, conduct a qualitative study and build a model to solve the problems relating to cargo delivery in cities, and present conclusions.

The main objectives of this article are the following: to identify the main aspects in the transportation of cargo by unmanned aerial vehicles (UAVs); to identify problems in the development of small freight flows, to analyse first and last mile features; to define unmanned aerial vehicles; to carry out research to identify problem areas in the application of drones; and to develop a transport model that will help to solve the main urban logistics problems.

The research methods hereby applied are a scientific literature analysis and an expert survey.

2. Theoretical Analysis of the Development of Small-Cargo Flows Using Unmanned Aerial Vehicles

2.1. Problems in the Development of Small Freight Flows

Prices. Cargo transportation volumes depend on price. Prices are set in light of the specific characteristics of a mode of transport, where two options are available: the first option is charging based on short-term marginal costs, while the second one involves increasing fees through short-term marginal costs to cover all transport costs (i.e., costs of operation, loading, etc.) [17]. Fuel costs account for the major share of the total costs in the transport sector [18]. The growing price of petrol and diesel increases the cost of transport; thus, companies increase their cargo transportation mark-ups to avoid losing profits. In order to save on logistics services, reducing fuel consumption to the minimum is important. The cost of fuel is the key component in setting the transport price [19].

By using unmanned navigation, overall transportation costs, including fuel costs, can be expected to decrease by transitioning to more efficient, safer, and better-managed traffic flows. However, to accurately assess potential changes in the cost structure, further research is needed, taking into account specific factors such as vehicle type, routes, and regional differences. Unmanned navigation can change the cost structure for road transport. Unmanned navigation systems can use more detailed information about road conditions, traffic flow, work zones, and other factors to choose optimal routes. This can reduce fuel costs, as the route is planned to avoid traffic jams, road closures, or other obstacles. Unmanned vehicles can be programmed to carry cargo or passengers at the optimal speed and select the most economical engine modes to reduce fuel consumption. Unmanned vehicle systems can coordinate their actions with other vehicles to maximise road usage. This can reduce traffic congestion, accelerate movement, and reduce waiting time, which is usually associated with fuel consumption. Also, unmanned navigation systems can monitor and analyse traffic conditions in real time and make decisions to avoid situations that could increase fuel costs, such as aggressive driving, excessive braking, or speed fluctuations.

For this reason, the use of new technologies such as UAVs could help to reduce the vehicle numbers on the roads for small parcel deliveries and also reduce fossil fuel costs.

Environmental pollution. The transport sector is a rapidly growing sector with the highest greenhouse gas emissions [20]. Epidemiological studies have shown that air pollution contributes to a wide range of adverse human health effects, including respiratory and cardiovascular diseases [21]. Varying carbon dioxide emissions result in companies facing volatility in transport service prices [22]. Vehicles must comply with emission requirements, and companies are encouraged to purchase newer vehicles that are less polluting or to look for new technologies for the delivery of goods. The use of UAVs for the delivery of small parcels would help to reduce the number of freight vehicles on the roads and, at the same time, air pollution in the cities.

Infrastructure. In many places, road infrastructure is not properly adapted for cargo transportation. Unpaved unsuitable roads and a low number of terminals contribute significantly to transport problems. Therefore, in order to transport small cargo efficiently, companies need to spend considerable resources on infrastructure development to deliver freight quickly and efficiently [23].

Long transportation times. With the growth of e-commerce and the growing number of people, small-cargo flows will continue to increase as a global trend [24]. Therefore, with increasing numbers of orders, the transport sector will continuously be pressured to deliver cargo to end users efficiently and as quickly as possible. Transport congestion significantly reduces traffic efficiency [25]. Electric vertical take-off and landing vehicles are expected to be the key drivers for urban air mobility (UAM) scenarios by satisfying on-demand air travel needs in the short or mid-term and also for small-cargo transportation.

Safety and security. Ensuring the safety and security of unmanned aerial vehicles in urban areas is crucial, as they can pose risks, including collisions, invasion of privacy, and misuse. It is important to pay attention to the implementation of strict rules governing the operation of UAVs in urban areas, including the requirements for pilot certification, the registration of UAVs, and compliance with flight restrictions. There is also a need to use geo-fencing technology to create virtual boundaries around sensitive areas, such as airports, government buildings, and congested public spaces, to prevent UAVs from entering restricted airspace.

UAVs need to broadcast real-time identification and location information so that authorities can track their movements and identify operators in the event of incidents or violations. Equipping UAVs with collision avoidance systems such as radar and optical sensors to detect and avoid obstacles in their flight path would reduce the risk of collisions with buildings, vehicles, and other unmanned aircraft.

Attention should also be paid to the implementation of encryption and authentication mechanisms to prevent unauthorised access to UAVs and their control systems, thus reducing the risk of hijacking or cyber-attacks.

It is important to establish guidelines for UAV operators to respect the privacy rights of individuals, including restrictions on surveillance and data collection activities. It is also important to develop protocols for responding to emergencies involving UAVs, such as accidents, malfunctions, or unauthorised intrusions, to reduce potential risks to public safety.

2.2. First and Last Mile

The location of the first and last mile also causes major disruptions in a city's overall logistics system. In order to avoid traffic congestion and gridlocks and make efficient use of small delivery companies, new solutions are being searched for to meet the needs of consumers without causing harm to the city. The recent emergence of self-service parcel terminals offers the possibility of picking up an order at a specific location, but this does not fully satisfy consumers.

The possibility of using unmanned aerial vehicles has been receiving increasing attention. UAVs are a new mode of cargo transportation that improves ecology, speeds up delivery times, and frees up the city [26].

The operating costs of UAVs depend on energy, and the optimisation of delivery is closely linked to optimal weight ratios and the price of the drone [27]. Their adjustable height allows these vehicles to travel to even hard-to-reach locations.

The full adaptation of UAVs in densely populated metropolises will make the delivery of small freight much cheaper than using existing courier or shuttle services. To achieve a fully automated transportation of goods by UAVs, a system that works flawlessly and is able to react by itself to certain failures in real time is needed [28].

Due to their relatively low emissions, drones are a better solution than motorcycles or trucks [29]. The net emissions of drones are quite low compared to traditional modes of transport, but they still exist [30]. Aircraft can help reduce air pollution in large cities, as most of them are powered by electricity.

Increasing consumer demand and the many problems of road transport make it inefficient to transport small goods in the last mile of a delivery by the existing modes of transport. The last mile or last kilometre is the last leg of a journey comprising the movement of goods from the transportation hub to the final destination for the consumer. In order to save the environment and deliver goods faster, a new and recently emerging technology—unmanned aerial vehicles—would come in highly handy. This technology can reduce the environmental problem of transport, allowing goods to be delivered to hard-to-reach places much faster than by any currently existing mode of transport.

2.3. Adaptation UAVs in Cities

2.3.1. Choosing Unmanned Aerial Vehicles and Their Control and Software

The increase in e-commerce and parcel deliveries has caught most shops and parcel delivery services unprepared, with delays, misdirection, or loss of parcels, leading to high customer dissatisfaction. All this is leading e-shops and parcel delivery services to increasingly look for alternative delivery methods. One of these is the delivery of parcels and goods by unmanned aerial vehicles, known as drones.

In Lithuania, drone delivery is still at a very early stage of development, as in most other countries. Until the beginning of this year, Lithuania had rules on the use of drones, and, since this year, certain European Commission regulations have come into force, setting out rules and requirements for the owners and pilots of drones in the EU. Compliance with these rules and requirements does not prohibit the transport of goods or parcels by UAVs. However, aircraft that are designed to carry dangerous goods, people, or fly over people are subject to certification requirements.

The delivery of goods and parcels by UAVs is a solution that can reduce delivery times, road congestion, environmental pollution, and delivery costs.

However, there are still a number of challenges, such as adopting rules and directives allowing the transport of goods and parcels by UAVs, ensuring customer privacy, and integration into existing supply chains. The first trials are underway in Lithuania, although delivery by UAVs is not new, as the potential of UAVs for parcel delivery had been discussed as early as in 2013, when Amazon started testing its fleet of UAVs under development. Later, in 2020, a major step was taken towards the legalisation of parcel delivery by UAVs when the US Federal Aviation Administration approved new rules allowing the operation of aircraft weighing more than 250 g over people and moving vehicles.

In addition, Amazon and several other companies, such as UPS and Wing, a subsidiary of Google, have obtained certificates allowing them to operate a fleet of unmanned aircraft. Amazon even has a target of delivering parcels within half an hour of ordering and sees UAVs as the technology with the most potential to achieve this goal.

In Lithuania, the delivery of goods by unmanned aerial vehicles (UAVs) is also not a new technology. Topocentras carried out a demonstration delivery where a mobile phone was delivered by UAVs from the parking lot of a shopping centre to a nearby skyscraper. In 2020, a Lithuanian record for parcel delivery by UAVs was set when a parcel was flown 5 km away to a real customer.

2.3.2. Stringent Technological Requirements

The concept of unmanned aerial delivery is quite simple. An order is created and placed on a mobile app or website and processed at a local delivery point. The parcel is packed in a special box, which is hooked onto an unmanned aerial vehicle (UAV) and delivered to the customer's home. The UAV is an essential element in this chain and is subject to stringent technological requirements.

The aircraft used to deliver parcels can be remotely and autonomously controlled. They must be equipped with warning systems for obstacle detection and avoidance, and their rotating parts must be protected.

One example is UPS, which has recently developed its fleet of delivery aircraft using wingcopters. This technology features a patented guide rotor mechanism that includes two flight modes: multi-rotor, which allows the aircraft to hover in the air, and fixed-wing, which allows it to fly forward. This allows the aircraft to take off and land vertically. Aerodynamic solutions ensure that the aircraft remains stable even in adverse weather conditions. The aircraft can cover a distance of up to 100 km with a parcel weighing around 2 kg. Amazon's newest parcel delivery aircraft has similar features to its predecessor from UPS. This aircraft can travel up to 24 km with a parcel weighing around 2 kg. Wing's parcel delivery aircraft are distinguished by their 1 m wingspan, which allows them to cover a distance of up to 20 km with a parcel weighing around 1.3 kg.

2.3.3. There Are Three Main Types of Drones

Multi-rotor drones have strong robotic arms and the highest pick-up capacity compared to other types of drones. They can be used for longer deliveries and for transporting heavy parcels. The drone's arms ensure that the cargo can be properly secured. They can transport cargo over longer distances. Hybrid drones have a slightly lower lifting capacity compared to multi-rotor drones. They have a lighter body and can fly to higher altitudes to avoid interference and obstacles. Hybrid UAVs represent a versatile solution for a wide range of aerial tasks, including surveillance, mapping, environmental monitoring, and cargo transportation. Their ability to harness the strengths of multiple propulsion technologies makes them well-suited for demanding and dynamic operational scenarios.

A hybrid UAV is a type of drone that incorporates a blend of propulsion systems, combining the advantages of different power sources for improved performance and versatility. Rather than relying solely on one type of propulsion, such as electric motors or internal combustion engines, hybrid UAVs integrate multiple power technologies. These may include combinations of electric motors, traditional fuel engines, fuel cells, or even renewable energy sources like solar panels. UAVs with hybrid propulsion systems offer several benefits: they can fly for longer durations and cover greater distances compared to drones powered solely by electric batteries. This extended flight time is advantageous for missions requiring prolonged aerial surveillance, mapping, or data collection. The combination of different power sources allows hybrid UAVs to carry heavier payloads without compromising flight performance. This capability enables the integration of advanced sensors, cameras, or other equipment for diverse applications. Hybrid UAVs can adapt to varying mission requirements and environmental conditions by leveraging different power sources as needed. This flexibility enables optimal energy management and performance optimisation based on specific mission objectives. By incorporating redundant power systems, hybrid UAVs offer improved reliability and safety during flight operations. Redundancy minimises the risk of power failure and ensures continued operation even in the event of system malfunction.

Fixed-wing drones can travel the planned distance at high speed and in a very short time. The delivery times are short and fast. The only drawback is that the packaging has to be light as such drones cannot carry much weight.

UAVs use an autonomous autopilot system. The terminal is equipped with a maintenance centre to be used for storing, charging, and servicing drones. Delivery drones operate in an environment where the public may be exposed to aviation risks. The system should be designed so that drones are treated as an aircraft or helicopter with the same aviation safety principles and general regulations. It should be mentioned that the main obstacle during their deployment would be the acceptance of the new mode of transport by people living in urban areas.

As UAVs are relatively rare, people are reluctant to accept untested innovations immediately. The deployment of a model can take from a few months to several years, depending on government restrictions and public attitudes. It is also important to stress that the implementation of this proposal will require completely new governmental regulations and legal aspects to avoid problems.

Also, having integrated into the drones the FlytOS smart modules and sensors with integrated SBC (Nvidia Jetson Nano, DJI Manifold 2, Raspberry Pi 3B+/4), these drones will be able to accurately land or take off and avoid collisions. Such integration with a UTM engine or national airspace services can give more information on the airspace, flight warnings, and weather conditions for optimal route planning, avoiding no-fly zones and manned aircraft.

2.4. Definition of Unmanned Aerial Vehicles

UAVs are still a new technology and only recently have their performance and use in the transport sector started to be explored [8]. The following is a list of the definitions of UAVs provided by different authors (see Table 1).

Table 1. Definitions of an unmanned aerial vehicle (compiled by the authors).

Author	Definition	Key Characteristics
Beard, McLain, 2012 [31]	A cargo drone is an electric or semi-electric vehicle with a certain number of rotors, capable of transporting cargo from point A to point B by air.	Type of air transport of cargo
Giones, Brem, 2017 [32]	A cargo drone is the first major step towards protecting nature in the logistics sector.	Environmental protection
Layne, 2015 [33]	A cargo drone is a vehicle for transporting very small loads in urban areas.	The future of urban logistics
Patel, 2016 [34]	A cargo drone is an electric vehicle offering the functions of cargo transport, mapping, surveillance, and photography.	Multifunctional means of transport
Wang, 2016 [35]	A cargo drone is a means of transporting goods in case of emergency.	Lightning-fast mode of transport
Goodchild, Toy, 2018 [36]	A cargo drone is an electric or semi-electric vehicle for transporting small cargo in hard-to-reach areas.	Transporting freight in hard-to-reach areas
Chauhan et al., 2019 [37]	A cargo drone is a means of transporting small cargo to reduce environmental pollution.	Environmental protection

Different authors provide different descriptions of cargo UAVs, but they all agree that they are a new and evolving mode of transport for small-cargo carriages. Most authors emphasise the advantage of this mode of transport in preserving nature. As unmanned aerial vehicles use electricity, they are an excellent solution to replace existing modes of transport, especially in urban or hard-to-reach areas.

With the growth of e-commerce and increasing numbers of people, the flow of small cargo will only increase [24]. Therefore, as the number of orders increases, so will the pressure on the transport sector to deliver cargo to end users efficiently and within the shortest possible period of time.

Transport congestion significantly reduces the efficiency of cargo delivery [25]. UAVs can reduce delivery times by up to 75% [38,39].

The delivery of small cargo and fast-food meals can contribute to meeting new consumer needs not only in metropolises but also in remote regions.

2.5. Barriers to the Use of UAVs

Unmanned aerial vehicles, like all technical devices, have parts that are subject to wear and tear.

Regulation of cargo UAVs. The most important aspect in cargo transportation is represented by governmental regulations, rules, and responsibilities, without which transportation in the airspace would be impossible [40]. Most people think that UAVs are uncontrollable, invasive, and disruptive devices in the airspace [41]. However, for this not to be the case, this new means of transport requires new legal regulations. The entire regulatory framework should be based on the protection of the landscape, settlements, people, airspace, and traffic [42].

Governments should ensure the presence of the necessary infrastructure. This will require highly accurate navigation and a coherent and connected overall system [43]. It could also include banning UAVs from certain areas, such as airports, military camps, government buildings, schools, and parks [44].

The problem of UAV routing. One of the most important problems in the last mile of the transportation of small loads by UAVs is the problem of vehicle routing [45].

Technical barriers of UAVs. The most commonly discussed problems include flight range, aircraft speed, batteries, and carrying capacity [46].

Also, it is necessary to determine how much and what kind of new infrastructure will be needed for UAVs. This problem can be solved by using a combination of UAVs and trucks for delivery [47].

Public attitudes towards UAVs. It is expected that, with more and more information and positive examples, public attitudes towards UAVs will significantly improve and change for the better in the future [48]. Exposure to noise can cause people to become irritable, stressed, and sleep deprived, also resulting in negative effects on the cardiovascular and metabolic systems [49].

Impact of unmanned aerial vehicles on wildlife. A number of research works have shown that wildlife–vehicle collisions are a major problem in many countries [50]. As drones usually fly at low altitudes, they will also pose a risk to wildlife and disturb the natural environment [51]. Automated drones may fail to detect flying birds or scare them away with their sound, colliding with them, and, thus, injuring the animal and damaging the cargo being transported and the UAV itself.

The regulation of unmanned aerial vehicle (UAV) corridors and designated zones. In Figure 1 is showed the regulation of unmanned aerial vehicle (UAV) corridors.

In Lithuania, the regulation of unmanned aerial vehicle (UAV) corridors and designated zones is governed by several institutions and legal acts. The Lithuanian Transport Safety Administration (TSA) is responsible for establishing and enforcing air traffic management and safety rules. It may participate in and coordinate the process related to UAV corridors and designated zones. The Civil Aviation Administration (CAA) may also have a role in regulating the use of UAV corridors and designated zones. This institution can provide recommendations regarding airspace usage and safety. The Special Forces Aviation Battalion (SPJ AVBAT) is the part of the Lithuanian Armed Forces responsible for the execution of military UAV operations and technical aspects. The State Border Guard Service of the Republic of Lithuania (VSAT) may be responsible for the management and utilisation of UAV corridors if they are related to border protection or territory surveillance.

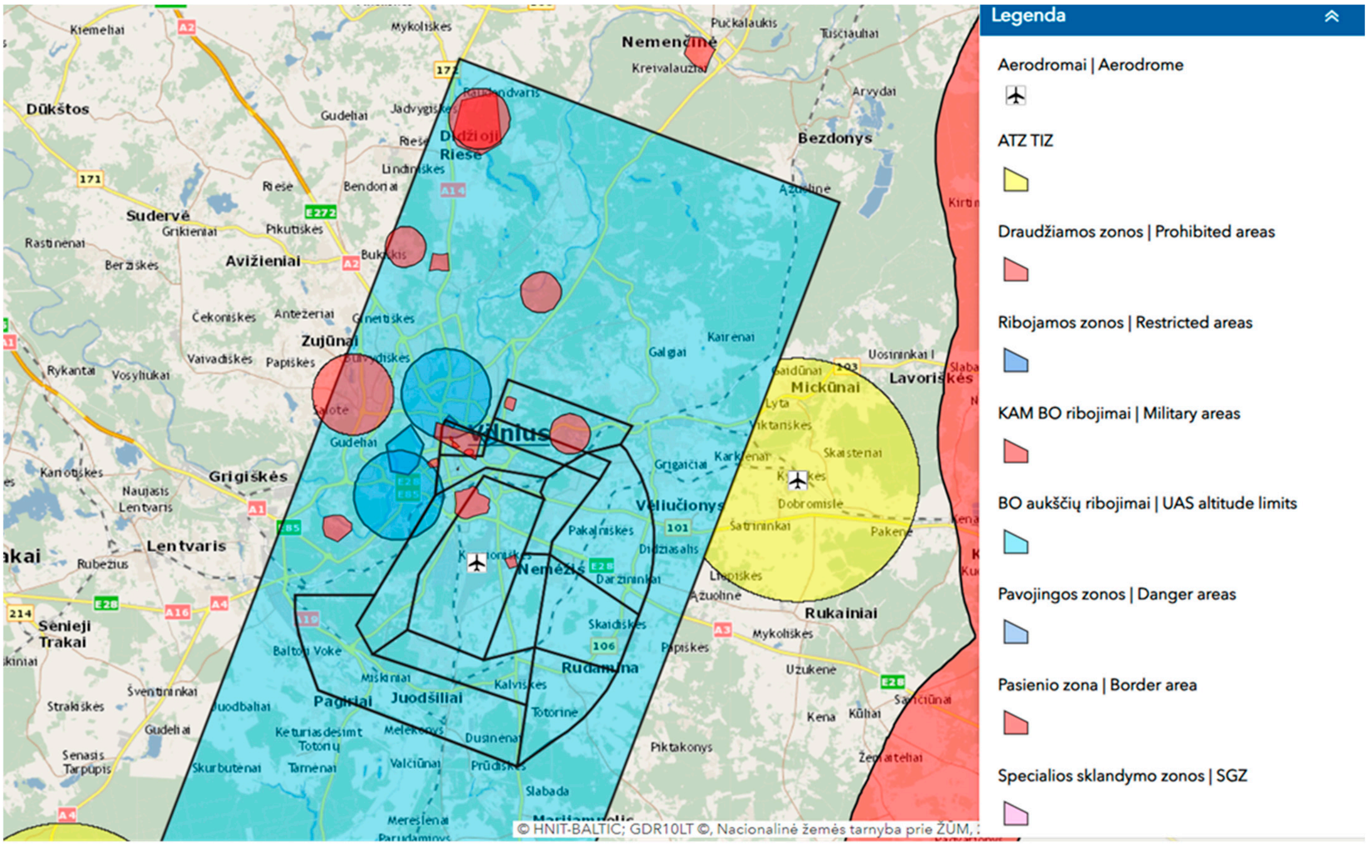

Figure 1. The regulation of unmanned aerial vehicle (UAV) corridors (source: maps.lt).

The legal framework relevant to the regulation of UAV corridors and designated zones may include civil aviation regulations, airspace usage rules, national security requirements, etc. This could encompass various legal acts, such as the Civil Aviation Act, security regulations, state border protection rules, and so on.

2.6. Formulating a Scientific Problem

If properly adapted, drones in urban logistics can operate separately or be integrated with other modes of transport, allowing for a more efficient use of infrastructure and for maximising the quality of transport for customers.

For drones to change and gain a foothold in the market, the problem of their application in logistics must be solved. One of the biggest obstacles to the adoption of drones is not a technological problem but a legal one. In many countries, there are no laws allowing UAV cargo transport, or they are very limited. The creation of this legal framework is severely hampered by people's ill-will towards this technology. People are not used to having unmanned vehicles constantly flying over their heads, and the fear that they may be used for surveillance rather than cargo transport prevents the rapid development of unmanned aircraft infrastructure and the creation of legal regulations.

The main aim of this article is to assess the applicability of UAVs in logistics and develop a model that has certain legal regulations and meets people's needs and societal attitudes, which would allow us to increase the flow of small-cargo shipments using UAVs.

3. Research on the Development of Small-Cargo Flows Using UAVs

3.1. Methodology of Research on the Development of Small-Cargo Flows Using Unmanned Aerial Vehicles

The qualitative research method was selected, as it is more acceptable for analysing the current problems in small-cargo transport and finding a solution to these problems through the use of a new mode of transport—unmanned aerial vehicles. A researcher has to take into account the requirements of their research participants. The form of a standardised interview and questionnaire was chosen to obtain experts' answers and reflections. The experts chosen for this qualitative research were privately presented with 10 questions in the form of a questionnaire. Following Kardelis [52], the questionnaire was designed according to all the research requirements and met the following criteria:

- The exact procedures and requirements for submitting answers to the questions were specified;
- An explanation was provided as to why the problem was being analysed and why this qualitative research was being conducted;
- All the questions were designed to be as simple as possible, so that the respondent would know exactly what information their answer would convey;
- The questions were precise and specific in order to obtain a correct understanding of the experts' views on the chosen topic;
- Understandable answer options within a limited scope were selected to accurately reflect the views of the experts interviewed;
- To ensure the anonymity of the experts, several questions were close-ended;
- The questions were formulated so as to give the experts the freedom to answer the questions simply, offering multiple choices;
- To ensure the accuracy of the questionnaire and retain the experts' attention throughout this research, the questionnaire was brief and clear, allowing us to collect strong and correct expert opinions.

The key research objectives were the following:

- to identify the main aspects affecting transportation by cargo UAVs;
- to define the role of UAVs in the transport sector;
- to analyse the types of existing drones that could be used to deliver small loads;
- to investigate whether the proposed use of drones as a solution to the problem will contribute to improving the transport of small goods.

Also, generally, in the expert research approach, the aggregated opinion of a group of experts is taken as the solution to the problem at hand (the outcome of the solution). If a decision is to be made on the basis of expert judgements, the degree of agreement between the experts' opinions is assessed. It is essential to determine the consistency of the experts' opinions by applying multi-criteria assessment methods. The reliability of the panel's judgements depends on the level of knowledge of the individual experts and the number of members. Assuming that the experts are sufficiently accurate measurers, it can be said that the reliability of the expertise of the panel as a whole increases with the number of experts. The type of survey used in this study was essentially a variant of the expert evaluation method described above.

In our case, the chosen method was important enough to clarify the consistency of the experts' opinions.

To identify the objectives of this study, 10 different experts were selected for questioning. This number of experts was chosen to ensure the accuracy and quality of the assessment of the consistency of their opinions. In order to reveal the competences of the experts, they were asked to provide their length of service in logistics, experience in the transport of small goods, and university degree. All the experts in the study had at least a Bachelor's degree and between 7 and 20 years of current work experience in the logistics sector. It was found that the minimum number of years of experience of the experts in the field of small goods' transport was 6 years. Also, all the experts interviewed had a Master's degree from a university. The questionnaire, as mentioned above, contained ten different questions (five closed and five open). To ensure the accuracy of the experts' answers, the qualitative questionnaire was administered in a separate private room, where there were no unauthorised people present at the time. This method allowed us to ensure the anonymity of the respondents and the accuracy of the answers. A list of questions was drawn up for the questionnaire, together with a justification as to why this particular question was being asked and what the answer would reveal.

All the included questions were based on an analysis of the problems and areas of operation of UAVs. The questions covered several problematic areas of UAV operation and deployment, namely, societal, economic, and political ones.

3.2. Methodology of Assessment of Expert Opinions

The Kendall's Coefficient of Concordance was used to assess this research and calculate the concordance between the experts' opinions.

To exclude non-concordant assessments, the method of calculating the concordance coefficient (Kendall's) was used to test the consistency in the experts' opinions. A group of selected experts m was assessed from the quantitative perspective using quality object indicator n (the experts were evaluated using a certain selected indicator m).

The selected experts (E_1, E_2, ..., E_m) were presented with the questionnaire, and quantitative importance scores (B_1, B_2, ..., B_n) were awarded for the quality criteria (X_1, X_2, ..., X_N) of the object based on the respondents' experience, knowledge, and opinions. This way, the experts received scores for their background and knowledge. The most important quality criterion received the highest score, awarding scores in a descending order, down to the lowest score, which was 1.

$$\sum_{j=1}^{m} B_{ij} = B_i. \tag{1}$$

In the course of our analysis of the questionnaire, a table of the scores awarded to the experts was drafted (see Table 2).

Table 2. Scores of importance awarded to the experts' opinions (compiled by the authors).

Expert Number		Marking of the Criterion Where i = 1, 2, ..., n			
		X_1	X_2	...	X_n
j = 1, 2, ..., m	E_1	B_{11}	B_{12}	...	B_{1n}
	E_2	B_{21}	B_{22}	...	B_{2n}
	...	...	...	...	...
	E_m	B_{m1}	B_{m2}	...	B_{mn}

The concordance between the experts' opinions was then calculated using Kendall's concordance coefficient W according to the resulting estimates and scores [53]. The score B_{ij} of each criterion was converted into rank R_{ij}. In this case, the most important criterion was changed to 1, then moving to the least important criterion, in an ascending order (where the least important criterion had the highest rank). The following formula was used to convert the scores into ranks:

$$R_{ij} = (n+1) - B_{ij}, \tag{2}$$

where m—number of experts; n—number of criteria; and B_{ij}—score awarded by the expert.

The dispersion concordance coefficient (W) reflected the sum of the ranks of each indicator (R_i) with respect to the experts, according to the following formula (where i = 1, 2, . . ., n):

$$R_i = \sum_{j=1}^{m} R_{ij}. \tag{3}$$

Specifically, R_i's deviation from the sum of squares S of the overall mean $\overline{R}$ was the following:

$$S = \sum_{i=1}^{m} \left(R_i - \overline{R}\right)^2 \tag{4}$$

This was followed by the formula of the overall mean $\overline{R}$:

$$\overline{R} = \frac{\sum_{i=1}^{n} R_i}{n} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} R_{ij}}{n}. \quad (5)$$

To obtain the average rank for each criterion, the sum of the ranks was divided by the number of experts (where i = 1, 2, . . ., n):

$$\overline{R_i} = \frac{\sum_{j=1}^{m} R_{ij}}{m}, \quad (6)$$

where R_{ij}—the rank assigned to the respondent's criterion; and m—number of respondents.

The formula for the sum of the ranks and the difference in the constant value was the following:

$$\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1). \quad (7)$$

The formula for the squares of the sum of the ranks and the difference in the constant value (see Table 3) was as follows:

$$\left[\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1)\right]^2. \quad (8)$$

Table 3. Ranks of expert opinions and their use (compiled by the authors).

Expert Number		Criterion Marking, Where i = 1, 2, ..., n			
		X_1	X_2	...	X_n
j = 1, 2, ..., n	E_1	B_{11}	B_{12}	. . .	B_{1n}
	E_2	B_{21}	B_{22}	. . .	B_{2n}
	. . .	. . .	. . .	. . .	. . .
	E_m	B_{m1}	B_{m2}	. . .	B_{mn}
Sum of ranks $\sum_{j=1}^{m} Rij$		R_1	R_2	...	R
Means of ranks (1) $\overline{R_i} = \frac{\sum_{j=1}^{m} R_{ij}}{m}$		. . .	. . .		. . .
Means of ranks (2) $\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1)$		. . .	. . .	. . .	. . .
Means of ranks (3) $\left[\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1)\right]^2$		. . .	. . .	. . .. . .	

The calculations added up to the total sum S, where S is the actual sum of the squares (in the presence of no associated ranks), then obtaining

$$W = \frac{12S}{m^2 n(n^2-1)} = \frac{12S}{m^2(n^3-n)}. \quad (9)$$

In practice, the concordance coefficient is used when its threshold value has been clarified and the estimates are considered to be still concordant.

Where the number of objects is greater than $n > 7$, the significance of the concordance coefficient is obtained according to Pearson's criterion (chi-squared) χ^2.

The random variable is calculated as follows:

$$\chi^2 = \mathrm{m(n-1)W} = \frac{\mathrm{12S}}{\mathrm{mn(n+1)}}. \quad (10)$$

Then, distribution χ^2 follows, with degree of freedom of $v = n - 1$. In our study, the level of significance α was selected from the distribution χ^2 table, with a degree of freedom $v = n - 1$, thus obtaining critical values. If the calculated value χ^2 was greater than the critical value χ^2, the experts were considered concordant.

When the value of the number of indicators m is between 3 and 7, the distribution χ^2 should be applied with caution, as the critical distribution value χ^2 may be higher than the calculated one, in which case concordance coefficient probability tables or tables of critical value S at $3 \leq n \leq 7$ would have to be used.

The minimum value of the concordance coefficient ($W_{\min}$) expresses the opinion of the experts on a certain criterion at a certain significant level α and a degree of freedom of $v = n - 1$, which is concordant, making the formula

$$W_{\min} = \frac{\chi^2_{v,\alpha}}{m(n-1)}, \tag{11}$$

where $\chi^2_{v,\alpha}$ is the critical Pearson statistic.

3.3. Concordance between Experts' Opinions

To check the concordance between the experts' opinions, the respondents were asked to number the most important factors that had the greatest impact on the delivery of small cargo in cities on a scale from 1 to 9, where 9 was the most important and 1 was the least important factor. These answers helped us identify the factors that slowed down the delivery of small goods and made it problematic. All the respondents interviewed were asked a question, listing nine answers in a sequence, assigning a letter to these influencing factors in a sequential order: A—hard-to-reach delivery address; B—shortage of drivers; C—insufficient pace of upgrading the roads and assignment of new addresses; D—environmental fees for cargo transport; E—price of transportation of first and last mile; F—transportation time; G—increasing competition; H—expensive fuel; and I—inefficient use of transport, empty kilometres.

All the experts' answers on the most important factors that have the greatest impact on the delivery of in cities are presented in Table 4.

Table 4. Experts' scores (compiled by the authors).

Expert Number	**Function Symbol**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
E_1	5	2	7	1	9	8	3	6	4
E_2	3	4	6	2	9	8	1	7	5
E_3	6	3	7	4	8	9	1	5	2
E_4	6	4	5	2	9	7	1	8	3
E_5	5	3	7	1	8	6	2	9	4
E_6	5	1	6	2	8	9	3	7	4
E_7	4	2	7	1	9	8	3	6	5
E_8	5	2	6	1	9	8	4	7	3
E_9	3	2	7	1	8	9	5	6	4
E_{10}	3	1	7	2	9	8	4	6	5
$\sum_{j=1}^{m} B_{ij} = B_i$	45	24	65	17	86	80	27	67	39

Then, the experts' answers, converted into ranks, were calculated using the following formula:

$$R_{ij} = (n+1) - B_{ij}. \tag{12}$$

According to the data in the table, all the squares of the sum of the ranks were added, and the total sum S was obtained:

$$S = 25 + 676 + 225 + 1089 + 1296 + 900 + 529 + 289 + 121 = 5150.$$

where S is the actual sum of the squares (in the absence of associated ranks). Then, Kendall's concordance coefficient was calculated as follows:

$$W = \frac{12S}{m^2 n(n^2 - 1)} = \frac{12S}{m^2(n^3 - n)} = \frac{12 \times 5150}{10^2(9^3 - 9)} = \frac{61800}{72000} = 0.86.$$

When the number of objects was greater than $n > 7$, the significance of the concordance coefficient was obtained using Pearson's criterion (chi-squared) χ^2.

$$\chi^2 = m(n-1)W = \frac{12S}{mn(n+1)} = \frac{12 \times 5150}{10 \times 9(9+1)} = 68.67.$$

Then, distribution χ^2 with $v = n - 1$ degree of freedom was carried out.

The level of significance α was chosen from the χ^2 distribution, as can be seen in Table 5.

Table 5. Ranks of expert answers and their sum and average (compiled by the authors).

Expert Number	Function Symbol								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
E_1	5	8	3	9	1	2	7	4	6
E_2	7	6	4	8	1	2	9	3	5
E_3	4	7	3	6	2	1	9	5	8
E_4	4	6	5	8	1	3	9	2	7
E_5	5	7	3	9	2	4	8	1	6
E_6	5	9	4	8	2	1	7	3	6
E_7	6	8	3	9	1	2	7	4	5
E_8	5	8	4	9	1	2	6	3	7
E_9	7	8	3	9	2	1	5	4	6
E_{10}	7	9	3	8	1	2	6	4	5
Sum of ranks $\sum_{j=1}^{m} Rij$	55	76	35	83	14	20	73	33	61
Rank average $\overline{R_i} = \frac{\sum_{j=1}^{m} R_{ij}}{m}$	5.5	7.6	3.5	8.3	1.4	2	7.3	3.3	6.1
Rank difference $\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1)$	5	26	−15	33	−36	−30	23	−17	11
The square of the sum of the ranks $\left[\sum_{j=1}^{m} R_{ij} - \frac{1}{2}m(n+1)\right]^2$	25	676	225	1089	1296	900	529	289	121

The lowest value of the concordance coefficient (W_{min}) expressed the experts' opinion on a given criterion, if the given significance level α and degree of freedom $v = n - 1$ were concordant.

To sum it up, if the calculated value χ^2 was greater than the critical value χ^2, the experts' opinions were concordant, while the ranks showed the common opinion of all the experts.

3.4. Analysis of Research Results

This Section first discusses the problems analysed in the literature and the qualitative empirical findings. As mentioned above, the aim was to investigate the problems of the transport of small cargo, the existing modes of transport, the situations where UAVs provide the most benefits in logistics, and the possible applications of UAVs in small-cargo transport. This analysis was mainly based on a literature review and experts' insights, examining the respondents' opinions on the most prominent challenges and drawbacks related to the current use of UAVs, analysing the resources required for drone deployment and their maintenance, and also answering questions related to the cost of using drones compared to other last-mile delivery methods.

Main ways to reduce first- and last-mile problems in urban logistics. The bar chart below lists the methods identified by the experts that they believe to reduce the first- and last-mile problem (see Figure 2).

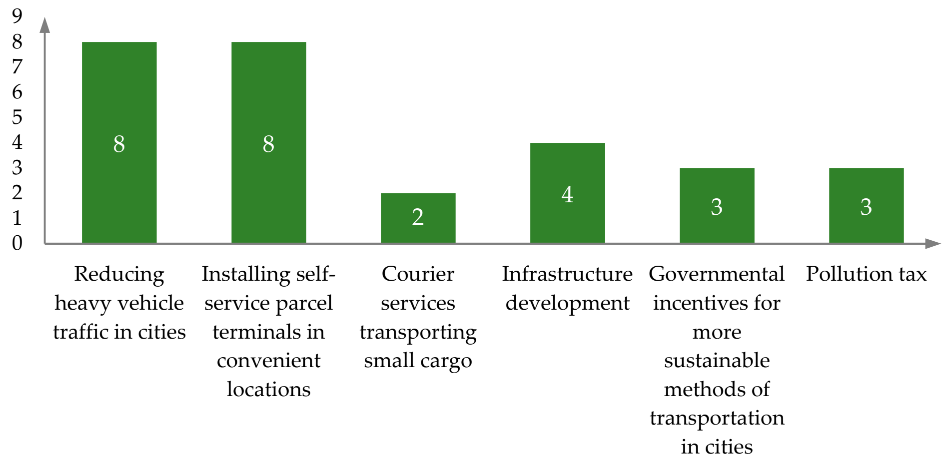

Figure 2. Ways to reduce first- and last-mile problems in cities identified by the experts (compiled by the authors).

Almost all the experts identified two main ways to reduce first- and last-mile problems in urban logistics in our open-ended question. These were bans on heavy goods' vehicles in cities and the installation of self-service parcel terminals in convenient locations in a city. Eight experts named both of these factors.

3.5. Key Factors to Consider When Introducing New Modes of Transport in Urban Logistics

In their answers, the experts pointed to increasing the sustainability of cities and reducing environmental pollution and social impact as the key factors. The experts divided urban sustainability into three main criteria: economic efficiency, environmental protection, and social wealth creation.

The problems arising from freight transport are quite diverse. The experts considered the environmental and accessibility problems associated with cargo transportation or distribution, particularly in urban areas, to threaten the viability and sustainability of urban areas. The efficient distribution of cargo reduces congestion and emissions. There are many solutions to these main problems, and the experts grouped them into four categories:

- Functional impact on the whole city, and, in particular, technical response to circulation needs by integrating the flow of goods in the overall traffic;
- Economic consequences, as cargo transport is related to the quality and efficiency of the servicing road;
- Integration into land-use planning;
- Social and environmental impacts with a direct effect on the quality of life.

Current modes of transport of small goods in cities. The bar chart below shows the currently available and used modes of transport of small goods in urban areas identified by the experts (see Figure 3).

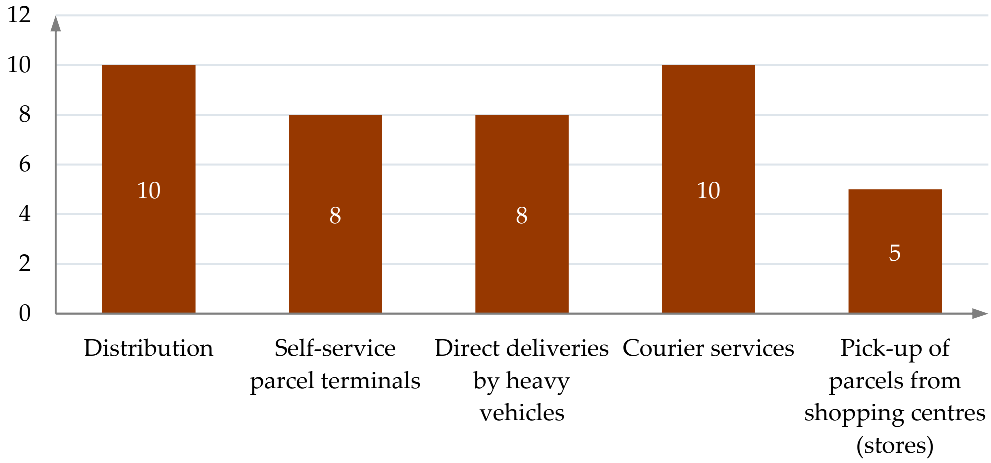

Figure 3. Experts' answers distinguishing the existing modes of transport of small goods in the city (compiled by the authors).

The experts' answers show that courier services and distribution are the main and most commonly used methods of delivery of small cargo. The main objective of distribution is accessibility and cost reduction. It must always be ensured that customers have access to a sufficient quantity of products and the ability to receive the replenishment of goods quickly and effortlessly.

Resources required for drones. Drones have certain requirements that need to be met before they can be used. The experts identified some of these special conditions, such as the right temperature, fast delivery, and trained personnel during the take-off and landing to receive a special package. In addition to trained personnel, special premises/warehouses must also be available to operate drones. At an organisational level, local warehouses are most often used for small deliveries. The experts highlighted activities related to the drones themselves as a necessary resource. They shared the view that drones are the most cost-effective way of delivering goods in the last-mile context when delivering to hard-to-reach locations or in the case of a need to receive the cargo urgently.

Most suitable cargo for UAV delivery. The pie chart below shows the experts' views on the most suitable cargo for transportation by UAVs (see Figure 4).

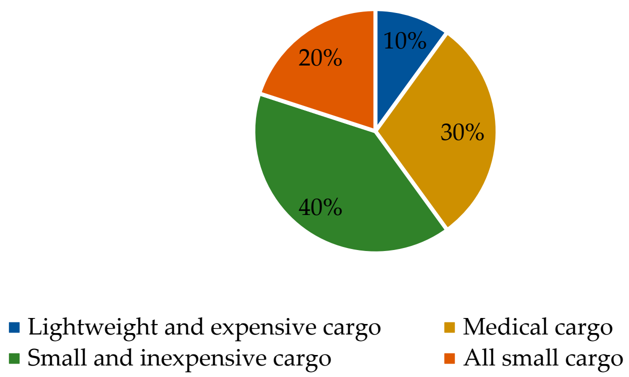

Figure 4. Experts' answers on the most suitable cargo for UAV deliveries (compiled by the authors).

All deliveries using UAVs could be classified as small deliveries, as UAVs are not currently capable of delivering heavier loads due to their "immobility" and relatively new technology. Three experts indicated that human organs, blood, vaccines, and other small medical supplies are the most suitable cargo for UAVs. Several experts also mentioned that drones could take over lightweight and expensive cargo, such as jewellery, but there is a high likelihood of such cargo being stolen. A total of 40% of the experts replied that UAVs would be able to transport small and inexpensive cargo and would be less likely to damage cargo in the case of accidents. Such cargo would not require additional insurance and could be carried in an easier manner in urban infrastructure.

Most suitable type of UAV for transporting small cargo. The pie chart below shows the experts' answers on the most suitable type of UAV for transporting small goods (see Figure 5).

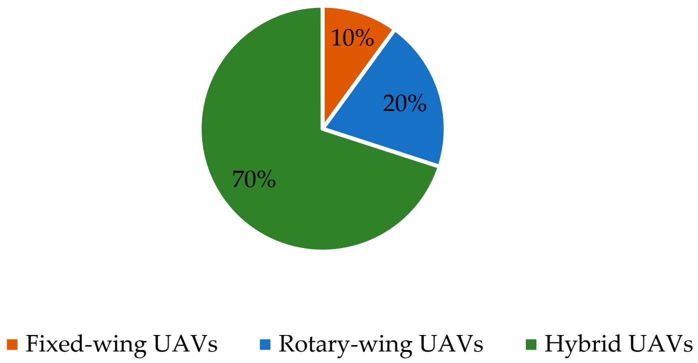

Figure 5. Experts' answers on the type of UAVs best suited for small-cargo transport (compiled by the authors).

In their answers, 70% of the experts said that the most suitable type of UAV is a hybrid drone, as it is quite solid and strong for delivering cargo of different weights.

Key challenges related to the use of drones. The main challenges are related to the weight and sensitivity of the items being transported. Four experts pointed out that the purchase price of drones is currently one of the biggest challenges. They also said that drones change and develop very quickly. This may lead to price changes in the future as the technology becomes more affordable. The total cost of the use of drones includes maintenance, storage, and the training of operators.

Reasons hindering deliveries by UAVs. The bar chart below illustrates the expert's answers as to why small goods are still not delivered by UAVs (see Figure 6).

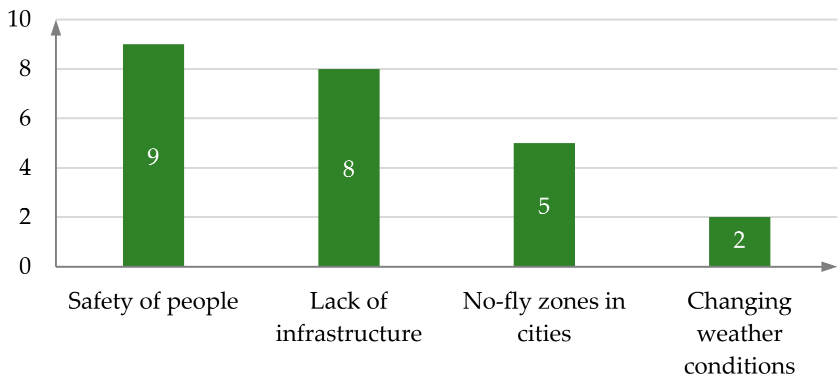

Figure 6. Experts' answers on the main reasons preventing the transport of small goods by UAVs (compiled by the authors).

According to the experts' answers, the main reason for the relatively slow development of the transportation of small cargo by UAVs is the safety of people and personal information. This was identified by 9 out of the 10 experts. As drones are mostly unmanned and fly along already-established air corridors, accidents can happen where drones fall and injure people walking on the ground.

Advantages of unmanned vehicles. The bar chart below shows the experts' responses on the advantages of UAVs for small-cargo transportation (see Figure 7).

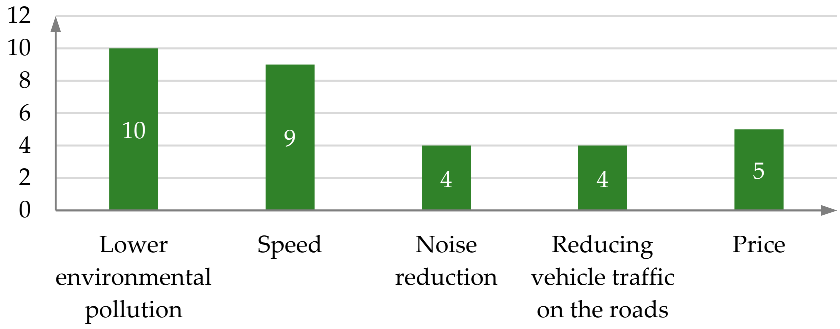

Figure 7. Experts' answers on the advantages of UAVs for small-cargo transportation (compiled by the authors).

The chart shows that all the experts recognized the advantage of UAVs as a means of reducing environmental pollution. Nine experts also identified the speed of UAVs: as drones do not require the existing roads, there is no congestion in the airspace, and this allows cargo to be delivered directly to the destination in the fastest available way.

4. Results: Proposed Model for the Development of Small-Cargo Flows Using Unmanned Aerial Vehicles

4.1. Proposed Model of Operation of Unmanned Aerial Vehicles

The analysis of the scientific literature and the surveying of the experts showed that the transport of small goods in the first and last logistics mile is one of the most important and most difficult parts of the system to manage in urban logistics. This part of the chain is constantly looking for the most efficient way to deliver goods to final consignees. The most challenging delivery situations are in densely populated and rapidly expanding cities. The e-commerce network is constantly expanding, and the demand for small parcel deliveries is constantly increasing. Optimising the first- and last-mile delivery of small consignments is a major focus, and new perspectives are constantly being sought to address this problem. In the parcel industry, parcels arrive from post offices to a central warehouse from which they are then distributed to other destinations, such as other post offices. In this transfer option, several parcels for different customers are brought to decentralised facilities that are easily accessible to the customers. This decentralised location may be either a parcel locker or a shop. Compared to home delivery, the delivery of multiple customer shipments to a decentralised pick-up location saves time and costs for the service provider, which speeds up the handling time for increasing volumes of shipments, reduces the delivery costs, and facilitates urban mobility. Post offices, usually located in high-traffic areas, are stationary, unattended delivery machines operating 24 h a day, 7 days a week. They store small goods for delivery to the final recipient and often also provide the opportunity to send parcels. Drones can be an excellent choice for such parcel services between the post office and the terminal. In the UAV systems already developed, the drone currently makes a direct flight to the customer's home or business, delivers the parcel, and returns to the base. The back-and-forth delivery model has some drawbacks associated with a distributed network of UAVs delivering packages using a one-way drone network. The drone delivers the cargo directly to the customer and returns back empty. The same delivery model—i.e., directly to the customer—is more expensive, as it requires twice as many resources, twice as much airspace, twice as much navigation, twice as long tracking times, and twice as much battery power. Everything is doubled, while the same end result is achieved. In addition, an empty return journey is a complete waste of time and an inefficient use of the drone. To improve the quality of life in cities and effectively apply the concept of the first and last mile, it is essential to develop an alternative to unmanned aerial vehicles (UAVs) for the transport of small loads. UAVs speed up the delivery time of small goods and reduce the costs incurred during delivery using conventional freight vehicles.

The delivery times for parcels via unmanned aerial vehicles (UAVs) to mailboxes or parcel lockers can be influenced by various factors. The distance between the distribution centre or hub and the destination mailbox or parcel locker will affect the delivery time. Shorter distances generally result in quicker deliveries. Flight speed and efficiency in the UAVs' flight can impact the delivery times. Faster UAVs can cover distances more quickly, reducing the delivery times. The operational hours of a UAV delivery service will determine when the deliveries can take place. Deliveries may be limited to certain hours of the day, typically during daylight hours and in good weather conditions. Adverse weather conditions such as high winds, rain, or fog can affect UAV operations and cause delays in the deliveries. Compliance with airspace regulations and obtaining the necessary permissions or clearances can influence the delivery routes and timings. Delays may occur if airspace restrictions are in place or if there is congestion in the airspace. The size and weight of the parcels that can be carried by the UAVs will affect the delivery times. Larger or heavier parcels may require additional time for loading and unloading. UAVs' battery life and the need for recharging between deliveries can impact the delivery times. UAVs may need to recharge or swap batteries, which can add to the overall delivery time. The delivery times for parcels via UAVs to mailboxes or parcel lockers will vary depending on these factors and the specific policies and capabilities of the drone delivery service provider. Typically, drone delivery services aim to provide timely and efficient deliveries within a reasonable timeframe. It is important to emphasise that the "Regular updating of Google Maps" means that Google periodically refreshes the data and information available on Google Maps to ensure their accuracy and relevance. This includes updating map imagery, street views, business listings, road information, and other geographical data. The frequency of updates to Google Maps can vary depending on several factors, including satellite imagery, street view, user contributions, partnerships, and data providers. The frequency of these updates to satellite imagery can vary depending on the availability of new imagery from the satellite providers. In some areas, imagery may be updated annually or even more frequently, while, in other areas, updates may occur less frequently. Street-view imagery is updated periodically as Google sends out Street View vehicles to capture street-level images. The frequency of these updates depends on factors such as the popularity of the area, changes in the road infrastructure, and the available resources for data collection. Users can contribute to Google Maps by adding or editing information about places, businesses, roads, and other features. These contributions can help keep map data up to date between the official updates from Google. Google may have partnerships with other companies or data providers that contribute to these map updates. These updates may occur on a separate schedule from Google's own data collection efforts. The frequency of the updates to Google Maps can vary widely depending on the type of data being updated, the availability of new information, and other factors. Google aims to provide the most up-to-date and accurate mapping data possible to its users.

There is a model for a new combined system of delivering lightweight, small goods to newly installed self-service parcel terminals in cities. This method is perfectly suited for online orders. It would use maps, which are updated on a regular basis. By locating the address of the consignee, the system could automatically suggest the nearest self-service parcel terminal, thus ensuring the safest and fastest delivery of small shipments to the right consignee in urban areas. It would also allow for choosing one's preferred delivery time if the goods are to be received when the consignee is away and cannot claim their package immediately.

An application where customers could check the status of their parcels should be introduced, allowing the customer to access it on any smart device having an internet connection. Also, a website should be developed for the creation of orders for the transport of goods by unmanned aerial vehicles. This system would have shipment status updates and last-mile-tracking capabilities. The website would allow users to check the status of their shipments in real time, and automatically send emails and notifications at different stages of the delivery (see Figure 8).

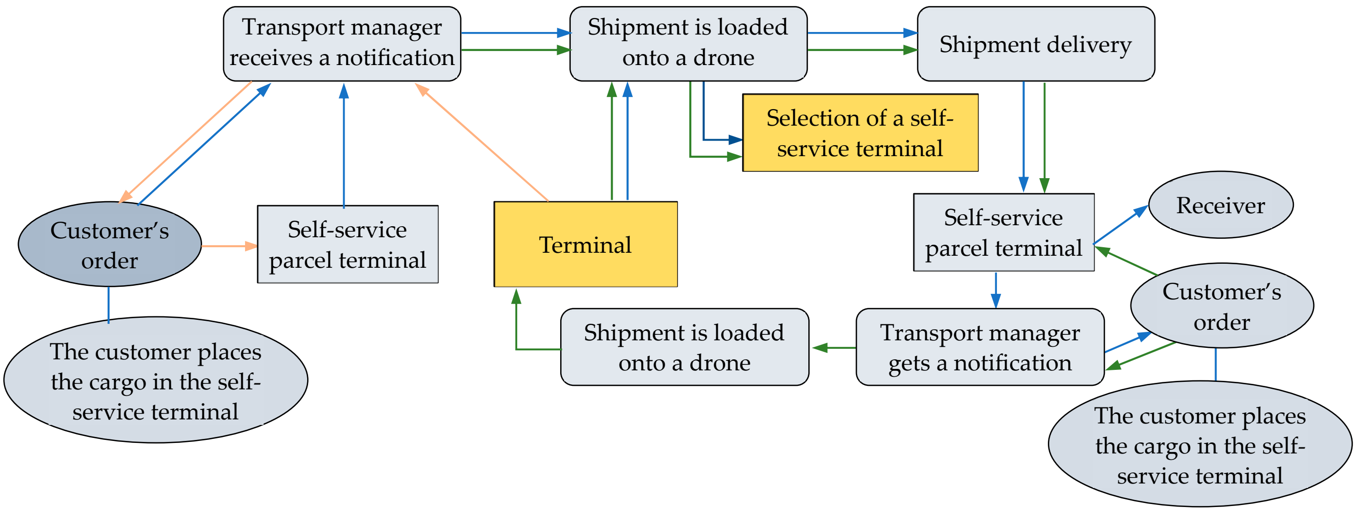

Figure 8. Model of the development of small-cargo flows using unmanned aerial vehicles in cities (compiled by the authors).

All shipments in this system would be delivered into a single terminal equipped for loading or unloading drones. Once an order has been placed online and the cargo has been received at the terminal, an unmanned aerial vehicle (UAV) with delivery authorisation will use the terminal's drone navigation systems and scanners to locate the shipment, pick it up, and deliver it to the selected location. It will also pick up the cargo from the self-service parcel terminal to be taken back to the loading terminal, thus ensuring the return or reshipment of shipments. This will make the use of UAVs more efficient, as self-service parcel terminals are designed not only for picking up small goods but also for sending them out. The aim of this system is to speed up the delivery of goods, make good use of the airspace, and reduce pollution and congestion in cities.

When an order is placed on the website, the customer will have to enter their details, such as full name, email address, mobile phone number, and delivery location. A PIN and a barcode will be generated and sent to the person having paced the order and the drone selected to deliver the order, specifically to the drone's smart information system. Orders can be placed online at home or at the selected self-service parcel terminal location using a touch-screen system. There shall also be a possibility to print out a barcode at the self-service parcel terminal to be attached to the parcel for the drone to recognise it. After placing a parcel into the self-service parcel terminal, the order-processing department will receive the information on the system and, once everything has been planned, instruct the UAV to transport the parcel to the warehouse. This system is a comprehensive UAV automation solution for the shipment of small cargo in the first- and last-mile transport stage.

Unmanned aerial vehicle (UAV) delivery refers to the transportation of cargo from point A to point B using unmanned aerial vehicles (UAVs). Such UAVs are either autonomous or remotely controlled by human pilots. The infrastructure that supports drone delivery operations requires the seamless integration of reliable drone hardware and software. All the shipments will be completed from the loading terminal to the selected self-service parcel terminal, or vice versa. If a shipment is forwarded further, a drone will pick up small cargo from the selected self-service parcel terminal and deliver it to the loading terminal from which the cargo will be loaded onto road vehicles for onward transportation.

4.2. Adaptation of Self-Service Parcel Terminals

The chosen drone will be able to carry up to 27 kg of cargo per flight. It will be able to automatically take off and land on smart self-service parcel terminals, which will be specially designed to load and unload small cargo automatically. *Dronedek* mail self-service parcel terminals will be used to this end. The self-service parcel terminals seamlessly integrate into automated processes, including sorting, scanning, and storing express mail, and will have high-tech features, such as facial recognition and ID scanning.

Dronedek mail self-service parcel terminals have a wide range of technical features, making them the most advanced on the market in terms of drone delivery capacity. These features include the following:

- Heated motorised doors;
- Soft platform to avoid damage to packaging;
- Lowering platform to increase packaging capacity;
- Climate control for food/beverage/pharmaceutical products;
- Letter slot for traditional mail;
- Biohazard and explosive detection sensor for reporting to emergency services;
- UV disinfection;
- Solar panel for power;
- Drone charging.

However, there are the issues of the maintenance costs and longevity. The average wear and tear of a drone is 10 years.

Safety. Emergencies such as flight system failure, bad weather, or other disasters can happen at any time. In addition to the standard drone fuses already installed in such an unmanned device, the FlytNow provides an emergency landing option. It is possible to set up selected landing points along a transport corridor and, in the event of a disaster, drop the drone at the nearest emergency point. The drone will also be equipped with advanced geo-fencing features, allowing to draw a polygon on the map along the delivery route to prevent drones from falling outside the specified area (no-fly zones).

To protect the drone in unavoidable situations, a safety parachute will be installed at the top of the drone to avoid accidents or loss of communication and allow safe landing without damaging expensive equipment and the drone itself.

Routes and transport corridors. To establish accurate transport corridors in the urban airspace, it will first be necessary to obtain authorisations for the transport of small goods in cities, as the transport of goods using unmanned aerial vehicles (UAVs) is strictly forbidden without the approval of the Federal Aviation Administration. Anyone flying a drone is responsible for flying in accordance with FAA guidelines and regulations. This means that, as a drone pilot, one needs to know the rules of the sky and where it is and is not safe to fly. Also, the above regulations also provide information on airspace restrictions, especially around airports, so that drones do not pose a danger to people or other aircraft. FAA-Recognized Identification Areas (FRIAs) are defined geographic areas where drones can be flown without remote ID equipment. The FAA provides a free digital toolkit of outreach materials to federal, state, and other partners to inform drone operators that flying in certain areas is prohibited. In order to establish precise transport corridors in the Vilnius airspace, it will first be necessary to obtain permits to transport small goods in the city, as it is strictly forbidden to transport goods using unmanned aerial vehicles (UAVs) without the approval of the Federal Aviation Administration. As far as conventional UAV operations are concerned, the project will start on a small scale and will be developed further. There will be three initial routes, where the drone takes off from the terminal to the post office and then returns back, which would mean returning along the same corridor. Deliveries will be made, when the route is clear, only during the day for now, but, if there is demand, we could consider the possibility of delivering small goods at night. This is technically viable but would require enhanced security systems and aviation approval. The battery endurance of the chosen drone is sufficiently high compared to the size of the Vilnius urban area, so waiting for permission to land or take off should not be a problem. With an initial fleet of three UAVs, the maximum capacity of the system will only be limited by the capacity of the lockers. There are currently two dispatch points, with 32 lockers each.

In the drone delivery system, drones will not travel using the current road route maps. UAVs need a different route and an air corridor that will bypass no-fly zones and tall buildings and reach an existing post office as quickly as possible. The drones will be provided with continuously updated maps, and these will be incorporated into the airspace. They will fly over buildings, and the shortest regulated air corridor will be created in agreement with the Lithuanian Transport Safety Administration.

The drones will be programmed to automatically transport cargo along the existing air corridor. Designating drone terminals involves clear signage and markings to indicate their purpose and areas of operation, making it easy for operators to identify authorised areas while adhering to safety regulations and operational guideline. Indeed, drone terminals are often labelled with signs or symbols such as "Drone Landing Zone" or "UAV Operations Area", clearly identifying the specific locations assigned to drone activities. Yellow markings typically denote the primary landing and take-off areas for drones within the terminal. These areas serve as designated zones for launching and recovering drones safely.

Navigation on the user's side is tracked by a map provided by the delivery system, to be followed by the drone like any other tracking system, except that the route is by air instead of on the ground. In any case, the drone's algorithm detects barriers and obstacles, manages its path, and sets it in such a way as to reach the user, while a trained professional located at the terminal monitors the drone's journey in real time.

As the drones will be operating over public airspace, security is taken very seriously, so the only take-off and landing points are at the top of the post office, self-service parcel terminal stations, and loading terminals. The drones will also fly along pre-defined "air corridors" between the parcel stations, which will be chosen to pose the least risk to the people below, including flying over covered walkways. The air corridors are designed so that we know who is in the route area, and the altitude is such that we can adequately separate the drones from known obstacles. Since drones are equipped with a safety system, it will always be able to deviate slightly from a straight path during the journey to avoid obstacles and ensure safety.

As mentioned above, based on the results of the literature analysis, the main aspects of UAV freight transport were defined, the problems of the development of small freight flows were identified, the first- and last-mile characteristics were analysed, and a model for the development of small freight flows in urban areas using UAVs was developed on the basis of the results of the expert survey method. It was then submitted to the same experts for evaluation.

In order to test the applicability of the model, new questions were prepared for the experts previously interviewed on how to reduce the problems of small goods' transport in urban logistics, how to solve the problem of security, and how to integrate terminals, post offices, and UAVs. The answers of the experts were positive, but some potential glitches in the implementation of the model were identified. The experts identified that the main bottleneck during deployment would be the adoption of a new mode of transport by the people living in these urban areas. As UAV transport is relatively rare, people are not immediately receptive to innovation. The deployment of this model could take from months to years, depending on the public's attitudes and government restrictions. The experts also stressed that the model requires new government regulations and legal aspects.

Experts' observations and suggestions for improving the model. As road transport is the most polluting mode of transport, the experts suggested that, instead of using the existing warehouse, a completely new terminal should be built to accommodate different modes of transport. This would further reduce transport costs and slowly achieve the European Union's ambition of combining transport modes in the future.

In summary, the use of unmanned aerial vehicles (UAVs) with the highest level of intelligence, automation, safety, and reliability would enable this delivery method to overcome the difficult road conditions and traffic congestion common in urban areas. Offering UAVs for the urban delivery of small goods as an innovative logistics solution would lead to the exploration of new routes. In a large and growing market, where more efficient first- and last-mile delivery are important, a new combined UAV system with postal machines could be the future solution for the faster and more sustainable delivery of small parcels to the end user.

5. Conclusions and Recommendations

1. The conducted analysis of the scientific literature showed that predicting the future of the development of UAVs and the effectiveness of this technology in the transport sector for first- or last-mile deliveries is a difficult task. The future market situation and the development of drones will depend on the improvement of UAVs, the readiness of society to accept this new mode of transport, and the cost-effectiveness of them in a certain region for a certain function.
2. Society's acceptance of drones and their regulation were identified as the key barriers to the development and integration of UAVs in the transport sector. The accommodation of such cargo flows requires a reliable airspace management system and new legal regulations to support the commercial delivery of cargo using drones.
3. The research conducted through the application of the expert survey method identified key factors related to improving urban sustainability and reducing environmental pollution and social impacts. The main and most commonly used modes of delivery of small goods were courier services and distribution. The security of people and that of personal information were identified as the key reasons for the relatively slow development of the transportation of small goods by UAVs. The research results also highlighted the advantages of UAVs in terms of their ability to reduce environmental pollution and their speed.
4. During the expert study, the application possibilities of drones in logistics were evaluated, and a model was created that would meet certain legal regulations, people's needs, and society's preferences, which would allow to increase the flow of small-cargo transportation with the help of drones.

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References

1. Brunelli, M.; Ditta, C.C.; Postorino, M.N. SP surveys to estimate Airport Shuttle demand in an Urban Air Mobility context. Transp. *Policy* **2023**, *141*, 129–139. [CrossRef]
2. Cacchiani, V.; Malandri, C.; Mantecchini, L.; Paganelli, F. A study on the optimal aircraft location for human organ transportation activities. *Transp. Res. Proc.* **2018**, *30*, 314–323. [CrossRef]
3. Stolaroff, J.K.; Samaras, C.; O'Neill, E.R.; Lubers, A.; Mitchell, A.S.; Ceperley, D. Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. *Nat. Commun.* **2018**, *9*, 409. [CrossRef]
4. Multidisciplinary Perspectives, Powered by Technology-Uncovering, Untangling and Understanding the World. 2018. Available online: https://www.pwc.com/gx/en/the-new-equation.html?WT.mc_id=CT3-PL300-DM1-TR2-LS4-ND30-TTA9-CN_the-new-equation-tne&gclid=EAIaIQobChMIjNLH0unwgwMVlpaDBx0PMwG7EAAYASAAEgI1W_D_BwE&gclsrc=aw.ds (accessed on 18 September 2023).
5. Amazon and Alibaba Are Pacesetters of the Next Supply-Chain Revolution. Retrieved 7 August 2019, from the Economist. 11 July 2019. Available online: www.economist.com/special-report/2019/07/11/amazon-and-alibaba-are-pacesetters-of-the-next-supply-chain-revolution (accessed on 20 September 2023).
6. Joerss, M.; Schröder, J.; Neuhaus, F.; Klink, C.; Mann, F. *Parcel Delivery: The Future of Last Mile*; McKinsey@Company: Chicago, IL, USA, 2016.
7. Russell, J. China's JD.com Tests Drone Delivery in Indonesia in rst Overseas Pilot. Retrieved from TC Join TechCrunch+. 22 January 2019. Available online: https://techcrunch.com/2019/01/22/jd-drone-indonesia/ (accessed on 18 September 2023).

8. Kellermann, R.; Biehle, T.; Fischer, L. Drones for parcel and passenger transportation: A literature review. *TRIP* **2020**, *4*, 100088. [CrossRef]
9. Kaszubowski, D. A Method for the Evaluation of Urban Freight Transport Models as a Tool for Improving the Delivery of Sustainable Urban Transport Policy. *Sustainability* **2019**, *11*, 1535. [CrossRef]
10. Qian, B.; Zhang, N. Topology and Robustness of Weighted Air Transport Networks in Multi-Airport Region. *Sustainability* **2022**, *14*, 6832. [CrossRef]
11. Patil, R.A.; Patange, A.D.; Pardeshi, S.S. International Transportation Mode Selection through Total Logistics Cost-Based Intelligent Approach. *Logistics* **2023**, *7*, 60. [CrossRef]
12. Comi, A.; Delle Site, P.; Filippi, F.; Nuzzolo, A. Urban Freight Transport Demand Modelling: A State of the Art. *Eur. Transp. Trasp. Eur.* **2012**, *51*, 1–8; ISTIEE, Institute for the Study of Transport within the European Economic Integration. Available online: https://www.researchgate.net/publication/227580431_Urban_Freight_Transport_Demand_Modelling_a_State_of_the_Art (accessed on 20 April 2024).
13. Comi, A.; Persia, L.; Campagna, A.; Polimeni, A. Revealing urban goods movements: Empirical evidences from some European cities. *Transp. Res. Procedia* **2018**, *30*, 275–284. [CrossRef]
14. Nuzzolo, A.; Crisalli, U.; Comi, A. A trip chain order model for simulating urban freight restocking. *Eur. Transp. Trasp. Eur.* **2012**, *50*, 1–7; ISTIEE, Institute for the Study of Transport within the European Economic Integration. Available online: https://www.openstarts.units.it/server/api/core/bitstreams/fc530374-5e23-4723-9acb-9e5a8dc96c72/content (accessed on 20 April 2024).
15. Nuzzolo, A.; Persia, L.; Polimeni, A. Agent-Based Simulation of urban goods distribution: A literature review. *Transp. Res. Procedia* **2018**, *30*, 33–42. [CrossRef]
16. Nuzzolo, A.; Crisalli, U.; Comi, A. A System of Models for the Simulation of Urban Freight Restocking Tours. *Procedia-Soc. Behav. Sci.* **2012**, *39*, 664–676. [CrossRef]
17. de Rus, G.; Socorro, M.P. Pricing and investment in alternative transport infrastructures. *Transp. Res. Part A* **2019**, *119*, 96–107. [CrossRef]
18. Kupfer, F.; Meersman, H.; Onghena, E.; Van de Voorde, E. The underlying drivers and future development of air cargo. *JATM* **2017**, *61*, 6–14. [CrossRef]
19. Miyoshi, C.; Fukui, H. Measuring the rebound effects in air transport: The impact of jet fuel prices and air carriers' fuel efficiency improvement of the European airlines. *Transp. Res. Part A* **2018**, *112*, 71–84. [CrossRef]
20. Ribeiro, S.K.; Kobayashi, S.; Beuthe, M.; Gasca, J.; Greene, D.; Lee, D.S.; Muromachi, Y.; Newton, P.J.; Plotkin, S.; Sperling, D.; et al. Transport and its infrastructure. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; Retrieved from UC Davis. Institute of Transportation Studies; Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A., Eds.; Cambridge University Press: Cambridge, UK, 2007.
21. Abramesko, V.; Tartakovsky, L. Ultrafine particle air pollution inside diesel-propelled passenger trains. *Environ. Pollut.* **2017**, *226*, 288–296. [CrossRef] [PubMed]
22. Hammoudeh, S.; Nguyen, D.K.; Sousa, R.M. What explain the short-term dynamics of the prices of CO_2 emissions? *Energy Econ.* **2014**, *46*, 122–135. [CrossRef]
23. Autonomous Aerial Logistics, No Runways Required. Available online: https://www.elroyair.com/ (accessed on 20 April 2024).
24. Yoo, W.; Yu, E.; Jung, J. Drone delivery: Factors affecting the public's attitude and intention to adopt. *Telemat. Inform.* **2018**, *35*, 1687–1700. [CrossRef]
25. Perboli, G.; Rosano, M. Parcel delivery in urban areas: Opportunities and threats for the mix of traditional and green business models. *Transp. Res. Part C* **2019**, *99*, 19–36. [CrossRef]
26. Doole, M.; Ellerbroek, J.; Hoekstra, J. Estimation of traffic density from drone-based delivery in very low level urban airspace. *JATM* **2020**, *88*, 101862. [CrossRef]
27. de Lange, M.; Gordijn, H.; Derriks, H.; Gelauff, G. Drones in Het Personenen Goederenvervoer. Kennisinstituut Voor Mobiliteitsbeleid (KiM) Ministerie van Infrastructuur en Milieu. 2017. Available online: https://www.kimnet.nl/publicaties/rapporten/2017/09/26/drones-in-het-personen---en-goederenvervoer (accessed on 20 April 2024).
28. Perera, S.; Dawande, M.; Janakiraman, G.; Mookerjee, V. Retail Deliveries by Drones: How Will Logistics Networks Change? *Prod. Oper. Manag.* **2020**, *29*, 2019–2034. [CrossRef]
29. Figliozzi, M. Carbon emissions reductions in last mile and grocery deliveries utilizing air and ground autonomous vehicles. *Transp. Res. Part D* **2020**, *85*, 102443. [CrossRef] [PubMed]
30. Elsayed, M.; Mohamed, M. The impact of airspace regulations on unmanned aerial vehicles in last-mile operation. *Transp. Res. Part D* **2020**, *87*, 102480. [CrossRef]
31. Beard, R.W.; McLain, T.W. *Small Unmanned Aircraft: Theory and Practice*; Princeton University Press: Princeton, NJ, USA, 2012.
32. Giones, F.; Brem, A. From toys to tools: The co-evolution of technological and entrepreneurial developments in the drone industry. *Bus. Horiz.* **2017**, *60*, 875–884.
33. Layne, N. Exclusive: Wal-Mart Seeks to Test Drones for Home Delivery, Pickup. Retrieved from the Reuters. 26 October 2015. Available online: https://www.reuters.com/article/us-wal-mart-stores-drones-exclusive/exclusive-wal-mart-seeks-to-test-drones-for-home-delivery-pickupidUSKCN0SK2IQ20151027 (accessed on 25 May 2023).
34. Patel, P. Agriculture drones are finally cleared for takeoff [News]. *IEEE Spectr.* **2016**, *53*, 13–14. [CrossRef]

35. Wang, D. The Economics of Drone Delivery. Retrieved from IEEE Spectrum. 5 January 2016. Available online: https://spectrum.ieee.org/automaton/robotics/drones/the-economics-of-drone-delivery (accessed on 15 November 2023).
36. Goodchild, A.; Toy, J. Delivery by drone: An evaluation of unmanned aerial vehicle technology in reducing CO_2 emissions in the delivery service industry. *Transp. Res. Part D* **2018**, *61*, 58–67. [CrossRef]
37. Chauhan, D.; Unnikrishnan, A.; Figliozzi, M. Maximum coverage capacitated facility location problem with range constrained drones. *Transp. Res. Part C* **2019**, *99*, 1–18. [CrossRef]
38. Poikonen, S.; Wang, X.; Golden, B. The vehicle routing problem with drones: Extended models and connections. *Networks* **2017**, *70*, 34–43. [CrossRef]
39. Bowes, P. Parcel Shipping Index: News and Highlights. Retrieved from Pitney Bowes Inc. 28 August 2018. Available online: http://www.investorrelations.pitneybowes.com/news-releases/news-release-details/pitney-bowes-parcel-shipping-index-reports-global-parcel (accessed on 15 November 2023).
40. Mckinnon, A. The possible impact of 3D printing and drones on last-mile logistics: An exploratory study. *EBE* **2016**, *42*, 617–629. [CrossRef]
41. Raj, A.; Sah, B. Analyzing critical success factors for implementation of drones in the logistics sector using grey-DEMATEL based approach. *Comput. Ind. Eng.* **2019**, *138*, 106118. [CrossRef]
42. Sah, B.; Gupta, R. Bani-Hani, D. Analysis of barriers to implement drone logistics. *Int. J. Logist. Res. Appl.* **2021**, *24*, 531–550. [CrossRef]
43. Lineberger, R.; Hussain, A.; Metcalfe, M.; Rutgers, V. Infrastructure Barriers to the Elevated Future of Mobility Are Cities Ready with the Infrastructure Needed for Urban Air Transportation? 2019. Available online: https://www2.deloitte.com/content/dam/insights/us/articles/5103_Infrastructure-barriers-to-elevated-FOM/DI_Infrastructure-barriers-to-elevated-FOM.pdf (accessed on 20 April 2024).
44. Lewandowski, K. Sustainable Usage of Freight Drones in City Centers, Proposition of Regulations for Safe Usage of Drones. *Sustainability* **2021**, *13*, 8634. [CrossRef]
45. Murray, C.C.; Chu, A.G. The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery. *Transp. Res. Part C* **2015**, *54*, 86–109. [CrossRef]
46. Hong, I.; Kuby, M.; Murray, A.T. A range-restricted recharging station coverage model for drone delivery service planning. *Transp. Res. Part C* **2018**, *90*, 198–212. [CrossRef]
47. Heutger, M.; Kückelhaus, M. *Unmanned Aerial Vehicles in Logistics. A DHL Perspective on Implications and Use Cases for the Lo-Gistics Industry. DHL Troisdorf, Germany: Customer Solutions & Innovation*; Marketing & Development, DHL CSI: Troisdorf, Germany.
48. Clothier, R.A.; Greer, D.A.; Greer, D.G.; Mehta, A.M. Risk Perception and the Public Acceptance of Drones. *Risk Anal.* **2015**, *35*, 1167–1183. [CrossRef] [PubMed]
49. Petchesi, I. Eionet Report. Analysis of Changes on Noise Exposure 2007-2012-2017. Spain: ETC/ACM. Retrieved Iulian Petchesi. Eionet Report-ETC/ACM 2018/14 cover Prepared by: ETC/ACM Consortium Partner Member Jaume Fons-Esteve (UAB, Spain) Published by: ETC/ACM. 28 November 2018. Available online: https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atnireports/eionet_rep_etcacm_2018_14_noiseexposuretrends2007-2017 (accessed on 20 April 2024).
50. Neumann, W.; Ericsson, G.; Dettki, H.; Bunnefeld, N.; Keuler, N.S.; Helmers, D.P.; Radeloff, V.C. Difference in spatiotemporal patterns of wildlife road-crossings and wildlife-vehicle collisions. *Biol. Conserv.* **2012**, *145*, 70–78. [CrossRef]
51. Mulero-Pázmány, M.; Jenni-Eiermann, S.; Strebel, N.; Sattler, T.; Negro, J.J.; Tablado, Z. Unmanned aircraft systems as a new source of disturbance for wildlife: A systematic review. *PLoS ONE* **2017**, *12*, e0178448. [CrossRef]
52. Kardelis, K. Research Methodology and Methods [Mokslinių tyrimų metodologija ir metodai]. Šiauliai. 2002. Available online: https://www.scribd.com/doc/37948910/K-Kardelis-Mokslini%C5%B3-tyrim%C5%B3-metodologija-ir-metodai (accessed on 20 April 2024).
53. Kendall, M.G. *Rank Correlation Methods*; Hofner Publishing House: New York, NY, USA, 1955.

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