7 (2): 251-261 (2023)

Journal of Aviation

https://dergipark.org.tr/en/pub/jav

e-ISSN 2587-1676

Drone Technology in Transportation Management: A Systematic Review and Framework for Future Research

Muhammed Turgut[1*], Bilal Şeker[2]

[1*]Tarsus University, Customs Management Department, 33400, Tarsus, Mersin, Türkiye. (muhammedturgut@tarsus.edu.tr)
[2] Ford Otosan A.Ş., Order Planning & Inventory Management Department, Gebze, Kocaeli, Türkiye. (bilalseker41@gmail.com)

Article Info

Received: 05 April 2023
Revised: 26 April 2023
Accepted: 05 May 2023
Published Online: 09 July 2023

Keywords:
Drone in Delivery
Drone in Logistics
Drone in Transportation
Drone Technology

Corresponding Author: *Muhammed Turgut*

RESEARCH ARTICLE

https://doi.org/10.30518/jav.1277694

Abstract

This study examines the current state of the drone technology literature in detail, both academically and industrially. It describes the advantages and disadvantages of drones in the use of logistics activities, the methods used in the studies and the gaps in the literature. In addition, this study aims to reveal the academic efforts about drone-based transportation systems that will have a say in the future and which areas require effort in the future. In this article, a systematic literature review (SLR) about the use of drones in the transportation industry has been carried out. In total, 56 articles published in Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Xplore and ScienceDirect (Elsevier) databases were examined in detail. The findings show that the use of drones in transportation activities is an effective method. However, the fact that it is a technology that has just been integrated into business processes reveals that there are aspects that need to be developed. Especially in the last ten years, they found that businesses have benefited from drone technology in their transportation activities that increased their last mile delivery speed, efficiency, accessibility and customer satisfaction.

1. Introduction

Logistics has become one of the indispensable elements of modern economies (Patchou et al., 2019). It is possible to perform an effective and efficient operation by adapting the developing technologies to logistics. In the age of technology, the logistics industry continues to grow rapidly. The rapid increase in demand in the e-commerce industry and the desire of consumers to receive their products as soon as possible pushed businesses to seek new delivery methods (Merkert and Bushell, 2020). Increasing logistics demand can only be realized with fast, convenient, modern and automated logistics operations (Lai et al., 2020). Unmanned aerial vehicles (UAVs) are being used more frequently by both the military and the civilian sector as a result of technological advancements and falling costs (Thiels et al., 2015). Unmanned aerial vehicles are employed extensively in the military, although their application in civil activities is still in its infancy (Kuru et al., 2019). Unmanned aerial vehicles, or UAVs, commonly known as "drones," are acknowledged as a prevalent future means of transportation for a variety of applications in the logistics sector (Javadi and Winkenbach, 2021). Drones and unmanned aerial vehicles have shown promise as a supply chain and logistics option (Merkert and Bushell, 2020). Unmanned aerial vehicles (UAVs) called drones are autonomous flying machines (Rabta et al., 2018). The fact that it has a high delivery speed compared to traditional logistics (Thiels et al., 2015) and that there is no need for a physical infrastructure (Foth, 2017) makes the drone-based logistics system advantageous. Additionally, it supports green logistics and is more eco-friendly than truck delivery. These distinctive characteristics of drone logistics offer benefits for drone logistics distribution. Many businesses such as Amazon, Wal-Mart, Google, UPS, 7-Eleven and Domino have tested and started to operate drones for the delivery of small packages (Lai et al., 2020).

Unmanned aerial vehicles' speed, flight capabilities, and autonomous operations enable businesses to respond quickly and efficiently (Rejeb et al., 2020). Numerous logistics processes are optimized with the help of drones, resulting in advantages in terms of speed and cost in supply chains for operations including warehousing, inventory management, transportation, and route planning (Shavarani et al., 2018). Despite the fact that the specifics of drone-based delivery operations are still being worked out and are subject to future government regulations, they differ significantly from conventional truck-based delivery operations (Chen et al. 2021).

It is expected that drone-based logistics systems, which have started to have an impact on designs and operations, will directly affect operations and planning in the future. Academic study on a variety of features of drone-based logistics systems is being done (Javadi and Winkenbach,

2021). In this study, we seek answers to the following research question:

What are the studies on drone logistics?

What are the advantages and challenges in drone logistics?

What theories and techniques have been employed in current research?

What inferences have been drawn from existing research?

What are the gaps in the literature on drone logistics?

For this purpose, we make the following contributions in our work. First, we classify the existing literature by conducting an extensive literature review on unmanned aerial vehicles. Secondly, we identify the advantages and disadvantages by reviewing and synthesizing the literature. Third, we identify the methods and theories used in the existing literature to guide those who will study in this field. As a result of the determinations made, we identify gaps in the literature. Considering these contributions, this study reveals the academic efforts about drone-based logistics systems that will have a say in the future and which areas require effort in the future.

2. Drone Technology in Transportation Management

Logistics activities, which have been constantly developing and changing from the past to the present, have left behind important milestones (Bonsor, 2018). One of these touchstones is drone transportation, which has emerged with the latest technology. Drones, also known as unmanned aerial vehicles, are already being used by some supply chain firms to do a variety of labor-intensive operations that are time-consuming, expensive, and high-efficiency.

The whole structure of the international air transportation and freight transport industry, especially in private delivery and warehousing, has been significantly impacted by the globalization of the world economy and its accompanying activities (Tumenbatur and Tanyas, 2021). With this, freight forwarder companies meet customer demands for delivery of goods, especially in terms of comprehensive services, delivery management, shipment processing, formalities, cargo picking and consolidation, etc. They significantly expanded the range of services on these issues (Marintseva et al., 2019). Businesses are implementing cutting-edge techniques to increase responsiveness and efficiency in the logistics sector. Drone use in logistics-related transportation tasks is a significant step in this direction (Sah et al., 2021).

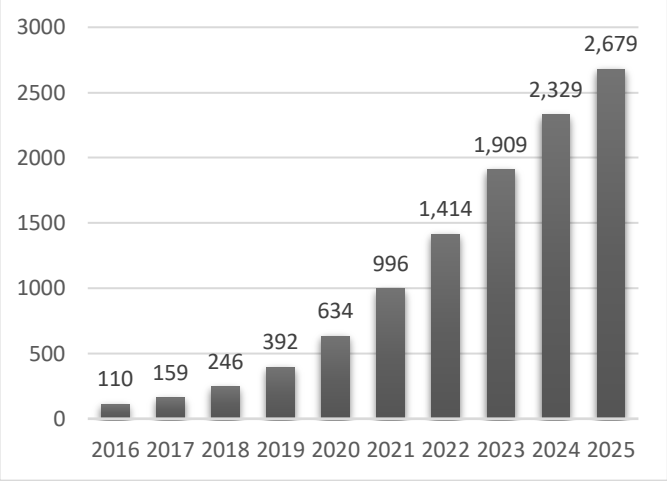

Figure 1. Projected Sales Units (Thousands) for Commercial Drones (Statista, 2019).

Figure 1 clearly shows that Dorne sales have increased significantly over the years. There are many reasons and developments that support this increase. Drone technology emerges as one of the important innovations of distribution operations in commercial activities (He, 2020). It is predicted that drones will be able to replace traditional operation methods in many commercial activities in the next 5 years, both in developing drone technologies and the rapid expansion in the diversity of their fields of activity. It is assumed that these developments will have a positive impact on drone sales. With less human operations and security infrastructure, drones significantly reduce work time and costs. They also contribute to the development of data analytics that enable companies to better understand and predict business performance (Garg, 2021). E-commerce companies have seen considerable growth in the number of daily parcels that need to be delivered in recent years, particularly in the number of exacting client expectations. In this aspect, the distribution method has significantly increased in cost, especially for the final mile. Businesses have started looking for creative autonomous delivery options for the final kilometer in order to stay competitive and keep up with expanding demand, such as autonomous drones/drones, which are a promising alternative for the logistics sector. Drone delivery systems have started to take off as a new way to lower delivery costs and delivery times in response to the success of drones in surveillance and remote sensing. In the upcoming years, it is anticipated that autonomous drone sharing systems would be a necessary logistics solution for the sector (Benarbia and Kyamakya, 2021).

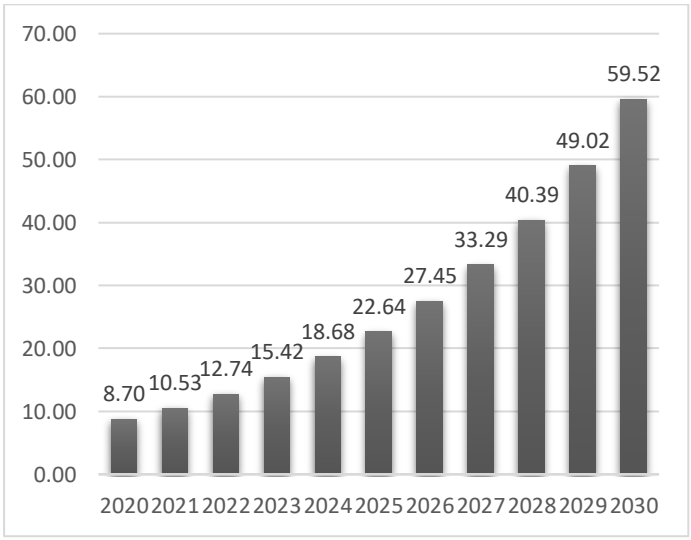

Figure 2. Market size of drone transport by years. (Precedence Research, 2020)

When the report on the market size of drone transport by the research organization Precedence Research, published in 2020, is examined, it is estimated that the industry, which has a market share of 12.7 billion dollars in 2022, will have a market size of close to 60 billion by 2030. Figure 2 clearly shows that the market size will increase rapidly every year and that this mode of transportation will be one of the leading transportation modes in the market in the future. On the other hand, milkrun drone transportations, may be a method of transport that is thought to be popular in the future and this may support to extend market size of Drone. Milk Run; It is a logistics system named after a milkman who delivers the milk

loaded in his vehicle to the distribution points and returns to the milk facility by collecting empty milk bottles from the same points on his return. In general terms, it is the supply of products by the manufacturer company from the suppliers at the specified points within the scope of a certain system, and the delivery of the supplied products to the facility of the manufacturer company. When moving to collect products again, it is to take the recycled packages or returns from the manufacturer and deliver them to the suppliers. Members of this cycle will not regulate transport operations but will be involved in the milk-run cycle and process.

One of the problems considered regarding drone transportation is the density of the drone's route point. The fact that the drone prototypes that will carry out the transportation process today are designed for single package delivery has created the need for a separate carrier drone for each shipment. It is predicted that this situation will negatively affect the drone traffic in the sky and the loss of time and energy that will occur on the routes where the drone visits. The most important solution proposal produced in the face of this problem is the idea of adapting the milk-run system to the drone transportation sector. This system, whose positive effects are undeniable in terms of economy, time and energy management; In the future, with the increase in drone carrying capacity and battery life, it is a realistic solution. System; It envisages that several packages to be delivered will be loaded onto the drone at once and distributed. However, there is no such drone or system plan among the transport drone prototypes created today.

3. Research Method

The purpose of this study, which aims to comprehend current trends and identify existing gaps in the scientific literature, was to apply a systematic literature review (SLR) as a research approach. In order to make an objective and valid evaluation, it is necessary to systematically examine the basis of a literature (Denyer & Tranfield, 2009; Gligor & Holcomb, 2012). A review is called “systematic” if it is based on clearly formulated questions, identifies relevant studies, evaluates the quality of studies, and summarizes methodology (Khan et al., 2003). Systematic studies use techniques to minimize biases and errors, as they cover published studies in a comprehensive manner. At the same time, they help to save time by providing information about the procedures and results of previous studies for the reviewers (Cook et al., 1997).

First, a preliminary list of keywords was determined. The initial list of search terms was not specified before to the search but instead developed during the course of the significant reading that was done while this study was being written. With this preliminary list, it was determined what other keywords that would reflect our work would be. (Table1) Related publications in the study published between 2016-2022 were found after a detailed online search to organize and synthesize. The titles and abstracts of the selected articles were reviewed. Articles outside the purview of the study were culled from the corpus after a thorough search among the authors. The main reason why 2016 was chosen as the starting year is that the concept of drone logistics is a phenomenon that emerged especially after Industry 4.0 technologies. It has become a concept that has received a lot of attention in the scientific literature since 2016. A literature review of the last six years provides a sufficiently comprehensive analysis of research in this area. As a result, over the past six years, the following significant online databases have been targeted: Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Xplore, and ScienceDirect (Elsevier). This research shows that the concept of drone logistics was accepted by academics and practitioners during the research and development years. In this study, we review and classify related studies to get an idea about drone logistics. After the necessary eliminations were made in the literature, 56 articles on drone logistics were taken into consideration. After examining each article, the articles were examined by classifying them according to topics and methodological approaches. This review's two major goals are to identify, classify, and summarize the present literature on drone use in logistics management as well as to pinpoint potential areas and avenues for further study.

Research Questions

The research questions we address in this study are:

RQ1: What studies have been done on drone logistics?

RQ2: What are the advantages and challenges in drone logistics?

RQ3: What theories and methods have been used in existing research?

RQ4: What conclusions have been drawn from existing research?

RQ5: What are the gaps in the literature on drone logistics?

Figure 3. Methodology Flow Chart

4. Studies on Drone Logistics

Within the scope of the study, Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Xplore, and ScienceDirect (Elsevier) were scanned and 56 studies were found and examined. The scope and contributions of these studies are given in the table below. Literature subject abbreviations are described as follows.

AI: Artificial Intelligence

UAVSC: Unmanned Aerial Vehicle Supply Chain

DSC: Drone Supply Chain Journal of Aviation.

Table 1. Literature Studies

References	Subject	Objective	Method	Contribution
Hua and Zhang	AI	In this study, a design for using drone technology combined with artificial intelligence in short-range deployments is proposed.	Modelling	With this study, artificial intelligence technology and drone technology are discussed from a macro perspective. It will help to increase the efficiency and lighten the human burden in short-distance transportation.
Fang & Hai	DSC	In this study, a model has been developed considering the constraints such as demand model, performance constraints, airspace constraints, load and durability of unmanned aerial vehicles.	Modelling	It contributes to the calculation of transportation costs in the use of UAVs in transportation.
Meincke and Geike	UAVSC	In this study, the use and potential of UAVs in cargo ground services are theoretically examined and simulated.	Simulation	A study that examines the importance of UAVs in air cargo supply chain processes and contributes to their use.
Varigonda et al.,	UAVSC	A multi-configuration unmanned aerial vehicle was created in this project to carry medical supplies.	Simulation	For the application of unmanned aerial vehicles in the medical field, a simulation was created.
Cvitanic	DSC	This study provides an overview of drone technology in transportation engineering problems with current drone transportation applications.	Literature Review	The use of drone technology in transportation activities has been examined, and its costs and benefits have been revealed.
Canetta et al.,	UAVSC	In this study, businesses providing services to the UAV industry in Switzerland were analyzed by MCDM method.	Modelling	The role of decision support systems in the use of UAVs has been examined.
Lai et al.,	DSC	In terms of national rules, technical safety, technical equipment, efficiency, risk prevention, and audience preference limits, this study assessed the demand from clients for drone logistics services.	Modelling	The Functional Distribution of Drone Logistics has been studied.
Troudi et al.,	DSC	This study addresses a problematic drone delivery package in an urban location.	Modelling	For the drone delivery fleet, a post-production analysis approach has been created.
Liu et al.,	DSC	This study focuses on truck and drone dual routing problem solving.	Modelling	Modeling is done for drone vehicle routing in low demand situations.
Olivares et al.,	DSC	This study proposes the use of a fleet of drones within a plastics manufacturing plant.	Modelling	A drone use model was developed during the transportation phase.
Das et al.,	UAVSC	This study proposes a new model that synchronizes drones and delivery trucks.	Modelling	A model has been developed that minimizes costs and maximizes customer service level.
Triche et al.,	UAVSC	This study investigated the usage of unmanned aerial vehicles in Malawi's healthcare operations.	Case Study	It highlights the effects of UAV use in the healthcare industry.
Iranmanesh et al.,	DSC	It suggests a path optimization algorithm for a data-carrying and -transmitting drone communication network.	Modelling	It has developed a new approach to smart transportation system and data communication.
Nyaaba and Ayamga	DSC	A systematic literature review of drone use in healthcare was conducted.	Literature Review	The study revealed the importance of drone use in medical interventions on the African continent.
Koshta et al.,	DSC	This study outlined the obstacles to the widespread use of delivery drones.	Modelling	It gives decision-makers and regulators a thorough insight to help open the door for the use of delivery drones.
Smith et al.,	DSC	In this study, the main problems in front of the public's use of drones were examined.	Survey	In this study, the perspective of societies on drone logistics has been evaluated and suggestions have been made in this regard.

Gonzalez-R et al.,	DSC	In this study, a network design was made using the mathematical model to expand the operating range of the drones. Suggestions were made for the installation of charging stations at suitable points in order not to interrupt the journeys of the drones and to meet their charging needs.	Modelling	A method has been developed to model the optimum installation points of charging stations.
Zhu et al.,	DSC	In the research, it is discussed that after an unexpected disaster, unmanned aerial vehicles (UAVs) deliver the necessary materials for first aid to the need demand points for humanitarian aid application.	Modelling	Ensuring the fastest distribution of medical supplies required for post-disaster first aid applications by using the assignment problem
Raj et al.,	DSC	This study seeks to identify these crucial success variables and the connections between them.	Modelling	Crucial success variables for drone use in logistics have been established
Mualla et al.,	DSC	In this study, the most used methodologies were revealed by using the ISO software quality model.	Modelling	Comparison of agent-based simulation methods in unmanned aerial vehicles
Ghelichi et al.,	DSC	The logistics routes of a drone fleet are optimized in this study to ensure the prompt delivery of medical supplies.	Modelling	Developing an optimum model by simulating the transportation of medical equipment to rural areas
Javadi et al.,	DSC	This article compares the delivery models using trucks and drones. A mathematical model has been developed to provide a synchronized timing and routing with the truck in the return of the drones sent for package delivery from the trucks.	Modelling	Truck and Drone Routing Algorithm (TDRA) is explained through two realistic case studies with created examples.
Chen et al.,	DSC	In this study, the policies to be implemented on how retailers should make the decisions they will encounter in drone-based delivery operations, when the drone delivery will be offered, which delivery capacity will be maintained and how much will be charged for these deliveries are emphasized.	Modelling	In order to find close to ideal closed form solutions, the paper develops a Markov decision process (MDP) framework and presents two heuristic methods.
Leon-Blanco et al.,	DSC	In the study, a model proposal that will support a minimum time loss by synchronizing a truck and more than one drone is emphasized.	Modelling	Synchronizing multiple drone movements with the truck is discussed.
Merkert et al.,	DSC	This study measured consumers' perceptions of drone delivery compared to traditional mail delivery.	Survey	It revealed the consumer view towards drone deliveries.
Mahroof et al.,	DSC	This study focuses on how to incorporate innovative solutions into agricultural supply chains, especially environmentally, economically, ethically and socially appropriate modes of transport.	Modelling	An efficiency-enhancing study on the use of drone transportation in the agricultural sector
Osakwe et al.,	DSC	A social and cognitive study on whether the utilize of drones in delivery processes will be accepted for end users in the coming years.	Literature Review	Consumer trends were examined in terms of drone use in shopping.
Merkert et al.,	DSC	In the study, which deals with the rapid spread of drone use and the negative effects of the uncontrolled growth of drone fleets, the importance of regulatory policies on this issue is highlighted.	Literature Review	Addressing threats and opportunities to enable the controlled proliferation of drone use in the future.
Chen et al.,	DSC	A study on establishing a relationship between base stations and drones	Literature Review	Integrating 5G and beyond technologies into drones by making use of base stations
Troudi et al.,	DSC	A VRP system is modeled to size and manage the drone fleet in logistics operations.	Modelling	Logistic Support Approach for Drone Delivery Fleet
Pan et al.,	DSC	In this study, a mixed uniform sampling approach called the Improved Compact Cuckoo Search Algorithm is used.	Modelling	Application of the Improved Compact Cuckoo Search Algorithm to Locate the Drone Logistics Center
Johannessen et al.,	DSC	In order to optimize the weight restrictions of flying and delivered loads in drones, several research based on tandem models and the traveling salesman problem are described in the study.	Modelling	A model is presented for drone transport of 6.5 million annual full analytical volume.
Erceg et al.,	DSC	Different examples of the worldwide use of drones in logistics are presented in the study. The problems are analyzed by giving examples of the legal regulation in Croatia.	Literature Review	Worldwide Legislation of Unmanned Aerial Vehicle Systems in Logistics and Examples of Their Use in Croatia

5. Advantages and Disadvantages of Drone Use

Compared to conventional delivery techniques, drone delivery has many benefits. It has many benefits, especially for last-mile deliveries where businesses must satisfy customer demand for quicker and less expensive delivery. Particularly in rural and distant places where delivery is challenging, drones offer a practical means to distribute goods. Like any technology, drone technology has many benefits. The literature studies of the advantages described in short articles below are shown in Table 2.

• It saves on distribution costs.1

• It paves the way for faster deliveries.

• It provides the opportunity to reach hard-to-reach areas.

• They lessen CO2 emissions and city traffic.

• It aids in maintaining inventory and warehouse movement under control.

• No shifts are necessary because the drone can work around-the-clock, every day of the year.

Table 2. Advantages of Using Drones in Logistics

Advantages	References
Drones use advanced navigation systems to determine routes in logistics operations. Authentication and advanced facial recognition systems for target delivery can also be integrated in their technologies. Its smart system determines the fastest and optimum route for delivery and also checks the degree of security of the delivery with weather controls. For these reasons, it is less costly than traditional logistics operations.	(Hau & Zhang, 2019)
It can be commissioned to carry out vital deliveries no matter what the terrain conditions.	(Varigonda & Others, 2021)
Drone use in transportation can improve delivery efficacy and efficiency while lowering fuel and labor costs. Additionally, it may result in a discernible decrease in greenhouse gas emissions.	(Pinto and Lagorio, 2022)
Drones have environmental benefits such as less air and noise pollution. Also, in Logistics, buying a fleet of drones is much cheaper than buying a fleet of traditional trucks.	(Raj and Sah, 2019)
Drones have benefits including moving faster in the air than on ground and getting around traffic in busy places.	(Mualla et al., 2021)
The most important benefits of drones are that they do not get stuck on road network boundaries, do not need pilots, are low cost and do not need a high level of infrastructure compared to traditional transportation vehicles.	Ghelichi and Others (2021)
Drones provide fast delivery for small/light packages. On the other hand, drone applications have provided a range of solutions, particularly for the rural distribution of medical supplies and emergency packages, where there is frequently underdeveloped road infrastructure in rural areas and limited availability of resources for infrastructure improvements.	(Javadi et al., 2021)
The use of drones in agriculture can create social benefits due to pesticide application and the support of waste with real-time data.	(Mahroof et al., 2021)
Drone deliveries offer the advantage of faster delivery and reduced complexity, as well as reduced privacy risks.	(Osakwe et al., 2022)
In the construction industry, drones are used for city and construction planning. This is less costly than using a conventional aircraft.	(Merkert and Bushell, 2020)
Drones can fly great distances, delivering life-saving medical supplies to people in hard-to-reach communities. This technology can be used to deliver goods to villages where visits by health workers are not regular and are less frequented for delivery. Another important advantage of drones is their energy consumption. Small UAVs powered by batteries consume much less energy than other means of transport.	(Garg, 2021)
As they are not affected by external factors such as traffic jams, drones also offer the flexibility needed to deliver where and when customers want.	(Yoo et al., 2018).
By using drone sharing networks for end-user delivery, emissions and the consumption of fossil fuels are reduced.	(Benarbia ve Kyamakya, 2021)
In B2C activities, drone technology has shortened delivery times compared to traditional methods and increased efficiency by reducing unsuccessful delivery rates.	(Mangiaracina et al., 2019)

In Table 2, many scientific studies expressing the added value created by the use of drones are shared. When the studies are examined, it can be said that the most important advantage of drones is that there is no need for pilots, they are less costly, they offer fast transportation, effective and efficient operations, and less infrastructure needs compared to traditional transportation vehicles. Additionally, one of the key benefits of drone technology is its support to the usage of low-carbon fuels and emissions reduction. Drone delivery systems face challenges in terms of development and success, just like many other sectors that are implementing new technologies. These obstacles include logistical, technological, and security concerns as well as legal ones. The information on the disadvantages of using drones is shown in Table 3 below.

Table 3. Disadvantages of Using Drones in Logistics

Disadvantages	References
Since it is a new technology, service network, return load planning, the absence of waiting stations during the new load plan appear as important questions at present.	(Hau & Zhang, 2019)
The limited flight distance and capacities are among the most important obstacles in drone transportation.	(Dorling et al., 2016)
Climate conditions, especially stormy weather conditions, can prevent drones from working.	(Varigonda et al., 2021)
Drones have high energy consumption and limited energy capacity.	(Mualla et al., 2021)
Drones typically cannot carry large and irregularly sized packages	(Javadi et al., 2021)
Lack of a safe place to drop packages at delivery points.	(Merkert et al., 2022)

In Table 3, the disadvantages in scientific studies with drone logistics are given. Despite tremendous attempts to advance drone delivery technology, there are still significant obstacles to drone delivery. These obstacles include the payload of drones, restricted flight range, bureaucratic procedures, and legal restrictions. Other important disadvantages are that the return load planning, service network and waiting station infrastructure have not been matured yet.

6. Theories and Methods Used in Current Studies

In this part of the study, the theories and methods used in the literature on the use of drones in logistics are discussed in detail. A total of 56 studies were reviewed from Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Xplore, and ScienceDirect (Elsevier) at the beginning of the study. In the continuation of the study, 33 articles were used among these articles that were thought to contribute to the study. Considered in the examinations, (Hua and Zhang, 2019) optimized the logistics processes by using artificial intelligence technology and drone technology in their study. In their study, (Fang and Hai, 2020) calculated the demand and costs in the last mile distribution using the Dynamic Allocation Algorithm method. (Meincke and Geike, 2018) analyzed the use of unmanned cargo planes in air cargo processes through simulation. According to (Varigonda et al., 2021) simulated the design, emulation, manufacturing and finally testing of UAVs that can land and take off without the need for a runway. In the study of (Canetta et al., 2017), they performed their analysis using the AHP technique, which is one of the multi-criteria decision-making methods. (Lai et al., 2020) analyzed customer demands using the KANO model. (Liu and Other, 2018) developed a drone truck routing model in their study. (Olivares et al., 2017) tried to solve the problem of routing the drone fleet using various heuristics and simulation. (Das et al., 2020) used Collaborative Pareto Ant Colony Optimization algorithm and Non-dominated Sorting Genetic Algorithm II (NSGA-II) methods in their study. (Triche et al., 2020) conducted a case study in their study. (Iranmanesh et al., 2019) used the Weighted Flight Path Planning algorithm in their study. (Nyaaba and Ayamga, 2021) examined the use of drones in medical activities in Africa using a systematic literature review. (Koshta et al., 2022) tried to identify obstacles by using the Gray Decision-Making Trial and Evaluation Laboratory technique in their study. (Smith et al., 2022) tried to determine the public's perception of drones and obstacles by using the survey method. In their study, (Gonzalez-R et al., 2020) used simulated annealing (SA) algorithm with an intuitive approach. (Pinto et al., 2022) utilizes a mathematical model and a heuristic technique to solve a network design issue that combines two infrastructure investment goals. (Zhu et al., 2020) analyzed the structure of risk belief systems using the network analysis method. (Raj and Sah, 2019) used the DEMATEL method, which is a multi-criteria decision-making technique combined with a gray-based approach. (Ghelichi et al., 2022) presented an optimization-based approach for the prompt distribution of assistance supplies to disaster-affected regions by A Chance Constrained Programming and Sample Average Approximation methods. (Javadi et al., 2021) presented a mathematical model and heuristic approach using Mixed-Integer Linear Programming and Truck and Drone Routing Algorithm. (Merkert et al., 2022) measured consumers' perceptions of drone delivery using the survey method. (Chen et al., 2021) developed a Markov decision process (MDP) and presented a near-optimal decision-making process with two heuristic solution approaches. (Leon-Blanco et al., 2022) developed a new agent-based system using the Truck-multi-Drone Team Logistics Problem (TmDTL) method in their study. (Mahroof et al., 2021) modeled and analyzed it using Interpretive structural modeling (ISM) methodology to help uncover 12 agricultural challenges that hinder its movement within the supply chain. In the study of (Troudi et al., 2017), it was seen that a VRP system was modeled to size and manage the drone fleet in logistics operations. In the study by (Pan et al., 2020), ın order to find a drone logistics hub, the Improved Compact Cuckoo Search Algorithm using mixed uniform sampling technology was used. In the study of (Johannessen et al., 2021), dual models and multiple studies based on the traveling salesman problem were discussed in order to optimize the weight limits of flight and transported loads in drones, and a model for the transport of 6.5 million annual full analytical volume by drone was presented.

7. Limitations of the Study

The technical specifications of the drones are excluded from the scope of the research. Ownership of drones is beyond the scope of the research. The purposes of use of drones, whether there are legal regulations of the states or not are excluded from the purpose of the study.

8. Findings at the end of the Study

In the future, drones are expected to be a widespread form of transportation for a variety of logistics-related uses. The constant and high travel speed of drones compared to conventional vehicles, the fact that they do not need physical road infrastructure, the direct travel and the fact that they are not exposed to traffic make this transportation stand out. It has been noted that logistics businesses can speed up deliveries and make their systems more responsive by using drone transportation (Jawadi and Winkenbach, 2021).

Drone transportation makes positive contributions to the prevention of increasing urban traffic, solving the problems caused by rapid growth in e-commerce, and congested business processes, especially in metropolitan cities. It has been observed that it has been employed by well-known businesses like Walmart, Amazon, and even some pizza delivery services, significantly enhancing the speed and effectiveness of deliveries. It is predicted that drone transportation, which is currently used in restricted areas, will be used more frequently in the future with high-capacity vehicles equipped with precise controls, GPS mapping and flight planning, geofencing, and bigger carrying capacities (Sarder, 2020).

On the other hand, drone applications have provided a number of solutions, especially for the rural distribution of medical supplies and emergency packages, where there is frequently underdeveloped road infrastructure in rural areas and limited availability of resources for infrastructure improvements (Jawadi and Winkenbach, 2021).

In addition, it is predicted that this most important technology will be preferred more in the coming period, as drones do not get stuck in road network boundaries, do not need pilots, are low cost and do not need a high level of infrastructure compared to traditional transportation vehicles (Ghelichi and Others, 2021). While the share of drone technology in transportation activities is currently around 12 billion dollars, it is expected to reach 60 billion dollars by 2030 (Precedence Research, 2020). These figures clearly show that drone transport will grow very rapidly in the sectoral market and increase its share. For this reason, it is recommended that businesses and public institutions that have not yet started to use this technology in their transportation activities should immediately implement business development applications that will integrate this technology into their business processes.

One of the important elements of drone technology is the rapid delivery of deliveries. Drones deliver packages by flying above these barriers, which are crucial for transportation because they are unaffected by poor road conditions or traffic congestion. Drones can deliver packages from origin to destination on the most convenient route and delivery time can be accurately estimated. Thus, drones not only provide incredibly quick delivery services but also the necessary freedom to deliver where and when customers desire (Yoo et al., 2018).

Additionally, the transportation industry is crucial in the spread of greenhouse gases, which have a variety of negative effects on the environment, including air, water, and global warming. According to this viewpoint, using drone sharing systems for end-user delivery can help reduce emissions and the need for fossil fuel energy sources. Drone-based delivery systems have the potential to replace a sizeable chunk of the current systems that rely on cars and motorcycles for short distances because they are predicted to have a substantially smaller carbon footprint. Additionally, drone-based delivery will significantly contribute to lowering accident rates and traffic jams, particularly in areas where the road network is already overused (Benarbia and Kyamakya, 2021). Despite substantial attempts to advance drone delivery technology, constraints inherent in organizing drone deliveries, such as constrained flying range, cumbersome administrative procedures, legal snags, and drone payloads, are among the main factors delaying drone delivery's advancement (Dorling et al., 2016).

9. What are the Gaps in The Literature on Drone Logistics

With the use of drones, some positive results have been achieved, such as reduced costs in transportation operations, shortened processes and reduced delivery errors. However, the fact that the use of this technology in logistics and transportation activities is still very new brings many shortcomings. It has been observed that there are some important gaps such as the fact that the states have not yet put into effect the legal regulations on this issue and that they cannot be used in large-scale transportation operations. In addition to these gaps, there are some important problems such as the lack of waiting stations for drones, the inability to plan for the return load, limited energy times, and the inability to deliver in safe areas. When civil applications of drone technology are investigated, its use in end product delivery, routing and optimization, medical equipment transportation and agricultural activities comes to the fore. In the research, no studies were found in the direction of using these technologies in capacity increase studies and in the field of passenger transportation. As a result of the study, it was found that there is a void in the literature regarding how to increase these technologies' carrying capacity, carry out long-distance transportation, leave the deliveries in safe areas, and use them for passenger transportation.

10. Conclusion and Recommendation

In this study, 56 articles from Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Xplore, and ScienceDirect (Elsevier) were examined. The pandemic epidemic that we have been experiencing recently revealed the necessity of an automation system that is free of human factor from business processes. In particular, the interruption of supply chains and the limited access of societies to vital factors such as food, cleaning and health materials have made us think of the existence of an unmanned process management in logistics and transportation operations. It is aimed that this study, which we have done at this point, will be a guide for researchers and industry professionals. During the study, many international sources were examined, and it was determined which models were used in these studies. The advantages and disadvantages of this new technology for businesses were also discussed. As a result of all these researches, it is seen that especially in the last ten years, businesses have benefited from drone technology in their transportation activities. As a result of this experience, when businesses analyzed their business processes, they found that they increased their final delivery speed, efficiency, accessibility and customer satisfaction.

Researchers and practitioners alike can learn from this study. Considering the details of the study, it is seen that drone waiting and charging stations are now considered as an important problem. In addition, the most important problems of drone transportation are the inability to plan the return load in drone deliveries, the need to improve the speed and capacity of drone transport, the need for a safe area in delivery, and the development of drones with the ability to carry in adverse climatic conditions. In the examination, it is clearly seen that there are gaps in these areas in academic studies. In addition, it has been determined that there is a gap in the use of these technologies in the field of passenger transportation. All these factors can be included in future studies as research questions, and it is recommended that these technologies be discussed in detail, especially in the legal, administrative and social dimensions.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Benarbia, T., & Kyamakya, K. (2021). A literature review of drone-based package delivery logistics systems and their implementation feasibility. Sustainability, 14(1), 360.

Bonsor, K. (2018). How Maglev trains work. Retrieved from, https://science.howstuffworks.com/transport/engines-equipment/maglev-train.html.

Canetta, L., Mattei, G., & Guanziroli, A. (2017, June). Multi criteria analysis applied on value chain definition in unmanned aerial vehicle (UAV) sector. In 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1096-1103). IEEE.

Chen, H., Hu, Z., & Solak, S. (2021). Improved delivery policies for future drone-based delivery systems. European Journal of Operational Research, 294(3), 1181-1201.

Chen, J., Wang, W., Zhou, Y., Ahmed, S. H., & Wei, W. (2021). Exploiting 5G and blockchain for medical applications of drones. IEEE Network, 35(1), 30-36.

Chen, X., Ulmer, M. W., & Thomas, B. W. (2019). Deep Q-learning for same-day delivery with a heterogeneous fleet of vehicles and drones. arXiv preprint arXiv:1910.11901.

Cook, D.J., Greengold, N.L., Ellrodt, A.G., & Weingarten, S.R. (1997), "The relation between systematic reviews and practice guidelines", Annals of Internal Medicine, Vol. 127 No. 3, pp. 210-6

Cvitanić, D. (2020). Drone applications in transportation. In 2020 5th International Conference on Smart and Sustainable Technologies (SpliTech) (pp. 1-4). IEEE.

Das, D. N., Sewani, R., Wang, J., & Tiwari, M. K. (2020). Synchronized truck and drone routing in package delivery logistics. IEEE Transactions on Intelligent Transportation Systems, 22(9), 5772-5782.

Denyer, D., & Tranfield, D. (2009), "Producing a systematic review", in Buchanan, D. and Bryman, A. (Eds), The Sage Handbook of Organizational Research Methods, Sage Publications, London, pp. 671-89, Ch. 39.

Dorling, K., Heinrichs, J., Messier, G. G. & Magierowski, S. (2016). Vehicle routing problems for drone delivery. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 47(1), 70-85.

Erceg, A., Erceg, B. Č., & Vasilj, A. (2017). Unmanned aircraft systems in logistics–legal regulation and worldwide examples toward use in Croatia. Business Logistics in Modern Management.

Fang, Z., & Hong-Hai, Z. (2020, September). A Method for "Last mile" Distribution Demand for Drones. In 2020 IEEE 5th International Conference on Intelligent Transportation Engineering (ICITE) (pp. 561-564). IEEE.

Foth, J. (2017). We haven't considered the true cost of drone delivery medical services in Africa. URL https://qz.com/africa/1090693/zipline-drones-in-africa-like-rwanda-and-tanzania-have-an-opportunity-cost/.

Garg, P. K. (2021). Unmanned aerial vehicles: An introduction. Mercury Learning and Information.

Ghelichi, Z., Gentili, M., & Mirchandani, P. B. (2022). Drone logistics for uncertain demand of disaster-impacted populations. Transportation research part C: emerging technologies, 141, 103735.

Gligor, D. M., & Holcomb, M. C. (2012). Understanding the role of logistics capabilities in achieving supply chain agility: a systematic literature review. Supply Chain Management: An International Journal.

Gonzalez-R, P. L., Canca, D., Andrade-Pineda, J. L., Calle, M., & Leon-Blanco, J. M. (2020). Truck-drone team logistics: A heuristic approach to multi-drop route planning. Transportation Research Part C: Emerging Technologies, 114, 657-680.

He, Z. (2020). The challenges in sustainability of urban freight network design and distribution innovations: a systematic literature review. International Journal of Physical Distribution & Logistics Management, 50(6), 601-640.

Hua, H. Y., & Zhang, Z. (2019). Application of artificial intelligence technology in short-range logistics drones. In 2019 8th International Symposium on Next Generation Electronics (ISNE) (pp. 1-4). IEEE.

Iranmanesh, S., Raad, R., Raheel, M. S., Tubbal, F., & Jan, T. (2019). Novel DTN mobility-driven routing in autonomous drone logistics networks. IEEE access, 8, 13661-13673.

Johannessen, K. A., Comtet, H., & Fosse, E. (2021). A Drone Logistic Model for Transporting the Complete Analytic Volume of a Large-Scale University Laboratory. International Journal of Environmental Research and Public Health, 18(9), 4580.

Khan, K.S., Kunz, R., Kleijnen, J. & Antes, G. (2003), "Five steps to conducting a systematic review", Journal of the Royal Society of Medicine, Vol. 96 No. 3, pp. 118-121.

Koshta, N., Devi, Y., & Chauhan, C. (2022). Evaluating Barriers to the Adoption of Delivery Drones in Rural Healthcare Supply Chains: Preparing the Healthcare System for the Future. IEEE Transactions on Engineering Management.

Kuru, K., Ansell, D., Khan, W., & Yetgin, H. (2019). Analysis and optimization of unmanned aerial vehicle swarms in logistics: An intelligent delivery platform. Ieee Access, 7, 15804-15831.

Lai, M. C., Liu, D., & Tsay, W. D. (2020). Functional deployment of drone logistics. In 2020 IEEE 2nd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS) (pp. 1-4). IEEE.

Leon-Blanco, J. M., Gonzalez-R, P. L., Andrade-Pineda, J. L., Canca, D., & Calle, M. (2022). A multi-agent approach to the truck multi-drone routing problem. Expert Systems with Applications, 195, 116604.

Liu, J., Guan, Z., & Xie, X. (2018). Truck and drone in tandem route scheduling under sparse demand distribution. In 2018 8th International Conference on Logistics, Informatics and Service Sciences (LISS) (pp. 1-6). IEEE.

Mahroof, K., Omar, A., Rana, N. P., Sivarajah, U., & Weerakkody, V. (2021). Drone as a Service (DaaS) in promoting cleaner agricultural production and Circular Economy for ethical Sustainable Supply Chain development. Journal of Cleaner Production, 287, 125522.

Mangiaracina, R., Perego, A., Seghezzi, A., & Tumino, A. (2019). Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review. International Journal of Physical Distribution & Logistics Management.

Marintseva, K., Yun, G., & Vasilenko, I. (2021). Delivery of special cargoes using the unmanned aerial vehicles. In Research Anthology on Reliability and Safety in Aviation Systems, Spacecraft, and Air Transport (pp. 1564-1587). IGI Global.

Meincke, P., Asmer, L., Geike, L., & Wiarda, H. (2018). Concepts for cargo ground handling of unmanned cargo aircrafts and their influence on the supply chain. In 2018 8th International Conference on Logistics, Informatics and Service Sciences (LISS) (pp. 1-10). IEEE.

Merkert, R., & Bushell, J. (2020). Managing the drone revolution: A systematic literature review into the current use of airborne drones and future strategic directions for their effective control. Journal of Air Transport Management, 89, 101929.

Merkert, R., Bliemer, M. C., & Fayyaz, M. (2022). Consumer preferences for innovative and traditional last-mile parcel delivery. International Journal of Physical Distribution & Logistics Management.

Moshref-Javadi, M., & Winkenbach, M. (2021). Applications and Research avenues for drone-based models in logistics: A classification and review. Expert Systems with Applications, 177, 114854.

Moshref-Javadi, M., Hemmati, A., & Winkenbach, M. (2020). A truck and drones model for last-mile delivery: A mathematical model and heuristic approach. Applied Mathematical Modelling, 80, 290-318.

Mualla, Y., Bai, W., Galland, S., & Nicolle, C. (2018). Comparison of agent-based simulation frameworks for unmanned aerial transportation applications. Procedia computer science, 130, 791-796.

Nyaaba, A. A., & Ayamga, M. (2021). Intricacies of medical drones in healthcare delivery: Implications for Africa. Technology in Society, 66, 101624.

Olivares, V., Córdova, F., & Durán, C. (2017). Transport logistics and simulation model for fleet of drones in a Mass Customization System. In 2017 CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON) (pp. 1-6). IEEE.

Osakwe, C. N., Hudik, M., Říha, D., Stros, M., & Ramayah, T. (2022). Critical factors characterizing consumers' intentions to use drones for last-mile delivery: Does delivery risk matter?. Journal of Retailing and Consumer Services, 65, 102865.

Pan, J. S., Song, P. C., Chu, S. C., & Peng, Y. J. (2020). Improved compact cuckoo search algorithm applied to location of drone logistics hub. Mathematics, 8(3), 333.

Patchou, M., Sliwa, B., & Wietfeld, C. (2019). Unmanned aerial vehicles in logistics: Efficiency gains and communication performance of hybrid combinations of ground and aerial vehicles. In 2019 IEEE Vehicular Networking Conference (VNC) (pp. 1-8). IEEE.

Pinto, R., & Lagorio, A. (2022). Point-to-point drone-based delivery network design with intermediate charging stations. Transportation Research Part C: Emerging Technologies, 135, 103506.

Precedence Research (2020). Drone Logistics and Transportation Market Size, Share, Growth Analysis. Retrieved from https://www.precedenceresearch.com/drone-logistics-and-transportation-market.

Rabta, B., Wankmüller, C., & Reiner, G. (2018). A drone fleet model for last-mile distribution in disaster relief operations. International Journal of Disaster Risk Reduction, 28, 107-112.

Raj, A., & Sah, B. (2019). Analyzing critical success factors for implementation of drones in the logistics sector using grey-DEMATEL based approach. Computers & Industrial Engineering, 138, 106118.

Rejeb, A., Rejeb, K., Simske, S. J., & Treiblmaier, H. (2021). Drones for supply chain management and logistics: a review and research agenda. International Journal of Logistics Research and Applications, 1-24.

Sah, B., Gupta, R., & Bani-Hani, D. (2021). Analysis of barriers to implement drone logistics. International Journal of Logistics Research and Applications, 24(6), 531-550.

Sarder, M. D. (2020). Logistics transportation systems. Elsevier.

Shavarani, S. M., M. G. Nejad, F. Rismanchian, & G. Izbirak. (2018). "Application of Hierarchical Facility Location Problem for Optimization of a Drone Delivery System: A Case Study of Amazon Prime Air in the City of San Francisco." The International Journal of Advanced Manufacturing Technology 95 (9–12): 3141–3153.

Smith, A., Dickinson, J. E., Marsden, G., Cherrett, T., Oakey, A., & Grote, M. (2022). Public acceptance of the use of drones for logistics: The state of play and moving towards more informed debate. Technology in Society, 68, 101883.

Statista (2019). Commercial Drones are Taking Off. Retrieved from https://www.statista.com/chart/17201/commecial-drones-projected-growth/

Thiels, C. A., Aho, J. M., Zietlow, S. P., & Jenkins, D. H. (2015). Use of unmanned aerial vehicles for medical product transport. Air medical journal, 34(2), 104-108.

Triche, R. M., Greve, A. E., & Dubin, S. J. (2020). UAVs and their role in the health supply chain: A case study from Malawi. In 2020 International Conference on Unmanned Aircraft Systems (ICUAS) (pp. 1241-1248). IEEE.

Troudi, A., Addouche, S. A., Dellagi, S., & El Mhamedi, A. (2017). Post-production analysis approach for drone delivery fleet. In 2017 IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI) (pp. 150-155). IEEE.

Troudi, A., Addouche, S. A., Dellagi, S., & Mhamedi, A. E. (2018). Sizing of the drone delivery fleet considering energy autonomy. Sustainability, 10(9), 3344.

Tümenbatur, A. & Tanyaş, M. (2021). Havalimani Kenti Kavrami: Türkiye'deki Bazi Havalimanlarinin Karşilaştirilmasi. Beykoz Akademi Dergisi , 9 (1) , 108-119.

Varigonda, V. K., Borole, A., Hudge, A., Yadav, C., & Annamalai, V. K. (2021). Feasibility of Multi-Configuration Unmanned Aerial Vehicle for Last Mile Delivery of Medical Supplies. In 2021 Asian Conference on Innovation in Technology (ASIANCON) (pp. 1-7). IEEE.

Yoo, W., Yu, E., & Jung, J. (2018). Drone delivery: Factors affecting the public's attitude and intention to adopt. Telematics and Informatics, 35(6), 1687-1700.

Zhu, X., Pasch, T. J., & Bergstrom, A. (2020). Understanding the structure of risk belief systems concerning drone delivery: A network analysis. Technology in Society, 62, 101262.

Cite this article: Turgut, M., Seker, B. (2023). Drone Technology in Transportation Management: A Systematic Review and Framework for Future Research. Journal of Aviation, 7(2), 251-261.