

Air transportation plays a key role in global trade and logistics. Speed, safety and flexibility make it the best option for many companies operating in the international market.

With each passing decade, aviation become more accessible. Despite high costs and environmental impact, air transport remains an indispensable element of global international transport, playing a strategic role in the development of the world economy. Taking into account modern trends and innovations, aviation continues to develop, becoming even safer, more efficient and more environmentally friendly.

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DRONE DELIVERY: WHEN WILL AUTONOMOUS TRANSPORTATION BECOME WIDESPREAD?

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Drone delivery is one of the most promising innovations in the field of logistics, which can significantly change ways of goods transportation. Thanks to use unmanned aircraft devices (UAVs) for cargo delivery, this method promises decrease of expenses, increase of delivery speeds and reduction emissions carbon dioxide. Successful test runs have already occurred in many countries, however large-scale implementation of drone delivery remains complicated tasks through legal , technical and infrastructural barriers .

The development of drone delivery is a part of global digital transformation, which encompasses automation and the use of artificial intelligence to improve efficiency of transport logistics. In addition to commercial advantages, drones can play

back key role in humanitarian missions, in delivery medicines and products in crisis regions. However, despite the significant potential, of mass implementation this technology needs solving a number of issues related to and from safety, legislation and technical restrictions.

Today, the drone delivery market is actively developing, and large companies invest in research and testing new solutions. Among main players in these industries worth to highlight:

- Amazon Prime Air is one of the pioneers in drone delivery, actively testing devices for the rapid transportation of small goods.

- Google Wing is a project of Alphabet, which already carries out commercial deliveries in the USA and Australia [1] .

- UPS Flight Forward is a division of UPS, specializing in autonomous transportation, especially in the medical field.

- DHL Parcelcopter - DHL is actively testing drone delivery in hard-to-reach regions of Germany.

- Zipline - specializes in the delivery of medicines and vaccines to remote areas of Africa and other countries.

Despite the successes achieved, the widespread use of drone delivery is limited by legislative barriers, infrastructural difficulties and the need to improve flight safety technologies. An additional obstacle is the low battery capacity, which reduces the flight range [2].

To increase the reliability and efficiency of drones in delivery, various aspects of technology are being improved, including navigation systems which shows that the use of advanced GPS and artificial intelligence allows drones to plot optimal routes and avoid obstacles. New lithium-ion and solid-state batteries increase the range of drones, making them more efficient Integration with urban logistics and systems are being developed to coordinate drones with transport and delivery services, helping to reduce congestion. Obstacle protection means that using sensors and machine learning algorithms help avoid collisions and adapt to changing conditions [3].

Drone delivery has a lot of advantages, obstacles and challenges for mass

implementation. Among of advantages mention should be made of speed, reduced costs, accessibility to-reach hard areas, environmental friendliness, relieving traffic, precision and autonomy: speed, reduced costs, accessibility in hard-to-reach areas, environmental friendliness, relieving traffic, precision and autonomy Speed - Drones can cover distances significantly faster than ground transport, bypassing traffic jams and other obstacles Reduced costs - Automation of the delivery process reduces labor costs.

Accessibility in hard-to-reach areas - Drones can provide deliveries to areas that are difficult to reach by traditional transport Environmental friendliness — the use of electric drones of reduces CO2 emissions compared to motor vehicles.

Relieving traffic — using airspace reduces the load on city roads and reduces accidents. Precision and autonomy — modern drones are equipped with GPS and artificial intelligence systems, which allows them to automatically determine optimal route and avoid obstacles.

Obstacles and challenges for mass implementation of drones are the following:

-Legislative restrictions — most countries do not have a ready-made legal framework for the large-scale use of drones in logistics.

-Safety — drones are susceptible to cyberattacks and technical failures, which can lead to accidents or cargo theft

-Need for infrastructure — it is necessary to create charging stations, control centers, take-off and landing sites.

-Limited payload — modern drones can only transport small loads, which limits their use in some industries.

-Public perception - some of the public is wary of drones due to safety, privacy and noise concerns.

-Weather conditions - drones are limited in their operation in rain, strong winds and other adverse weather conditions.

-Cybersecurity - the risk of drone hacking and interference with navigation systems.

-Environmental impact - despite reducing CO2 emissions, drones create noise,

which is a concern in cities.

Obstacles and Challenges for the Mass Implementation of Drones in the Logistics Industry The logistics industry is undergoing a transformation driven by automation, data analytics, and advanced delivery systems. Among these, unmanned aerial vehicles (UAVs), commonly known as drones, are positioned as a disruptive innovation with the potential to revolutionize last-mile delivery, warehouse management, inventory control, and even inter-facility transport. However, the mass-scale implementation of drones in logistics remains encumbered by a range of persistent and multifaceted challenges. These obstacles span across regulatory, technical, infrastructural, operational, economic, environmental, and societal domains.

According to analysts, the drone delivery market is expected to grow rapidly. By 2030, drone-based logistics may come a common feature in urban and suburban environments. Key drivers of this growth include technological advancements, evolving regulatory frameworks, and increasing demand for fast and efficient delivery services, particularly in healthcare] In the logistics sector, where timing, safety, and cost-efficiency are paramount, regulatory uncertainty poses a significant barrier to drone adoption. Many countries restrict drone operations to specific altitudes and zones. Flying beyond visual line of sight (BVLOS)—critical for logistics—is either banned or heavily regulated. Commercial drone delivery requires airworthiness certifications, operator licensing, and insurance policies, often involving costly and bureaucratic procedures that deter widespread use.

Cross-border drone delivery is legally ambiguous, with little to no harmonization in drone laws across jurisdictions, which stifles the scalability of international drone-based logistics networks: Legal frameworks tend to be stricter in urban areas, where drone delivery could be most effective for last-mile logistics, making deployments in city centers extremely limited [4].

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logistics, technical and infrastructure-related limitations are perhaps the most immediate constraints. Most commercial drones have limited carrying capacity, often suitable only for small parcels (under 5 kg). This restricts their use to a narrow segment of deliveries and excludes bulk or heavy logistics. Drones typically offer 20–40 minutes of flight time, limiting their delivery radius and requiring frequent recharging. This makes them inefficient for longer-range or high-volume delivery operations. In dynamic environments such as cities, the risk of collision with buildings, birds, cables, or other drones remains high. Advanced navigation systems using AI and real-time mapping are still developing. Mass deployment requires a network of drone stations, charging hubs, and safe landing areas in both urban and rural environments. These facilities are currently lacking in most cities. Integrating drones into existing logistics chains is complex, both in theory and practice demands coordination between drone fleets and inventory management systems. fully automated pick-pack-ship systems which are still rare. Large numbers of delivery drones will require drone-specific traffic management systems (UTMs) to avoid airspace congestion and ensure safety. Such systems are still in pilot phases globally and logistics operations require high levels of reliability. Drones must have redundancy mechanisms for navigation, propulsion, communication to meet these standards, Logistics operations require high levels of reliability. Drones must have redundancy mechanisms for navigation, propulsion, and communication to meet these standards.

Despite declining hardware costs, drone logistics remains economically challenging on a large scale, setting up a drone logistics infrastructure—from fleet procurement to maintenance facilities and operator training—requires significant capital expenditure. Drones have relatively short lifespans and high maintenance needs due to exposure to weather and environmental factors. This leads to higher operational expenditure over time/ The economic model for drone delivery is still in its early stages. While it may reduce labor costs, the overall value proposition remains unproven at scale, particularly in cost-sensitive supply chains.

Safety and security are central concerns in logistics, where accidents or data breaches can have major financial and reputational consequences. Drone crashes,

especially in populated areas, could cause injuries, property damage, or even fatalities, resulting in liability issues and public backlash, drones can be intercepted, jammed, or stolen, especially when delivering high-value goods.

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Environmental and Social Impacts here are rather great. Although drones are often promoted as a sustainable alternative to trucks and vans, they bring their own environmental and social considerations. The buzzing sound of drones, particularly quadcopters, can become a significant nuisance in urban or suburban areas. The demand for lithium batteries to power fleets of drones raises questions about sustainability, recycling, and dependence on rare earth materials. Delivery drones flying through forests, parks, or near water bodies may disturb ecosystems, especially bird habitats/ Skepticism about drones—whether due to privacy concerns, safety fears, or general unease—can hinder adoption, especially in communities not involved in the decision-making process [5]. Drones offer a vision of faster, more efficient, and automated logistics—especially in the crucial and costly last-mile delivery sector. However, the path toward mass implementation is fraught with challenges that are technical, legal, economic, and societal in nature. Realizing the full potential of drone-based logistics requires coordinated action among governments, private companies, and civil society to establish regulatory frameworks, develop infrastructure, ensure safety, and gain public trust. Only then can drones become a truly scalable and sustainable pillar of modern logistics networks. Drone delivery has great potential and could be a revolutionary step in logistics. However, its mass implementation needs to address a range of challenges related to security, regulation, public trust and technological restrictions. If this question will be overcome, then in the near future we will see large-scale use of drones for transportation cargo all over the world.

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COMPARATIVE EVALUATION OF NIGHT AND DAYTIME SMALL-BATCH CARGO DELIVERY SYSTEMS IN URBAN ENVIRONMENT

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The growing demand for fast and efficient urban freight transportation, determined by e-commerce and same-day delivery expectation, has raised concerns about the sustainability and cost-efficiency of current logistic systems. The investigation provides a comparative evaluation of small-batch cargo deliveries during daytime and nighttime in urban environment. The study focuses on analyzing cost structures, delivery times, environmental impacts, and logistic challenges. Using mathematical modeling, route optimization algorithms (e.g., Clarke-Wright savings method), and real-world data from a Ukrainian city, the study highlights the potential of nighttime delivery as an effective alternative to traditional daytime schedules, while addressing its limitations and implications for urban logistic policy and infrastructure planning.

As cities continue to grow and urban populations increase, the strain on last-mile delivery services intensifies. The integration of smart city technologies, such as real-time traffic monitoring and adaptive delivery scheduling, may further enhance the effectiveness of nighttime logistics. These innovations can enable more responsive, eco-conscious delivery systems capable of meeting rising demand without compromising urban sustainability goals. The increasing volume of small-batch deliveries—parcels, food, pharmaceutical goods—has transformed the landscape of urban transportation. Rapid urbanization, combined with growing consumer expectations for same-day or next-day delivery, has put immense pressure on logistic systems, particularly in densely populated cities. Urban freight systems must now