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Drones in Transportation

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ABSTRACT

Unmanned aerial vehicles (UAV) and unmanned aircraft systems (UAS), commonly termed drones, have the potential to become some of the most influential and iconic technologies of the 21st century. Dones are very popular among the American people, so much so that there are more than one million drones registered with the FAA. Drone integration into distribution and transportation systems is one of the most exciting developments in this field. They can enhance the logistics and transportation sectors, where efficiency, speed, and cost-effectiveness are paramount. Drone delivery could influence not only shipping procedures, but the transportation industry as well. This paper studies the various uses of drone in the transportation industry.

KEYWORDS: *drones, unmanned aircrafts, unmanned aerial vehicles (UAVs), unmanned aircraft systems (UAS), transportation, transportation industry*

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INTRODUCTION

Drones, also known as Unmanned Aerial Vehicles (UAVs), have been around since the 20th century. They first came into existence for military purposes. As the technology improved and costs reduced, drones started visiting other sectors of the market like aerial photography and agriculture. Drones combine three key principles of technological modernity: data processing, autonomy, and boundless mobility. Drones are driven by a general motivation to make processes faster and more flexible, while improving precision and cost-efficiency. Depending on their technological specifications, electrically powered delivery drones can lift weights in the range of 1–8 kg, and can conduct flight missions in a range of 10–50 km.

The current state of transportation operations is undergoing significant transformation. Traditional methods like mailmen, UPS deliveries, and brick-and-mortar stores are still prevalent, but innovative approaches are emerging, particularly in the use of drones. One of the industries that offers the most potential to leverage drone technology is transportation. With a wide range of possibilities, drones could influence the future of the industry in every aspect, from mobility to infrastructure development and traffic management. We have heard rumors about companies like Amazon, UPS, DHL, and other delivery giants exploring the possibilities of providing some of their services through drones.

WHAT IS A DRONE?

At least three terms are used to describe drones, depending on how they are operated. The terms include Unmanned Aerial Vehicles (UAVs), Unpiloted Aircraft System (UAS), and Remote Piloted Aircraft System (RPAS). The FAA defines drones, also known as unmanned aerial vehicles (UAVs), as any aircraft system without a flight crew onboard. Drones include flying, floating, and other devices, including unmanned aerial vehicles (UAVs), that can fly independently along set routes using an onboard computer or follow commands transmitted remotely by a pilot on the ground. A typical drone is shown in Figure 1 [1]. A drone is usually controlled remotely by a human pilot on the ground, as typically

shown in Figure 2 [1]. Drones can range in size from large military drones to smaller drones. Drones, previously used for military purposes, have started to be used for civilian purposes since the 2000s. Since then, drones have continued to be used in intelligence, aerial surveillance, search and rescue, reconnaissance, and offensive missions as part of the military Internet of things (IoT). Today, drones are used for different purposes such as aerial photography, surveillance, agriculture, entertainment, healthcare, transportation, law enforcement, etc.

Drones work much like other modes of air transportation, such as helicopters and airplanes. When the engine is turned on, it starts up, and the propellers rotate to enable flight. The motors spin the propellers and the propellers push against the air molecules downward, which pulls the drone upwards. Once the drone is flying, it is able to move forward, back, left, and right by spinning each of the propellers at a different speed. Then, the pilot uses the remote control to direct its flight from the ground [2],

Drone laws exist to ensure a high level of safety in the skies, especially near sensitive areas like airports. They also aim to address privacy concerns that arise when camera drones fly in residential areas. These include the requirement to keep your drone within sight at all times when airborne. In the United States, drones weighing less than 250g are exempt from registration with civil aviation authorities. If your drone exceeds 250g in weight, you will also require a Flyer ID, which requires passing a test [3]. It is necessary to register as an operator, be trained as a pilot, and have civil liability insurance, in addition to complying with various flight regulations, and those of the places where their use is permitted.

Most drones have a limited payload, usually under 11 pounds. Drones are classified according to their size. Here are the different drone types:

- Nano Drone: 80-100 mm
- Micro Drone: 100-150 mm
- Small Drone: 150-250 mm
- Medium Drone: 250-400 mm
- Large Drone: 400+ mm

One of the emerging trends in drone use for factories is the utilization of LiDAR technology. LiDAR stands for Light Detection and Ranging. This technology provides accurate depth information essential for understanding the three-dimensional structure of the environment. LiDAR sensors emit laser beams to measure distances to objects, creating high-resolution 3D maps of the surrounding terrain and objects. The ability to capture detailed data through LiDAR technology has opened up opportunities for better predictive maintenance, reduction in inspection times, and overall cost savings [4].

TRANSPORTATION DRONES

Drones are part of larger networks called Unmanned Aerial Systems (UAS), which not only include the vehicles but also the controllers, sensors, GPS, and radio components that work together to complete the mission. Transportation drones are used to transport people and packages. They could revolutionize urban transportation by reducing traffic congestion, lowering emissions, and improving quality of life.

Drones have been used for years by the military and government, but using drones for commercial package delivery is becoming a new industry. The government is investing high capital for the installation of drones in a transportation business that helps in providing relief to the people by transporting medicines, food, and other things during an emergency.

Drone technology now seems to provide a new solution to old transportation problems such as congestion and delivery. The drone transportation market is experiencing rapid growth driven by advancements in autonomous technologies and the increasing demand for efficient, cost-effective deliveries. The market is at the intersection of cutting-edge robotics development and the logistics industry's need for speed and efficiency.

APPLICATIONS OF TRANSPORTATION DRONES

Departments of Transportation are increasingly using autonomous drones for monitoring and performing inspections of critical infrastructure such as bridges and highways. Common areas of applications of drone in transportation include the following [5]:

- *Drone Taxis:* Passenger drones, so called air taxis, have already proven their technical ability to transport passengers within or between cities. Drones would carry one or two passengers over short distances. Passenger drones with their ability to transport a maximum of five passengers (or even less) per air taxi are equally limited by capacity. As travel time savings may more likely be realized with increasing flight distances. Air taxis' limited battery capacities account for another setback regarding the central promise of time savings.
- *Drone Delivery:* In a world where convenience and promptness are crucial, customers expect quicker deliveries. Consequently, businesses have been compelled to reconsider their plans to find more economical and effective methods, including drone logistics. Delivery drones are

currently among the most intensely discussed emerging technologies. Drones would deliver packages to customers. As soon as several parcels have to be delivered conventional delivery methods remain more energy efficient, especially in cases where recipients can be grouped along routes. Individual drone-based parcel delivery services are already being rolled out. Figure 3 shows a typical delivery drone [5].

- *Cargo Drones:* This can be a very scary term but less so if it helps us move large objects, which is why cargo drones are likely to be viewed positively by the public. They are closer to being at a store near you than you think. Currently, there are four different cargo drone use cases, in varying states of implementation: automation of intralogistics, covering factories and warehouses; parcel delivery (first/last mile), catering to dense urban areas; supply of medical goods, normally to hard-to-reach places; and transportation of air freight, usually in rural areas. An important application for cargo drones as one would imagine is medical supply transport. The parcel delivery sector will shape the future development of cargo drone use cases and other drone applications. Typical cargo drone delivery is shown in Figure 4 [6].
- *Urban Air Mobility* (UAM): Drones might be a feasible answer to urban air mobility (UAM). While the field is still very much in its early stages, UAM envisions a network of smaller, electric, and highly automated aircraft able to provide transportation within cities. This on-demand service would rely highly on drones.
- *Infrastructure Inspection:* Departments of Transportation are increasingly using autonomous drones for monitoring and performing inspections of critical infrastructure such as bridges and highways. An autonomous drone can eliminate the need for a manual inspection which can be difficult and dangerous. Autonomous drone inspections are also less expensive to perform. Using autonomous drone technology to monitor and inspect infrastructure can improve workflow efficiency and lower costs. By leveraging their high-resolution image and video, and its capacity to reach inaccessible or dangerous locations, drones play a critical role in developments like bridges, power lines, and tall buildings. Regular inspections with drones can help identify maintenance issues in a quick and efficient way that can save time, money, the longevity of a structure, and the safety of people who use it. Transportation and other individual state agencies throughout the US have been increasingly adopting the use of drones for critical infrastructure such as bridges. Figure 5 shows a typical infrastructure drone inspection [7].
- *Emergency Response*: Emergency response and disaster relief rely heavily in the transportation industry due to their need for rapid deployment, evacuation and rescue, supply chain support, infrastructure restoration, aerial support and surveillance, traffic management, route optimization, etc. Drones' capabilities offer a quick alternative to survey affected areas, identify potential hazards, locate survivors, reach inaccessible or hazardous environments, deliver supplies, and in general facilitate relief efforts with speed, efficiency, and reduced human risk. Figure 6 shows a drone-delivered medical supply [8].
- *Traffic Management:* Drones featuring advanced sensors and cameras could offer a great solution for effective traffic management in congested areas. By providing real time data, drones can help optimize traffic flow and routes. Figure 7 shows a typical traffic situation [5].
- *Surveying:* Drones have revolutionized our perspective and utilization of aerial technology. Drones can carry out topographic surveys for new routes or alterations to an existing corridor with similar accuracy to measurements collected by traditional methods, but in significantly less time. It can be as straightforward as using drones to simulate and confirm the proper topographic location and height at which to install traffic cameras to ensure complete 360-degree visuals. The raw aerial imagery made by a drone can be translated into orthomosaics, composite images made by stitching together hundreds of smaller images taken by drones and then corrected for distortion. Post-incident, a drone can collect imagery for a visual snapshot of the scene.
- *Postal Service:* The Postal Service has winnowed down the companies bidding to build the next generation of its delivery vehicles - and one of them is offering up an all-electric truck that doubles as a drone launcher. The Service also wants lower maintenance requirements and better fuel economy than its current fleet, as well as design flexibility to allow for the incorporation of future technology. Integrating drone technology on top of electric truck is the best solution for the Postal Service. The drone delivers a package either on its own or controlled by a pilot remotely to another address a mile or two away, saving the

mail carrier time and allowing them to reach more addresses.

BENEFITS

The expectations of using drones for modes of transportation are dominated by economic benefits. What makes drones particularly innovative is their ability to operate in complex environments. They can fly over traffic jams, reach isolated rural locations, and even work in adverse weather conditions, all while providing real-time tracking and monitoring of goods in transit. They can also play a significant role in planning and designing maintenance of traffic plans during construction of transportation projects. Drones are increasingly used in combination with traffic patrol vehicles to monitor and manage congestion and traffic incidents. Other benefits include the following [9]:

- *Mobility:* Some see drones as an opportunity for sustainable mobility. The emergence of passenger drones is witnessed as a major trend in the mobility sector, transforming the way people move around. Mobility here is understood as a social phenomenon that must be evaluated according to its consequences for a variety of actors. In addition to an interest in the social "production" of movements, contemporary mobility studies focus on sustainable mobility concepts and the understanding of the mobile "subject." Figure 8 shows passenger drones connecting other transport mode [10].
- *Cost:* It is primarily expected that drone-supported logistics services will lead to lower costs for companies in the rapidly growing and price sensitive logistics sector. The integration of drones into supply chains can reduce delivery times, lower costs, and address logistics challenges in remote or congested areas. Because drones collect large amounts of data in a fraction of time it might take using traditional methods, they can also save money and reduce staff time.
- *Sustainable Transportation:* One of the world's key challenges today is to reduce the global CO2 footprint. Transportation is also considered critical because the sector's emission levels have continuously grown. A sustainable transportation future would mean to travel less, with shorter distances and using more eco-friendly modes of transportation. Assessing the environmental benefits of delivery drones is complex and dependent on the respective deployment scenario. Drones are regarded as an environmentally friendly technology for both logistics and passenger transportation. The main reason is the fact that drones are a fully electric transportation technology. For example, air taxis are considered to reduce carbon/noise footprint in comparison to fossil-fueled helicopters. In order to make drones a (more) environmentally friendly technology, the electric energy powering drones would have to be fully generated from renewable energy sources.
- *Travel Time Reduction:* Travel time reduction is achieved by avoiding the ground traffic congestion. Given travelers' tendency to spend achieved time savings on additional or longer trips, there is reason to believe that this mechanism would also apply in the case of passenger drones. Insufficient air traffic management capacities are also known to drastically hamper time savings in aviation
- *Asset Management:* In the initial planning stages, drones can help planners be smarter about thinking through the entire life cycle of a project, avoiding overdesigning projects, saving costs, and reducing timelines. Once a highway or bridge has been planned, designed, and constructed, drones can help manage these assets.
- *Medical Supplies:* Fast and reliable transportation of medical goods can save lives. A public-private partnership will use drones to deliver critical medical supplies and food during the crisis. The future of drones in transportation and logistics will allow doctors to order a medical supply they need via phone and get it delivered by a drone.

CHALLENGES

Beyond delivery drones' technical capabilities there are various limiting factors that render the notion of actual ground traffic reduction questionable. Transport-related promises of delivery drones lack a scientific validation. Economic expectations are juxtaposed with quite complex and differentiated concerns regarding societal and environmental impacts. Another challenge is the interdiction of storage and dissemination of personal data without knowledge of the person concerned. How do we control 100,000 drones in the air flying at once? Other challenges include the following [9]:

- *Societal Concerns:* Societal perspectives of civil drone deployment have so far played a comparatively marginal role. There is lack of acceptance for drones among the public. Negative societal implications of using transportation drones form the dominating issue within potential problems.
- *Societal Change*: Occurrences of societal change are the major problems identified. The widespread use of drones could divide society if some people benefit while others are concerned.

The most frequently addressed societal benefit is the reduction of traffic congestion and the shortening of commuting times.

- *Ethical Concerns:* Ethical problems represent potential problems in drone transportation. The concern of privacy violations is the key issue here. There are concern about the lack of transparency regarding aims and purposes of drone operations. It is followed by issues of data privacy and the potential of increased surveillance. Delivery drones also bear the potential of (intentionally or unintentionally) causing privacy infringements when deployed close to private spaces.
- *Environment Concern:* A key consideration in any transportation planning project is environmental impact. The topic of environment and sustainability is mostly characterized by a lack of solid scientific evidence and uncertainties about the environmental impact of drones. Key issues in environmental planning and environmental review are traffic impacts (including safety) and congestion. Additional potential problem areas of using drones for transportation purposes include negative effects of noise pollution. There are uncertainties regarding actual energy efficiencies and emissions of delivery drones.
- *Regulations:* The evolving regulatory landscape poses a challenge. In terms of necessary conditions, comprehensive regulations for drone operation are the number one priority. For example, will there be rules and guidelines on how to navigate drones within designated air space? Debates on drones are strongly dominated by technical and regulatory issues. The debate is characterized by predominantly technical and regulatory problems and barriers which are considered to prevent or impede the use of drones for parcel and passengers transportation. There are concerns about the prohibitive effect of strict regulation and about the lack of legal standardization. Legal solutions comprise the establishment of a mandatory registration of drones, creating codes of conduct, and extending the regulatory frameworks to better protect privacy rights.
- *Security:* Potential safety and security problems of drone use are perceived to be a major issue. The threat of potential misuse of drones by criminals and terrorists also plays an important role. The technology is not anticipated to make transportation more safe and secure.
- *Battery Efficiency:* There are difficulties concerning battery capacity and data communication. Longer flight times and more substantial payload capacities are critical. Future drone systems will need innovations in battery technology to handle heavier loads and cover greater distances.

CONCLUSION

Drones are not yet able to conduct complex multiple deliveries and therefore can hardly be considered a competition for conventional city logistics. As delivery and passenger drones may soon come closer to real life implementation they will become more 'tangible' to wider parts of society. Drones are already making a huge impact, and the possibilities are still endless. Drones are expected to become a "game changer technology" for the transportation sector, with the potential to revolutionize logistics processes and passenger transportation. The race to create autonomous flying vehicles is on, with companies such as Uber, Airbus and Volocopter already developing them.

Although drones are already common in security services, military, and agriculture, their use as transportation devices is still in its infancy. Drones have the potential to become an iconic technology of the 21st century. We are nowhere near the full potential of this future-now devices. Future development of drone technologies will be increasingly dependent on public acceptance. The future of drone transportation hinges on further advancements in AI, sensor technology, and autonomous flight systems. More information about drones in the transportation industry can be found the following related journals:

- *American Journal of Transportation*
- *Transportation Research Interdisciplinary Perspectives*

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Figure 1 A typical drone [1].

Figure 2 A drone is usually controlled by operators on the ground [1].

Figure 3 A typical delivery drone [5].

Figure 4 A typical cargo drone delivery [6].

Figure 5 An infrastructure drone inspection [7].

Figure 6 A drone-delivered medical supply [8].

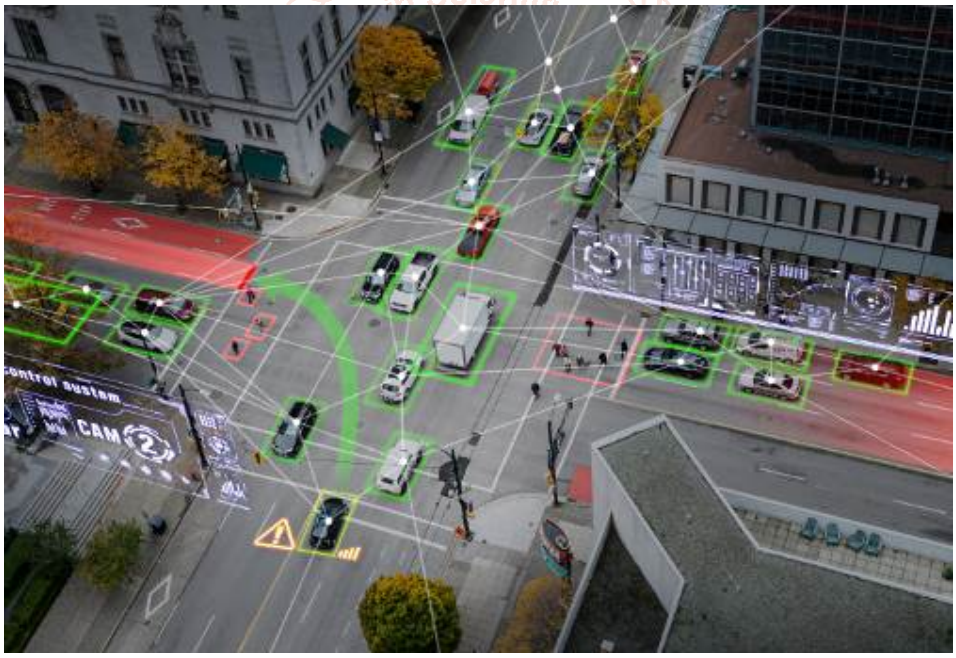

Figure 7 A typical traffic situation [5].

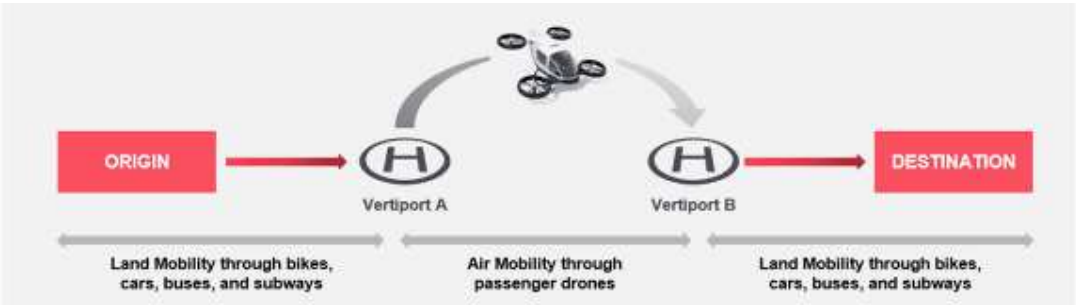

Figure 8 Passenger drones connecting other transport mode [10].