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Business Applications of Cargo Drones in the EU

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Abstract

Drones have become ubiquitous in various industries due to their versatility and efficiency in performing various tasks, from agricultural operations to search and rescue missions. This paper explores the use of drones, particularly cargo drones, in revolutionizing logistics and transportation systems. Medium-range cargo drones offer the potential to transform freight transportation by offering independence from traditional infrastructure and potentially reducing environmental impact. However, the integration of UAVs into existing logistical operations faces several challenges, including regulatory hurdles, technological limitations, and public perception issues. Drones can become a viable form of cargo transportation given that the regulatory challenges are addressed and can be efficiently integrated into the existing logistic operations. It would ultimately result in an efficient last-mile delivery option and will revolutionize the logistics industry.

Keywords: UAV; Drones; Air logistics; Cargo Business, EU, Autonomous flight

1. Introduction

Unmanned Aerial Vehicles (UAVs) are remotely or autonomously controlled aircrafts using advanced software and wireless technology. They come in different shapes and sizes and serve a variety of functions. Their roles are becoming more physical, and they are changing the industries they work in. For example, in precision agriculture, they are utilized to apply agrochemicals and distribute seeds. In forestry and agriculture, unmanned aerial vehicles (UAVs) are utilized for diverse purposes, such as watering plants, measuring surfaces, assessing damage caused by wild

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animals or bad weather, and diagnosing plant illnesses (Karbowski & Minda, 2023). UAVs are saving lives as they are utilized in maritime rescue and firefighting. They also have recently taken the task of transporting groceries, packages, medication, and humanitarian aid – often in far-off places with restricted access (Bogue, 2023). UAVs are also used in military applications like the detection of land mines, and they are anticipated to be indispensable in counterterrorism and counter-illegal migration activities in the future (Reddy & Venkatesh, 2023). UAVs have also been utilized in search and rescue operations at disaster sites, as well as in medical and humanitarian actions to facilitate the rapid delivery of medical supplies and equipment (Koščáková et al., 2023). UAVs are also being used in warehouses to improve productivity through stock inspection, inventory management, and visual feedback (Bayas et al., 2023).

Table 1. Drone types, their use cases, advantages, and disadvantages. Source: (https://www.auav.com.au/articles/drone-types/)

Drone Type	Advantages	Disadvantages	Uses and Prices
Multi-Rotor Systems	• Vertical take-off and landing • Hovering-enabled flights • User-friendliness • Greater camera control • Ability to operate in confined spaces	• Shorter flight durations • Smaller payload capacity	• Aerial Photography • Aerial Inspection, Thermal reports, 3D scans. • Price: ranging from $5k to $65k for professional drones
Fixed-Wing Systems	• Increased coverage area • Extended flight time • Enhanced speed	• Space-demanding launch and recovery • No hovering capability • Difficult for novice pilots • Higher costs	• Aerial Mapping, Precision Agriculture, Surveillance, Construction. • Powerline inspections. • Price ranging from $25k to $120k for professional drones
Single-Rotor Systems	• Hovering-enabled flights • Greater endurance due to Gas-powered engine • Vertical take-off and landing • Greater payload capabilities	• Difficult for novice pilots • Higher costs	• Aerial LIDAR laser scan and drone surveying • Price ranging from $25 to $300k for professional drones
Fixed-Wing Hybrid Systems	• Vertical take-off and landing • Long-endurance flight	• Best of both worlds: With a little trade-off in hovering and forward flight. • Still in development	• Deliveries/Logistics • Price: TBD, in development

According to Garg (2022) and Rennie (2016), there are several types of drones, including fixed-wing UAVs, single-rotor drones, multirotor (Quadcopters, Hexacopters, and Octocopters), and fixed-wing VTOL UAV systems. Because of their longer flight times and greater durability, fixed-wing drones are a good fit for package deliveries and remote inspections. Multirotor drones, on the other hand, are considered for search and rescue operations as they can hover in one spot and are more agile as compared to quadcopters (Sönmez et al., 2023). Smaller drones are often used for recreational purposes, but other drones, like tactical, reconnaissance, large combat, non-combat, target and decoy, and

GPS drones, are employed for military or commercial purposes. Drones for photography are also used to capture high-resolution images of large areas and are outfitted with professional-grade cameras (Rennie, 2016).

Fig.1. (a) Single-Rotor UAVs; (b) Multi-Rotor UAVs.

Figure 2. (a) Fixed-Wing UAVs; (b) Fixed-Wing Hybrid UAVs

Figure 3. (a) Small UAVs; (b) Micro UAVs; (c)Tactical UAVs

UAVs can be categorized according to their dimensions, weight, altitude, endurance, and landing technique (Okulski & Ławryńczuk, 2022). The materials used to construct drones, like fibreglass or carbon fibre-reinforced composites, are essential for boosting strength and lowering weight (Hiromi & Eiji, 2017).

This paper aims to review the current cargo drone technology and its suitability and commercial viability in the context of the EU. The review seeks to offer insights into the technological aspect of medium-range cargo drones, their business potential, current impediments towards complete adoption, and envisaged benefits associated with successful integration.

2. Technological advancements in UAVs and Cargo Applications

Cargo transportation presents a rational means to push unmanned aircraft into the commercial landscape and is expected to catalyze public acceptance across all areas. Cargo drones, due to their modular design, can transport loads of various sizes, shapes, and masses, providing a practical and cost-effective alternative to traditional cargo transportation methods. These drones can transport diverse types of goods, such as palletized or depalletized packs, hazardous materials that can be moved by air to reduce risk and can be dropped into collection or drop zones without requiring individual landing platforms (Bridgelall, 2023; Neubecker et al., 2017; Ruini, 2017; Mishra et al., 2023; Davydov, 2017).

Schiano et al. (2023) developed a drone system made of carbon fiber with an elliptical shape allowing efficient movement. Drone docking structures can facilitate stability in cargo transportation to their destination by allowing a safe approach and landing (Obaidi, 2015). Cargo drones can also benefit from cutting-edge features such as multi-factor authentication subsystems, scheduling coordinators, and management portals for a more secure package delivery (Kim, 2018). Despite these benefits, drone delivery systems have a few drawbacks and hurdles that limit their complete incorporation into the current logistical operations, like legal restrictions, security issues, and technological constraints (Ross, 2023). Nevertheless, it is a fact that medium-range cargo drones can transform the transportation and delivery industry by offering faster deliveries and easier access to remote areas (Schiano et al., 2023).

Various types of engines are used to propel drones with a medium range. A hybrid engine mechanism combines electrical motors and fuel engines to achieve a high payload-carrying capacity over an extended flight time (Ghassan et al., 2023). Another type of engine used is a microturbine engine. Some drones combine noise and vibration reduction technology to extend their range and improve safety (Dutczak, 2023). Modern electromagnetic engines offer low consumption, longevity, and AC/DC current compatibility (Bae, 2019). Several factors should be considered while deciding the engine type for a specific cargo operation, including vibration and noise reduction, long-term drive capability, weight reduction, durability, and failure resistance to prevent crashes (Bae, 2019; Ishikawa, 2023). Various engine types provide distinct benefits and features to enhance power and propulsion, such as annular, radial flow gas turbine, or solid rocket injection engines (Heuvel, 2023; Wen et al., 2019). Table 2 discusses commercially available drones with different engine types, characteristics, and use cases.

Table 2. Technical specifications and use cases of available cargo drones.

Drone Model	Engine Type	Carrying Capacity	Distance Range	Use
Volansi Voly C10	Electric	Up to 10 kg	Up to 50 km	Delivering medical supplies, spare parts
Elroy Air Chaparral	Hybrid-electric	Up to 100 kg	Up to 500 km	Autonomous cargo delivery
Skypersonic Skycopter	Internal Combustion	Up to 20 kg	Up to 200 km	Surveillance, monitoring, cargo delivery
Dronamics Black Swan	Fixed-pitch IC Engine	Up to 350 kg	Up to 2,500 km	Medium-range cargo transport
Wingcopter 198	Electric	Up to 6 kg	Up to 100 km	Delivery of urgent goods
Quantum Systems Vector	Electric	Up to 5 kg	Up to 100 km	Mapping, surveying, agriculture
UAVOS UVH-EL3	Electric	Up to 100 kg	Up to 300 km	Cargo delivery, surveillance
F-drones FD52	Electric	Up to 5 kg	Up to 50 km	Maritime deliveries, logistics
RigiTech Ranger	Electric	Up to 50 kg	Up to 150 km	Agriculture, surveillance, cargo delivery
Swoop Aero SP22	Electric	Up to 4 kg	Up to 250 km	Medical supplies, pathology specimens
Volocopter VoloDrone	Electric	Up to 200 kg	Up to 40 km	Heavy cargo transport
DHL Parcelcopter	Electric	Up to 6 kg	Up to 40 km	Parcel delivery
Flypulse FP1	Electric	Up to 30 kg	Up to 200 km	Aerial survey, cargo delivery

The carrying capacity of cargo drones varies from 1.3 to 2.27 kg (Peinecke & Mühlhausen, 2022), with efforts to integrate larger drones, capable of carrying up to 1000 kg, into national airspace using the EASA Specific Category (Izyumov et al., 2021). Multiple drones can autonomously transport heavy payloads, with capacities of up to 2 kg with two vehicles and up to 3 kg with three vehicles (Bulka et al., 2023). Moreover, A U.S. startup is exploring a novel concept for seaplanes that might eventually grow into massive cargo drones capable of carrying 109 metric tons of cargo across the Pacific, landing on their own in the ocean, and unloading at ports worldwide. The goal of the 2014-founded business Natilus was to construct massive cargo drones that could transport goods across international borders considerably faster than ships and for around half the cost of piloted aircraft (Hsu, 2023). Various factors influence the capacity of a cargo drone, including payload weight, energy efficiency impacting flying range, and airspace regulations (Arogeti & Yehezkel, 2023; Jassowski & Thirunahari, 2016; Peinecke & Mühlhausen, 2022). Bridgelall (2023), in a study, notes that airspace regulations, payload weight, and energy efficiency all impact a cargo drone's operational range. Arogeti and Yehezkel (2023) suggested that operators can optimize their drones' range for future missions by developing an energy model that calculates the energy usage depending on the wind speed and direction. With today's battery technology, cargo drones can travel up to 4 km (Bridgelall, 2023), and with investigations into unique trajectories to enhance safety, day-to-day cargo drone operations can become a reality very soon (Peinecke & Mühlhausen, 2022). Cargo drones exhibit potential for long-distance transportation, offering an environmentally friendly alternative to ground transportation (Kornatowski, Mintchev, et al., 2023).

Delivery of sizeable cargo items via cargo drones faces some challenges, such as safety issues, limited storage, and obstacles. Exposed rotating propellers present a great hazard to humans and can be solved by retrofitting the drone with protective cages (Nurgaliev et al. (2023), also foldable cages offer a great solution for the transportation and storage of these modular drones (Bridgelall, 2023). Navigational issues due to the presence of obstacles in drone delivery routes can be resolved by introducing smart systems like Artificial Intelligence and reinforced learning for drones (Martin et al., 2023). Commercialization of medium-range cargo drones faces several impediments like security concerns, regulatory complexities, high capital costs, increased consumer demands, environmental problems, and technical limitations (Cao et al., 2023; De Reyes & Macneill, 2023; Kornatowski, Bhaskaran, et al., 2023; Nurgaliev et al. 2023; Schiano et al., 2023). Addressing these challenges is critically important for the successful implementation of medium-ranged cargo drones into the current logistical industry and to improve their overall commercial viability. Data-enabled tools, progressive policy measures, and enhanced flight operations could greatly benefit their successful integration into the current business models. Li et al. (2023) propose utilizing general aviation airports as branch distribution networks for cargo drones to ensure safe operations alongside manned aircraft. Bridgelall, 2023 specifies urban regions where cargo drone deployments would significantly impact drone operations, especially when transporting hazardous materials, to enhance drone safety, effectiveness, and environmental advantages. Meanwhile, another researcher presents a vehicle routing problem with drones, combining Branch-and-Price and Lagrangian relaxation methods to enhance delivery services' effectiveness and economy (Comtet et al., 2023).

Medium-range cargo drones can provide numerous benefits like cost savings, timely deliveries, greater flexibility, and emission-free modes of transportation (Nurgaliev et al., 2023). Additionally, real-time tracking, efficiency gains, and safety enhancements are all possible with drones, improving accessibility and consumer satisfaction (Kirschstein, 2023). However, various obstacles and constraints must be addressed before widespread acceptance, including public perception, battery life and range limitations, weather conditions, safety and regulatory requirements, and navigation challenges (De Reyes & Macneill, 2023). Additionally, the energy-saving capacity of drones is influenced by structural features and environmental factors, with urban areas posing challenges for energy conservation compared to rural areas (Li et al., 2023).

3. Recent Cargo-drone Practices in the EU

The development and use of cargo drones have received support from the European Union through several initiatives. Geographical UAS zones, or "geo zones," have been established as of December 31, 2020, after the new drone regulations. Drones meeting specific technical and operational requirements are allowed entry into these zones, along with usage restrictions. A UAS Geozone, is a defined region of the airspace where the use of unmanned aircraft, like drones, is regulated and restricted. The purpose of these Geozones is to facilitate the safe and controlled integration of unmanned aerial systems (UASs) and drones into the airspace, especially in regions with high aviation activity, sensitive areas, or where specific airspace management is needed. The Geozone aids in airspace management and guarantees the safe coexistence of drones and unmanned aerial systems (UASs) with other users of the airspace, including manned aircraft.

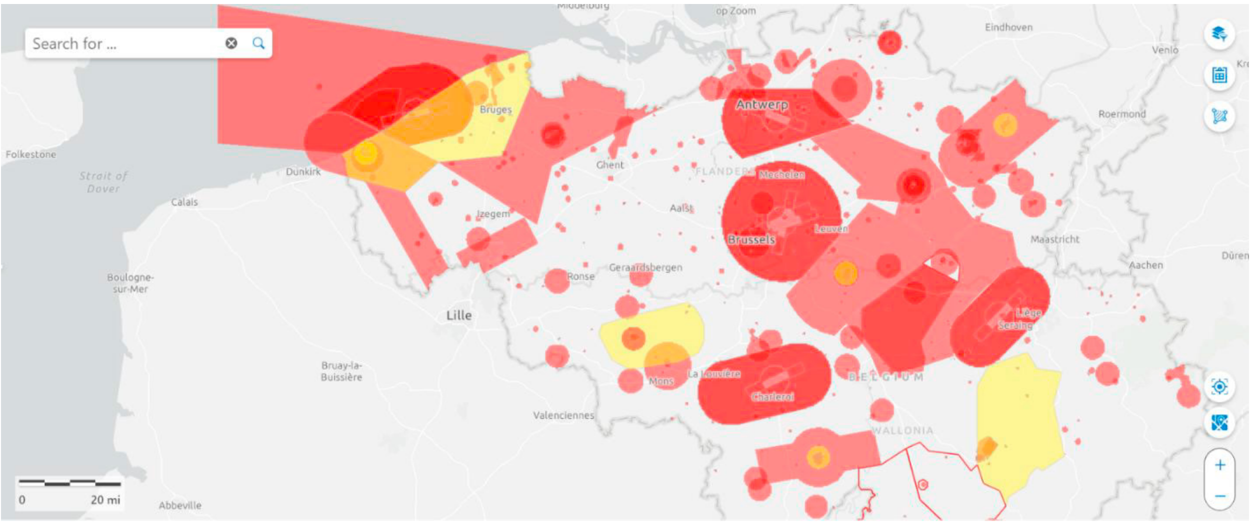

Figure 4. UAS geographical zones statuses in Belgium (yellow color-become active today, red-active. White- not active). Source: (https://map.droneguide.be/)

Projects like SAFIR-Med aim to demonstrate the use of cargo drones for medical deliveries in Antwerp, Belgium. The European Union funds this project and has several partners, including Skeyes, Helicus, Unifly, and DronePort. Dronamics is a Bulgarian company that offers cargo drone services and operates a network of drone ports across Europe, including one in Liege, Belgium (O'Brien, 2022). Their drone system, "Black Swan", can carry up to 350 kg of cargo and fly for up to 2,500 km (Piscopo, 2022). Compared to traditional air freight, they claim that they provide reduced costs, expedited delivery, and reduced emissions (O'Brien, 2022). DronePort is a business park and testing facility in Sint-Truiden, Belgium, catering to innovative companies in the aviation and drone industries. Repurposed from a military airfield, it is now used for civil aviation, particularly for drones and unmanned aerial systems (UAS). Its transition altitude is 4,500 feet AMSL, which is classified as G airspace. The idea is to offer infrastructure and services for commercial drone operations in a given area. It's like an airport, only with drones instead of people. It can manage airspace, logistics, and drone fleet services. It can also function as a node to link various drone ports and build a drone delivery network.It provides a range of amenities and services, including coworking spaces, meeting rooms, office spaces, workplaces, UAS test zones, and Limburg Regional Airport for start-ups, scale-ups, and established businesses (Droneport.eu, 2024).

In the EU, the category labeled as "certified" handles the riskiest operations by EASA. This applies to any future drone flights carrying people, like the air taxi, for example. The strategy employed to guarantee these flights' safety will be strikingly like that of manned aviation. Because of this, an appropriate authority will grant the approval to the air operator, and the remote pilot must possess a valid license. Also, these aircrafts will require a certification from a competent authority for airworthiness. In the long run, it's anticipated that drone automation will rise steadily until fully autonomous drones can operate without the assistance of a remote pilot.

4. Commercial Viability of UAVs: Potential Challenges

There's growing interest in finding better ways to transport goods and solve associated challenges. Liebhardt and Pertz (2022) suggest setting up a network of flights for moving agricultural equipment, spare parts, and aid during flood relief missions in Europe. Jassowski and Thirunahari (2016) suggest using drone swarms to boost cargo capacity, while Jones and Pannell (2017) discuss the potential of image processing cargo detection using optical markers. Theoretically, these models could allow smaller drones to deliver with greater efficiency at a lower cost.

The success of medium-range cargo drones is determined by two main factors: government regulations and technological advancements (Raj & Sah, 2023). Government regulations define the legal and operational requirements for cargo drones, while technological advancements are critical to the development and effectiveness of these drones. However, the biggest problem with larger drones is their successful incorporation into National Airspace, and that means devising exact routes and other safety measures to ensure the reliability and the safety of these larger vehicles (Bridgelall, 2023; De Reyes & Macneill, 2023). Nevertheless, medium-range cargo drones can change the landscape of transport services (Peinecke & Mühlhausen, 2022; Zhang, 2023).

Several regulatory challenges must be overcome to facilitate the commercialization of medium-range cargo drones. These include integrating larger drones into national airspace, addressing privacy and security concerns, and creating a regulatory framework that supports commercial drone operations (Bassi, 2023; T. Jones, 2023; Olsen, 2017; Vannoy & Medlin, 2016). Additionally, there are apprehensions related to data collection, use, privacy safeguards, telecommunications and cyber-security violations. Overcoming these challenges requires collaboration between stakeholders, including governmental regulators, industry players, and technology providers. Adoption of cargo medium-range cargo drones can yield a 34% cost reduction when just compared to trucks alone and could reduce greenhouse gas emissions by up to 96% for last-mile deliveries (Tamke & Buscher, 2023; Coindreau et al., 2021). However, several factors also impact the overall efficiency of operations, like weather, flight restrictions, and customer density (Kirschstein, 2020; Charoenwut, 2020; Rodrigues et al., 2022).

5. Conclusion

This paper surveys the medium-range cargo drones, recent technological developments, current practices in Europe, their commercial viability in the EU's landscape, and potential challenges faced toward complete integration into the logistical operations. Cargo drones can potentially revolutionize business by providing a cheap and environmentally friendly mode of goods transportation. Governmental policies and regulatory frameworks to accommodate drone delivery operations could greatly aid in seamless adoption. The article also highlights the technological constraints faced by the current drone technology and how things could improve by integrating state-of-the-art technology with drone delivery operations. To summarize, medium-range cargo drones hold the promise to revolutionize the logistics industry, and with governmental cooperation, they can become a great tool for smart logistical operations, providing endless benefits to society.

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