Drone Deliveries: Taking Retail and Logistics to New Heights

2024 Outlook & A Perspective Beyond

PwC Drone Powered Solutions

Global Centre of Excellence in Drone and Geospatial Technologies

2024

Aleksander Buczkowski

Director
PwC Drone Powered Solutions

We are on the verge of an integrated drone delivery ecosystem which will transform retail and logistics last-mile delivery markets. This comprehensive report advocates drone delivery integration in various sectors, in which retail chains, logistics companies, restaurant chains, etc., can create new sales channels, reach additional clients, enhance last-mile delivery efficiency and lower capital expenditure when expanding their businesses.

Pilot projects, business cases and market implications from our studies suggests that drone delivery technology and their associated markets will exponentially increase in the next 10 years, with industry leaders like Walmart already investing in this transformative technology. Within this report's pages, there are analyses of these key industry leaders, and the impact that their investments will have on bridging accessibility gaps and reducing CO_2 emissions associated with logistics.

Through our in-depth research, invaluable experience and unparalleled expertise in drone technology, we strive to support and elevate stakeholders worldwide throughout the operational and regulatory challenges such as UTM management, whilst providing strategic advice into the implementation of drone platforms, deployment models and their associated operational frameworks. Together, we can utilise the innovative drone technology that will revolutionise the future of last-mile deliveries and further propel the retail and logistics markets.

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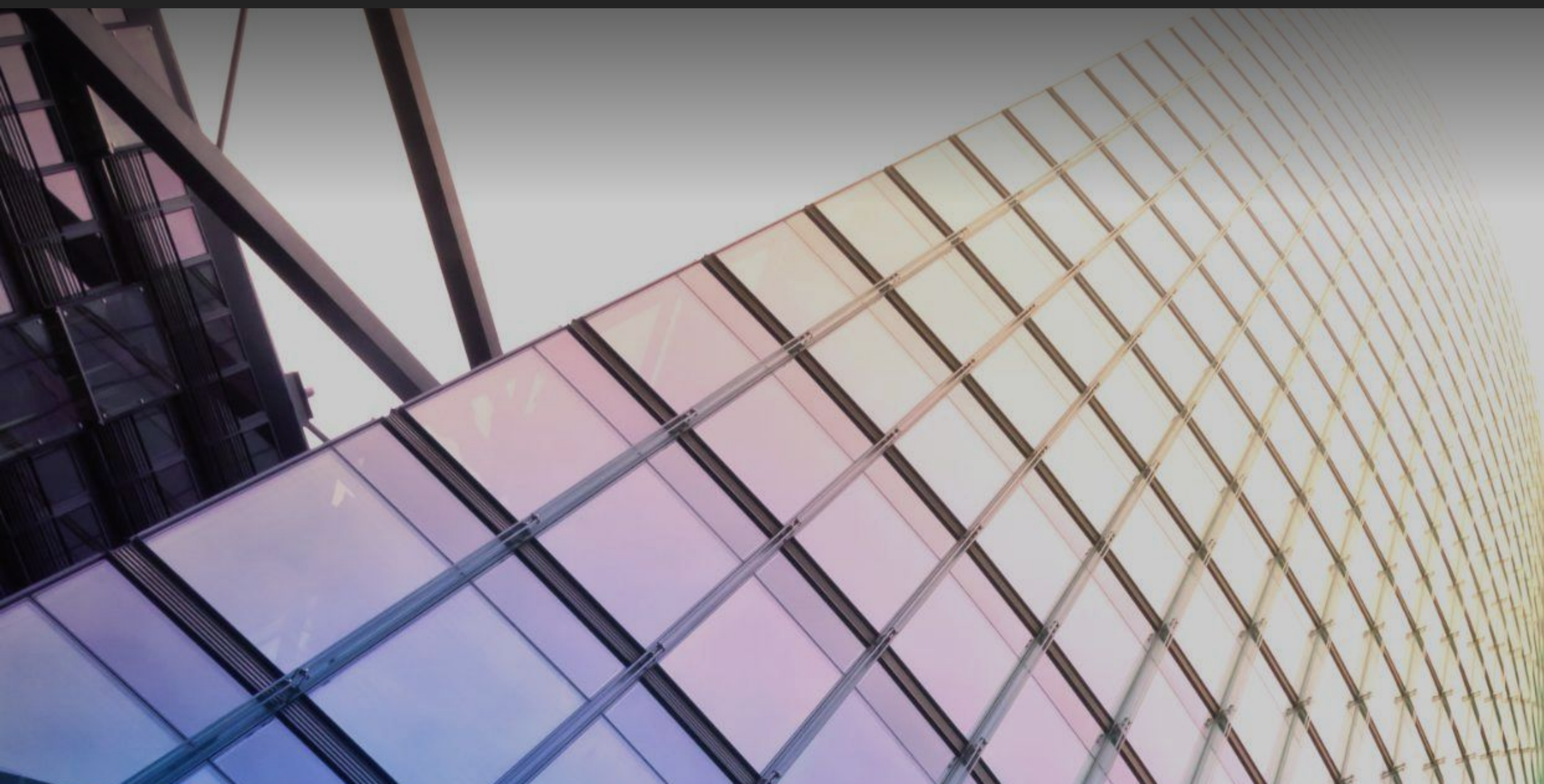


Executive Summary

Executive Summary

Drone technology is a game-changer in multiple industries and delivery drones have the potential to transform last-mile logistics.

According to our estimates, **around 5 million** business-to-consumer **(B2C) drone deliveries** will occur **worldwide in 2024**, indicating a notable shift in logistics.

Our projections suggest that advanced air mobility (AAM) of goods could serve approximately **67% of the global population**, particularly suburban and rural residents, **potentially substituting 389 billion traditional deliveries worldwide in 2034**.

With unit economics estimating **delivery costs to be around $2 in 2034**, unmanned aerial systems (UAS) offer an enticing alternative for businesses to penetrate new markets, enhance customer satisfaction, and boost profitability, particularly in areas where traditional last-mile deliveries struggle.

Along with increased adoption, the unit economics are rapidly improving – with the average unit cost per delivery **currently ranging between $6 and $25**. This price is expected to **drop by more than 70% over the next 10 years**, which will not only match traditional last-mile delivery costs, but surpass them and create an inflection point for the industry as it achieves widespread adoption.

2024 **14,000** deliveries daily

2034 **808m** deliveries worth **$65bn** at a cost of **$2** each

This report explores the market potential for drone deliveries in the context of **retail and logistics companies** – showing how the adoption and leverage of the technology can radically transform how these businesses operate and how they serve their customers.

This report focuses solely on commercial drone deliveries related to B2C applications. As such, other civil drone delivery use cases and operations scenarios (e.g. mission critical, shore-to-ship, industrial deliveries, etc.) are not part of this document's scope.

All financial figures are expressed in US dollars.

Drone Deliveries:

Taking Retail and Logistics to New Heights

Estimated market size*

* Value of B2C goods delivered by drones

$251m
[2024]

$4bn
[2029]

$65bn
[2034]

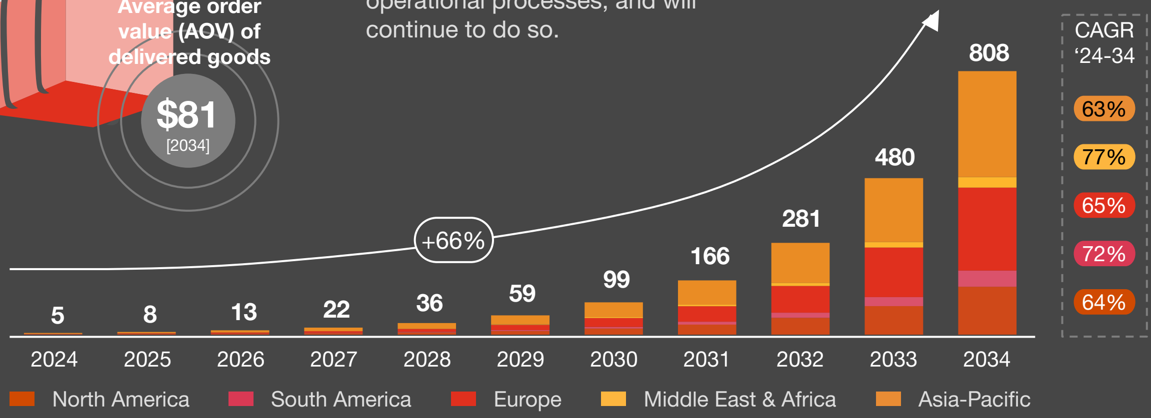
Cost of single delivery
$2
[2034]

Average order value (AOV) of delivered goods
$81
[2034]

Drones, with years of accumulated development and proven technical capabilities are becoming long-sought delivery solutions. Major commercial players, like Walmart, Amazon, and DHL, believe strongly in this technology, have invested in full-scope deployments in their operational processes, and will continue to do so.

It all started from swift aerial deliveries of medical supplies to remote areas in Africa. Shortly after, **it was evident that this model will also elevate commercial applications, mainly for retail and logistics** where drone deliveries could bring the most value to customers.

Number of B2C drone deliveries, million



Answering strategic questions to launch drone delivery

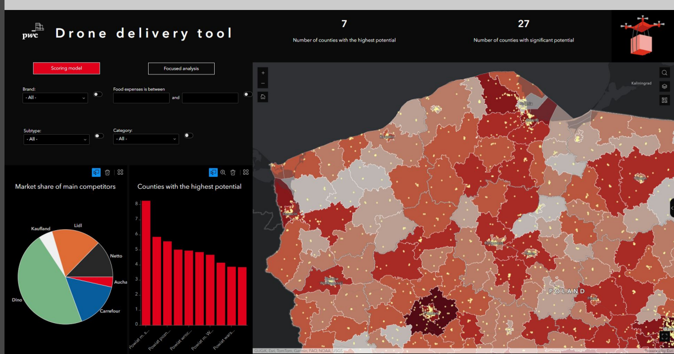
1 What to deliver?	a. Prescription medicine	b. Food	c. Parcel & e-commerce	d. Other goods		
2 Where to deliver?	a. Urban	b. Suburban	c. Rural	d. Remote		
3 What technology to select? — **Aircraft / Platform**	a. Multirotor	b. VTOL	c. Fixed-wing			
Payload release mechanism	a. Land and drop off	b. Window frame	c. Locker	d. Winch	e. Winch with droid	f. Parachute
4 How to organise operations?	a. Point-to-Point	b. Hub-and-Spoke				

PwC Global Drone CoE offers support with:

- **Strategic Advisory**
- **Market Sizing**
- **Target Operating Model**
- **Regulations and Compliance**
- **Business Case**
- **Site Selection**

PwC Drone Delivery Location Finder

Our tool Advanced Geospatial Analysis Tool



Quotes

Sabine Durand-Hayes

Partner
Consumer Markets Global Leader
PwC France

With a projected 74% CAGR increase in drone-delivered goods over the next decade, early drone adoption is advantageous. Despite challenges, the opportunities for companies embracing this technology are immense.

Consumers now seek reassurance and reliability amid financial, ecological, and technological disruptions. Drone delivery passively meets these demands, offering eco-conscious consumers environmental benefits, value-conscious consumers cost-efficiency, and innovation-driven consumers cutting-edge experiences.

Whilst delivery services represent a small retail market segment, last-mile delivery is the most expensive, time-consuming, and disruption-prone. Implementing drones will cut overall cost, improve delivery times, and enhance your brand image, customer satisfaction, and customer loyalty—outcomes supported by past market trends.

Mieczyslaw Gonta

Partner
Retail, Consumer and Industrial Products Leader
PwC CEE

CEE's consumer and retail markets are rapidly evolving, driven by energy, political, and environmental challenges. In the wake of COVID-19, the region has shown remarkable resilience when navigating inflation, supply chain uncertainties, labour shortages, and energy crises. This resilience has fostered innovative solutions crucial for future growth.

Our CEE market research highlights a decisive shift towards digitisation and automation, reflecting a consumer base that increasingly expects these advancements. Drone delivery, as a major recent innovation, plays a critical role for businesses, especially those focused on last-mile logistics. Beyond improving operational efficiency, it acts as a key differentiator, positioning them as industry leaders in an ever changing market.

Drones also contribute to ESG goals by reducing carbon emissions and minimising environmental impact, aligning with CEE's commitment to sustainable innovation and green growth.

1 Drone Deliveries in a Nutshell

Introduction to Drone Deliveries

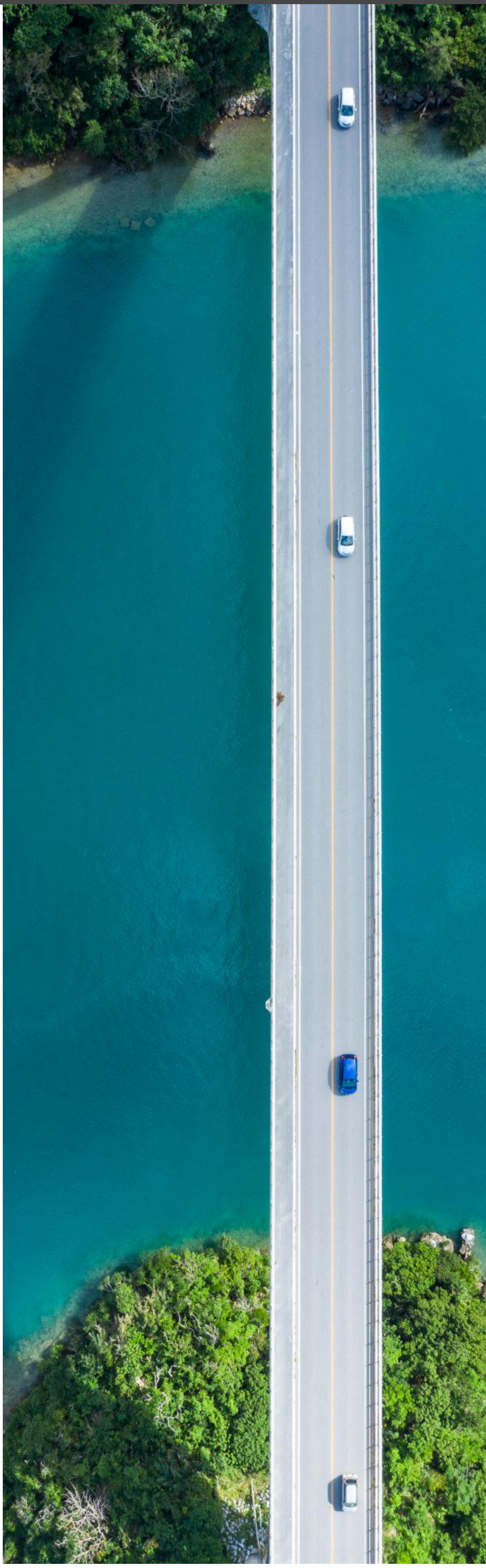
ONE of the most exciting commercial applications of drone technology in the recent years is the delivery of goods. Retailers and wholesalers have spent a tremendous amount of time, effort, and resources over the past few decades to optimise last-mile delivery and ensure seamless, convenient, and reliable delivery outcomes for millions of consumers around the world. However, this task is notoriously complex, and even with very mature distribution networks, there are still some major challenges that these players face when it comes to delivering goods to customers. Drone technology is well placed to address some of these, such as:

- To be able to deliver parcels/takeaways within minutes after their preparation;
- To deliver parcels/takeaways to destinations far from city centres;
- To limit the carbon emissions related to deliveries for the benefit of local communities and the environment;
- To be affordable and convenient to handle.

Thanks to technological advancements and successful pilot projects worldwide, these benefits have been proven and as such, drones have quickly become a viable option for complementing or even replacing conventional models of last-mile delivery. The end-to-end value proposition has become more mutually beneficial, for the business delivering the goods and the consumers receiving them, as a result of current drone delivery operations and the benefits they will have on last-mile deliveries in the future.

Our analysis of existing drone projects shows that by embracing the technological and revenue-generating potential in drone deliveries, retailers and logistics companies can improve the client experience, reach new client segments, and increase the efficiency of their operations. Moreover, this presents an exciting opportunity for investors who are seeking further exposure to the fast-growing drone industry.

The following sections of this report aim to explore the fundamentals of B2C drone deliveries and encourage further consideration of how unmanned aerial systems can catalyse innovation within the logistics and retail sectors.



From Idea to Reality: The Origins of Drone Deliveries and Current Landscape

THE IDEA of using unmanned aerial vehicles, more commonly known as drones, for commercial delivery, has been a hot topic since 2013. Back then, Amazon announced plans to use drones to deliver packages to customers by air. The announcement occurred a year after Matternet performed successful medical delivery trials with drones in Haiti and the Dominican Republic.

In the following years, the drone delivery industry saw a global surge in interest and experimentation. Companies like Wing, Zipline, and DHL conducted successful drone delivery trials in Australia, Rwanda, and Germany, respectively, which sparked a wave of innovation and regulatory response. Civil Aviation Authorities (CAAs) worldwide began to develop temporary mechanisms to allow such operations, and by 2017, regulatory frameworks, such as those established by the Federal Aviation Administration (FAA) in the United States, started to accommodate commercial drone operations, further propelling the growth of the industry.

The outbreak of Covid-19 in 2020 dramatically impacted consumer behaviour, pushing more people to shop online which increased demand for contactless delivery solutions. This surge in e-commerce and the need for safe, efficient delivery methods further accelerated the adoption and interest in drone delivery services as a viable and attractive option for last-mile logistics. As a result, many companies and regulatory bodies expedited their efforts to integrate and facilitate drone delivery services to meet the evolving demands of the market.

By 2023, the level of global demand had reached such a point that we estimate over 1 million successful B2C drone deliveries were conducted. In 2024, we expect these numbers to double to 2 million B2C deliveries globally. This proliferation of drone delivery services revolutionised last-mile logistics and laid the groundwork for future innovations in supply chain management and beyond.

2013

Amazon CEO Jeff Bezos announces plans for Amazon Prime Air, a drone delivery service, sparking widespread interest in drone delivery.

2016

Alphabet's subsidiary, Wing, launches a pilot drone program in Australia, delivering small packages to homes in a suburb of Canberra.
Zipline begins delivering medical supplies via drones in Rwanda, showcasing the potential for drones to provide life-saving services in remote areas.

2019

UPS receives FAA approval to operate a fleet of drones for package delivery in the US, marking a significant milestone for commercial drone delivery.

2020

COVID-19 pandemic accelerates interest in contactless delivery methods, leading to increased investment and experimentation in drone delivery solutions.

2021

Drone delivery services expand globally with companies like DHL, FedEx, and JD.com conducting trials and launching commercial operations in various countries.

2022

Regulatory frameworks for drone delivery continue to evolve, with governments worldwide adapting regulations to accommodate the growing industry while addressing safety and privacy concerns.

2023

Technological advancements in drone technology, including larger payload capacities, longer flight times, and improved navigation systems, further enhance the feasibility and efficiency of drone delivery services.

2024

Drone delivery becomes increasingly integrated into supply chain logistics, with drones having a clear upcoming role in widespread last-mile deliveries for e-commerce, healthcare, and humanitarian aid.

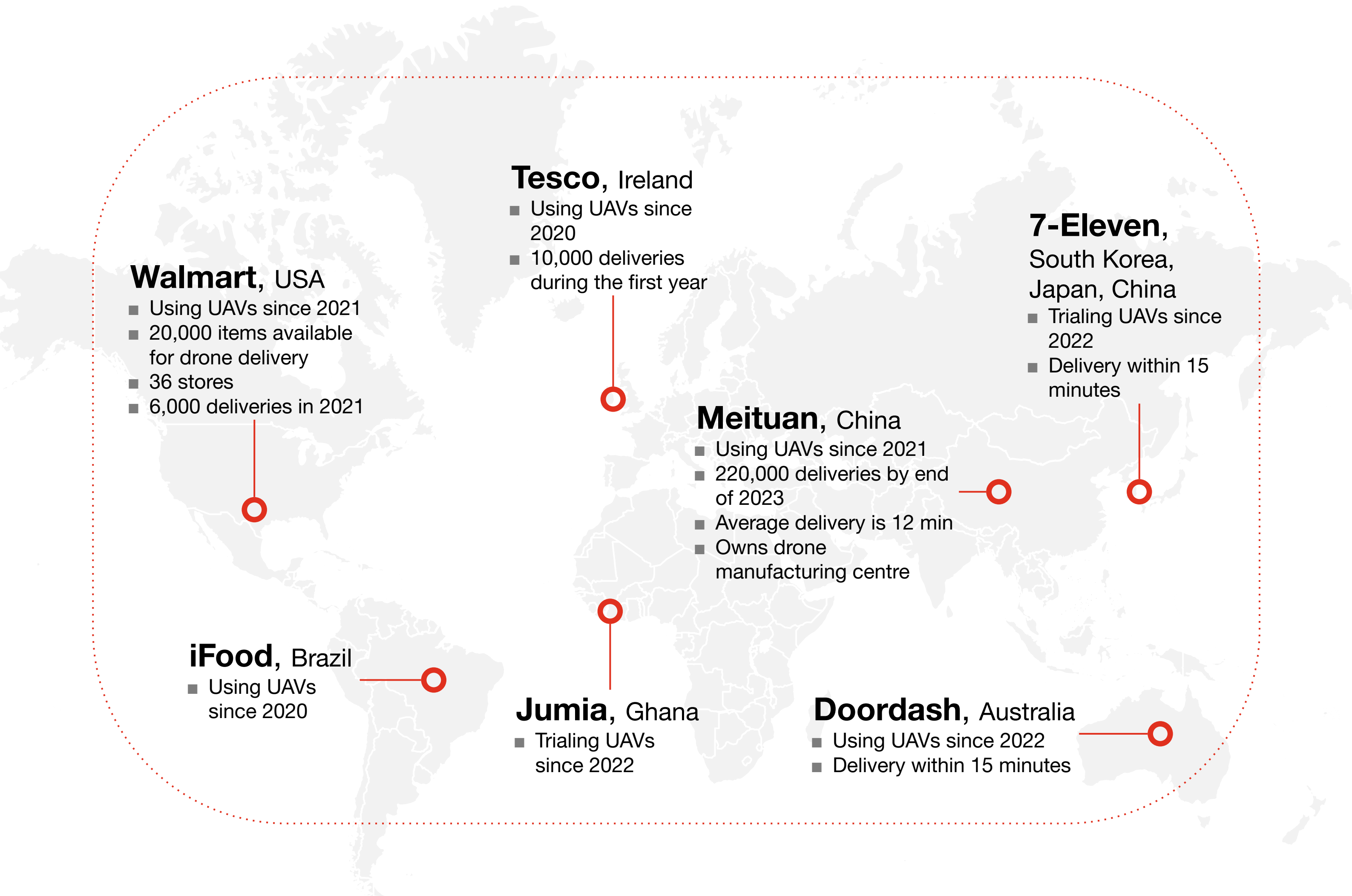


Figure 1.1. Examples of grocery stores, food delivery platforms and e-commerce companies that are trialing or using unmanned aerial vehicles (UAVs) to deliver goods to consumers.

Initially focused on transporting medical supplies to healthcare facilities, the true potential of drone delivery lies in the consumer market, offering unprecedented opportunities for businesses.

Business-to-consumer drone delivery services are expanding worldwide, with numerous companies and startups testing and implementing drone solutions. While the technology is still in its early stages, there is growing interest and investment in this innovative approach to last-mile delivery.

One of many notable examples of growth in the drone delivery sector is Wing, a subsidiary of Alphabet Inc. Wing has shown impressive progress, reaching 100,000 deliveries in three years by August 2021[1]. Remarkably, in just seven months, they doubled that number. By September 2023, Wing had completed over 350,000 deliveries in the United States, Australia, and Finland, handling a variety of items from packages to over-the-counter medicine[2]. This rapid expansion highlights the potential for drone delivery to significantly impact last-mile logistics.

2024

5m deliveries

Realised market potential for B2C drone deliveries in 2024

$251m

Value of goods delivered by drones in 2024

Market Size and Market Potential

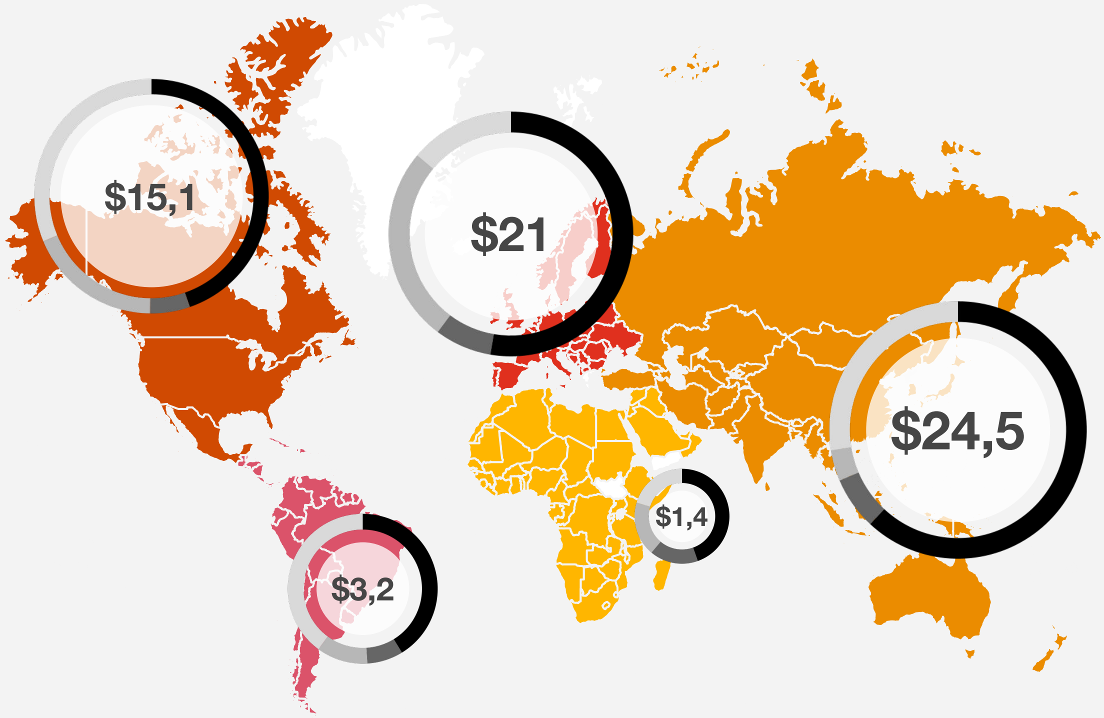


Figure 1.2. Value of Goods Delivered by Drones by Region and Type of Goods, 2034, $ billion

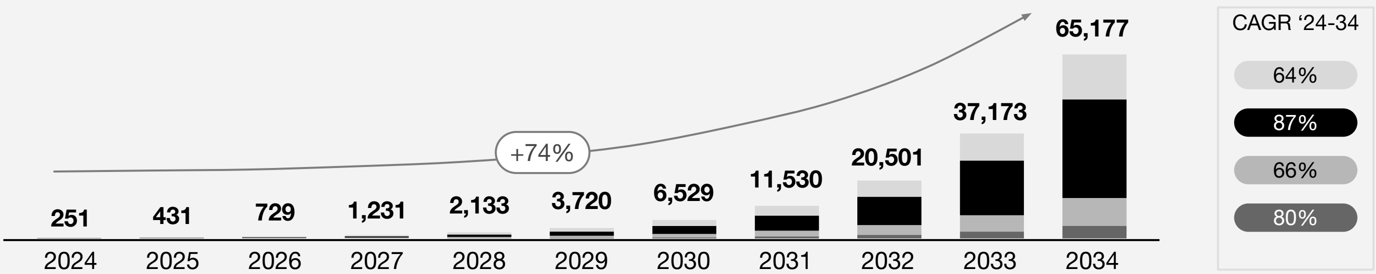


Figure 1.3. Value of Goods Delivered by Drones by Type of Goods, 2024-2034, $ million

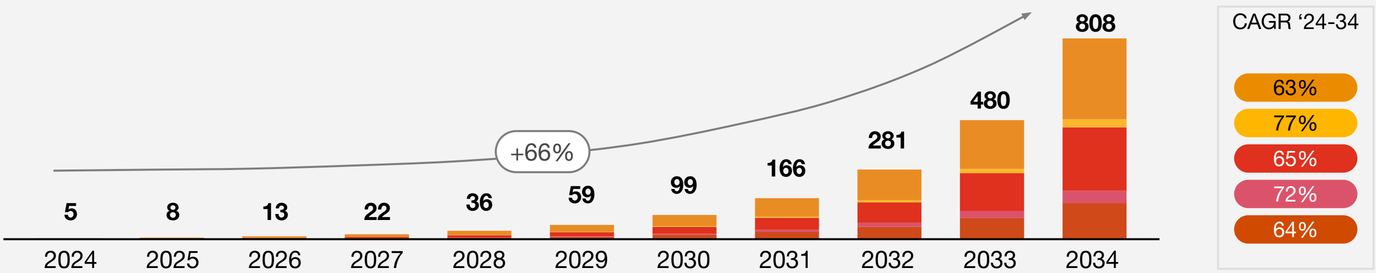


Figure 1.4. Volume of B2C Drone Deliveries by Region, 2024-2034, million

Type of goods delivered

Parcel & e-commerce | Prescription medicine | Food | Other goods

Region

North America | South America | Asia-Pacific | Europe | Middle East & Africa | Not covered

IN 2024, an estimated 14,000 daily deliveries will accumulate to 5 million B2C drone deliveries worldwide. This figure is projected to soar to an impressive 808 million within ten years (fig. 1.4).

Despite notable regulatory and operational constraints, particularly pertaining to Beyond Visual Line of Sight (BVLOS) drone operations, the potential for drone delivery to revolutionise the last-mile logistics industry remains substantial. In 2034, an estimated 389 billion last-mile deliveries can be substituted by drone-enabled services globally, highlighting the vast scope of this emerging technology.

At present, the Asia-Pacific region holds a dominant position in value and volume, closely followed by Europe and North America. This highlights the global reach of the transformative drone delivery trend.

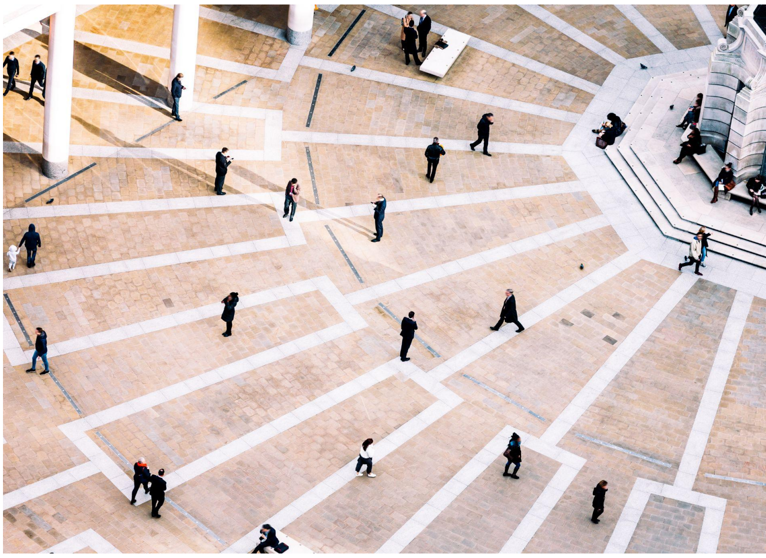
Over the next decade, this gap is expected to narrow, with Europe projected to solidify second place and have the potential to overcome the Asia-Pacific in the long run. The value of goods delivered to consumers by drones worldwide will grow by the CAGR of 74% on an annual basis, from $251 million in 2024 to $65.1 billion in 2034.

Our analysis reveals significant growth in drone delivery services across various sectors, such as parcel and e-commerce delivery, food delivery, and goods delivery. This trend indicates a growing acceptance and usage of drone technology in retail and logistics, pointing towards a promising future for the drone delivery market.

A significant share of products available in supermarkets and restaurants are eligible to be transported by drones. Similarly, a significant portion of goods sold offline from places like malls can feasibly be delivered to their final clients from, for example, the rooftops or parking lots of such buildings.

There is also a growing market for highly valuable parcels containing goods such as electronics, jewellery, gifts, and premium clothing, with customers paying extra for the convenience of having their goods delivered within minutes of ordering rather than by traditional same-day or next-day delivery.

The food segment, however, holds the largest share of all deliveries and will continue to do so.



2034

389bn deliveries

Full market potential for B2C drone deliveries in 2034

808m deliveries

Realised market potential for B2C drone deliveries in 2034

$65bn

Value of goods delivered to consumers by drones in 2034

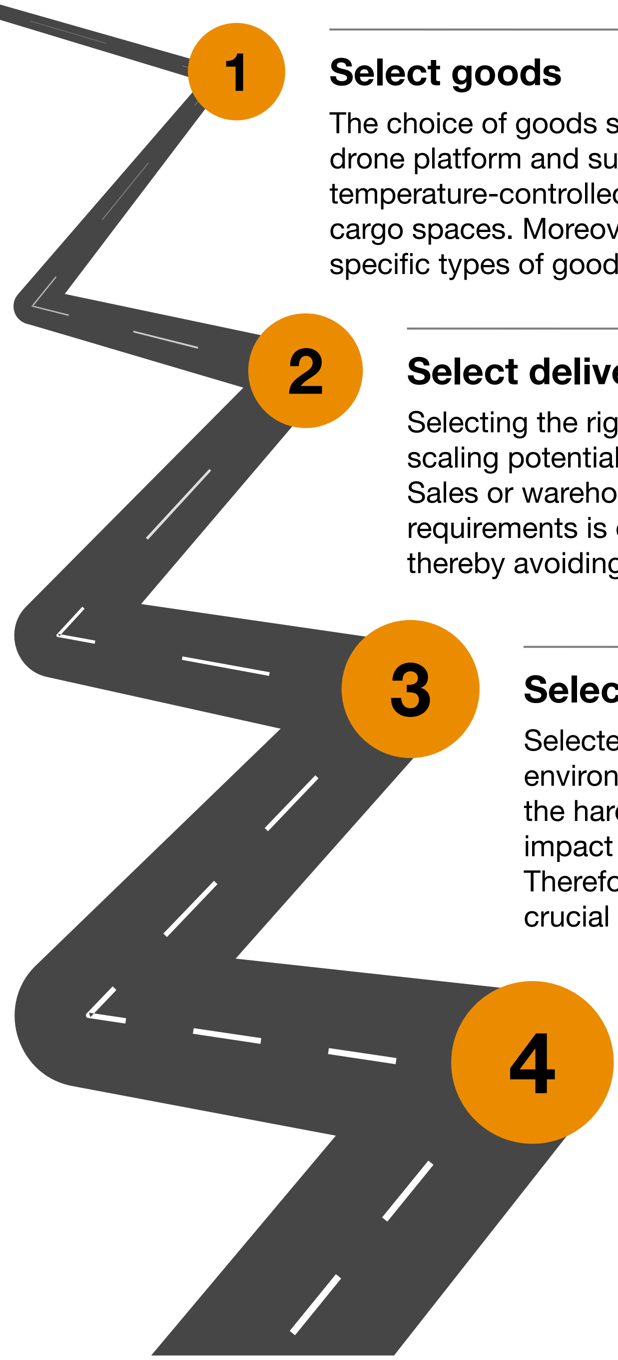
An example of the increasing adoption is the Chinese Meituan app, which delivered 184,000 food orders in just a year and a half after launching the service[3].

Manna Drone Delivery has 22 commercial partners across Europe, ranging from restaurants to supermarkets and fast-food operators to pharmacies. In a Dublin suburb that is served by drone delivery services, **40% of residents** have already started to make orders[4]. The company started operations in 2020 and aims for over one million deliveries by the end of 2024[5].

2 Getting Started with Drone Deliveries

Journey Overview

DEFINING the strategy for drone delivery should be a critical starting point for every retail, logistics, and food and beverage business. After years of slow growth, the concept of rapid delivery using drones has now been proven viable with hundreds of thousands of deliveries worldwide, despite awaiting regulatory approval for large-scale operations. The following sections outline the journey for strategic implementation of drone delivery, considering key elements required to ensure efficient operations, regulatory compliance and customer satisfaction, ultimately leading to success in the emerging drone delivery market.



Select goods

The choice of goods significantly influences the drone delivery strategy, especially the drone platform and supporting infrastructure. Food and medicine may require temperature-controlled compartments, while parcels and groceries may need larger cargo spaces. Moreover, understanding the demand for rapid delivery services of specific types of goods, in a given area is critical.

Select delivery area

Selecting the right geography is crucial for initiating drone delivery and evaluating scaling potential. The market assessed is limited to flight distance from Points of Sales or warehouses. Understanding each area's social, operational, and legal requirements is essential for compliance, efficiency and community acceptance, thereby avoiding regulatory hurdles and logistical challenges.

Select technology

Selected technology determines adaptability to different operating environments and the efficiency of the delivery process. For instance, the hardware's maintenance and operational requirements directly impact the drone delivery operations' overall cost and efficiency. Therefore, carefully considering and selecting the proper technology is crucial in shaping an effective and scalable drone delivery strategy.

Select operating model

Setting up processes and the required infrastructure (i.e. charging stations and maintenance facilities) influences the range, scope and unit economics of drone delivery operations. Careful consideration and optimisation of operational elements are essential in establishing a robust and scalable drone delivery strategy that can adapt to evolving market demands and regulatory requirements.

How can PwC help you?

PWC is a trusted partner to elevate retail and logistics with drones. We bring the unique expertise and methodologies of our PwC Drone Powered Solutions team which has experience in technology, tools, regulations, operations and market sizing, to our advisory capabilities in retails and logistics.

Strategic Advisory

Developing end-to-end strategies for deploying drone delivery operations

Business Case

Calculating the economics of implementing drone delivery operations

Regulations and Compliance

Analysing country specific regulatory and operational landscapes to determine how to comply with rules surrounding drone delivery operations

Target Operating Model

Selecting approaches to efficiently implement and scale up drone technology in line with companies' ambitions and goals

Market Sizing

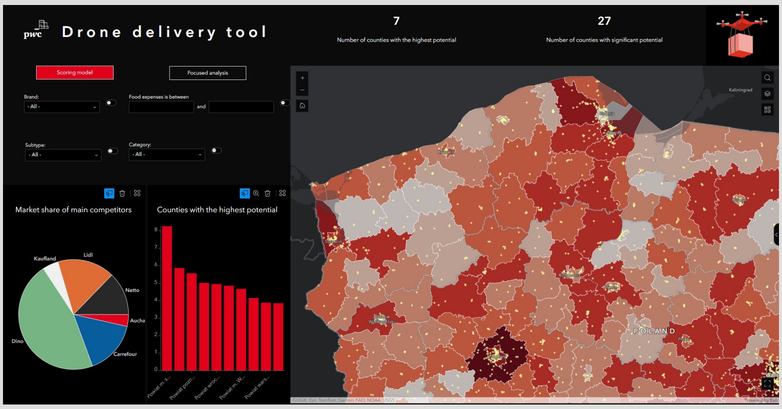
Analysing market size based on geodemographic data for specific sites, based on parameters such as the range of different delivery platforms and deployment models

Site Selection

Using our **PwC Drone Delivery Location Finder** tool to identify sites most suitable for drone delivery operations

(read more on page 22 of the report)

PwC Drone Delivery Location Finder



The **PwC Drone Delivery Location Finder** is a geospatial tool allowing businesses to assess **the feasibility of implementing drone delivery services** to their establishments, calculate and benchmark local markets and select sites.

It analyses multiple variables relating to **regulations, operations, drone platforms**, environment and **physiognomy, local market** and **population**, as well as other parameters.

Selecting the Right Products for Delivery

MOST goods can be delivered by air if they fit within the drone's weight and volume limitations. Exceptions include hazardous materials, which constitute a small market segment.

Successful examples, such as Speedbird Aero's food delivery in Brazil and Wingcopter's parcel deliveries in Germany, demonstrate diverse applications of drone delivery and its potential to transform last-mile logistics.

Items/types of commercial goods most suitable for B2C drone deliveries are presented below:

- **Food** – ready-to-eat meals and meal kits from restaurants and dark kitchens.
- **Goods** – grocery and non-grocery items from supermarkets and shopping malls.
- **Parcel & e-commerce** – same-day delivery from post and logistics facilities of the rest of businesses not mentioned above.
- **Prescription medication** – prescription medicine from pharmacies and pharmaceutical logistics facilities.

The type of goods being delivered influences the design and implementation of drone services. Each category presents unique challenges and requirements to ensure efficient delivery. For instance, food delivery may require temperature-controlled compartments, while prescription medication might need tamper-evident packaging. The technology, logistics, and regulatory compliance must be tailored to meet these specific needs.

Food

The food industry, driven by consumer demand for convenience and efficiency, is exploring drone delivery. Drones must be equipped with secure and insulated packaging to maintain food quality. They can deliver a variety of items, from hot coffee to ice-cold beverages, making temperature-controlled compartments essential.

Goods

Many goods sold offline, such as those from shopping malls, can be delivered by drones, benefiting mall operators. Ensuring safe delivery of items, from jars of jam to expensive jewelry, requires secure packaging that adapts to different sizes and shapes. Proper weight distribution is also crucial for safe handling.

Parcel & E-commerce

The rise of e-commerce increases the relevance of drone delivery. Studies indicate that up to 70% of urban parcels[6] and about 85% of Amazon's goods[7] are eligible for drone delivery. Efficient sorting and organisation enable quick retrieval and loading, minimising delivery time. Secure packaging protects items during transit.

Prescription Medication

The growth of telemedicine highlights the potential for drones in medical deliveries. Secure and tamper-evident packaging is essential for sensitive medical products. Compliance with pharmaceutical regulations and temperature control for certain items ensure safe and effective delivery to patients.

In summary, selecting the right products for drone delivery requires careful consideration of packaging, regulatory compliance, and the specific needs of the goods being transported. This ensures the successful integration of drone technology into various delivery contexts.

Identifying Suitable Delivery Areas

DRONE delivery technology offers significant opportunities for transforming logistics, but the pace of adoption will vary based on locational challenges and constraints.

In urban centres, near-term adoption is limited due to several unique challenges. Drone flights over densely populated areas pose increased safety risks, and there are fewer suitable landing zones and drop-off locations. Creating the necessary infrastructure, particularly on rooftops, is complex. While drones will eventually play a role in urban environments, the adoption process is expected to be slow and measured.

In contrast, suburban, rural, and remote areas are better suited for drone deliveries and are likely to see faster adoption. These regions often lack adequate delivery options due to the high costs and logistical challenges of traditional methods. Drones can bridge this accessibility gap, significantly improving service efficiency and cost-effectiveness without facing the challenges of densely populated urban areas.

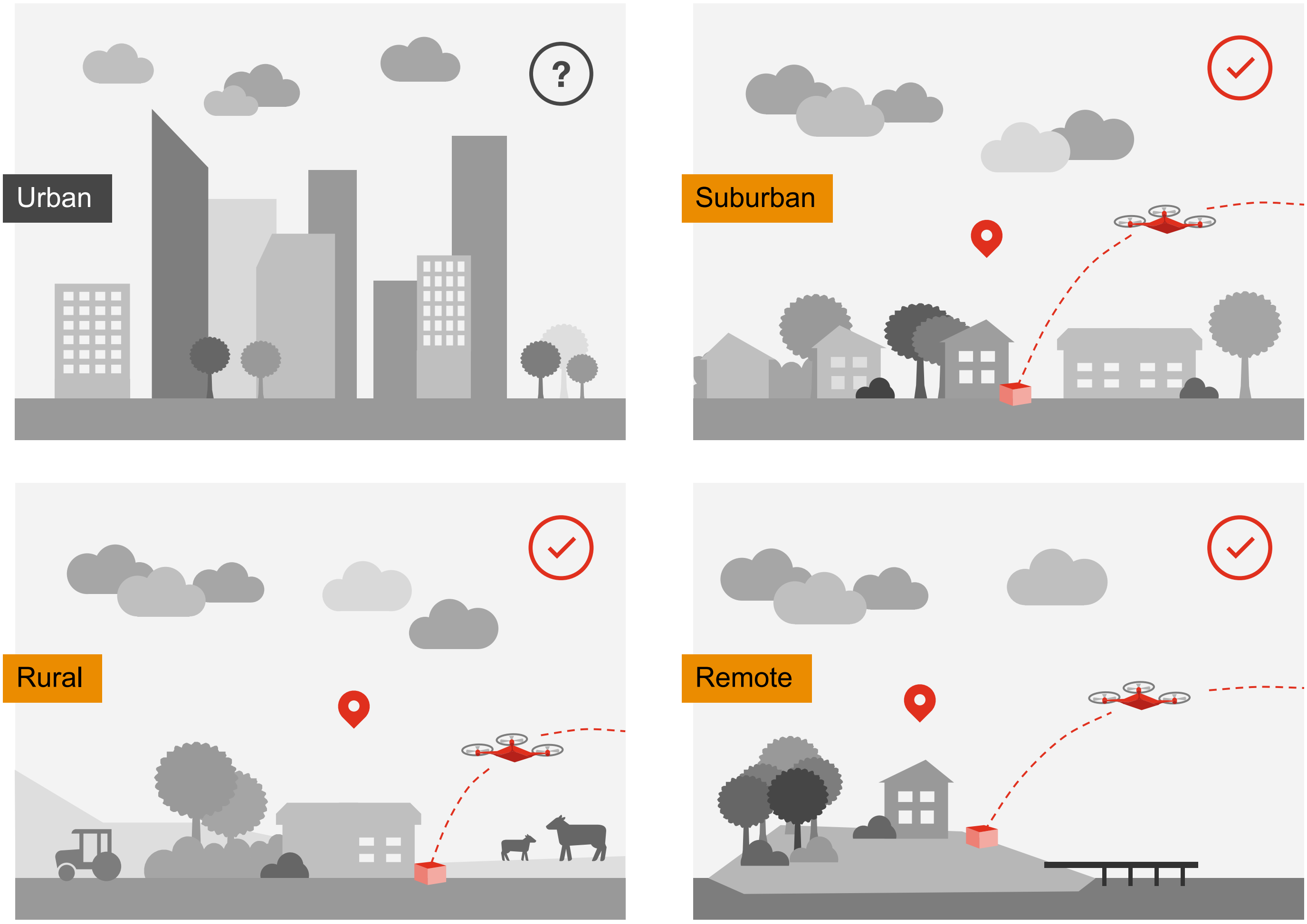


Figure 2.1. Suitability of drone delivery in different geographies in terms of solutions and landing zones for safe and efficient operation.

A crucial factor for drone delivery operations, particularly when designing the operating geography and catchment area, is the type of housing where end consumers reside. Urban areas typically feature townhouses, condominiums, and apartments, whereas suburban and rural areas are dominated by semi-detached or detached houses. Understanding these distinctions is vital for developing an effective drone delivery strategy.

Semi-detached or detached houses are best suited for drone delivery for several reasons:

1. **Space for Safe Landings:** These houses often have yards or driveways that provide suitable landing/payload release spots for drones. This space allows for safe, unobstructed deliveries, minimising the risk of damage to property or surrounding structures.

2. **Lower Operational Risks:** Suburban areas are less densely populated than cities, reducing operational risks and making it easier to obtain permits. The suburban landscape also allows for flight paths that avoid flying over neighbouring properties, addressing privacy concerns associated with drone delivery in densely populated areas.

The layout and space around semi-detached or detached houses eliminate the need for additional infrastructure, making them well-suited for drone deliveries. Given the complex operational conditions in urban areas, the majority of drone delivery operations take place in suburban and rural regions.

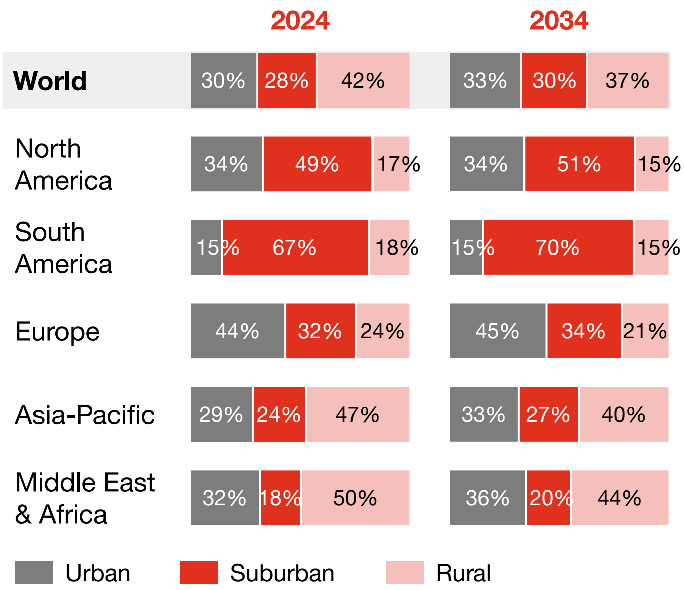


Figure 2.2. Percentage distribution of population by residing areas, 2024 and 2034.

Our analysis indicates that in 2024, nearly two-thirds of the global population live in suburban and rural areas (figure 2.2), primarily in semi-detached or detached dwellings. These areas represent a significant untapped market for drone deliveries, especially considering the lower availability of other delivery methods in such areas.

These metrics vary by region: for example, 85% of the South American population lives in suburban and rural areas, compared to 56% in Europe. Despite these differences, the substantial market size makes a strong case for adopting drone delivery technology.

Potential market of

5.8bn people

Living in suburban and rural areas in 2034

When exploring potential drone delivery locations, it's important to consider their specifics. Each location present unique challenges and opportunities for drone delivery services.

Dimension	Comment
Regulations	Both national and local regulatory requirements should be considered to ensure compliance
Airspace Zones	Particular attention should be paid to no-fly or restricted zones, which may make it impossible to serve specific areas or require significant flight path adjustments
Climate and Weather Conditions	Heat, cold, rain, fog or strong winds impact drone delivery operations, from hardware selection to operational procedures
Locations of Points of Sales	The location of existing stores, restaurants, warehouses or partners' infrastructure and their distance and travel time to end consumers should be considered
Geodemography	Population characteristics, such as age, gender, education, income, and occupation, can influence the adoption of drone technology and willingness to use such services
Population Density	Flying a drone in more densely populated areas carries greater risk and requires compliance with stricter regulatory requirements
Competition	Competitors influence decisions around pricing strategies, service offerings, and customer acquisition tactics
Landscape	Forestry areas, mountains, differences in altitude and pressure, and distances between islands will not only impact the selection of hardware and operational procedures but will determine the locations of drone hubs from which the drones will take off and land

Table 2.1. Factors to consider while assessing the feasibility of drone delivery operations in different locations.

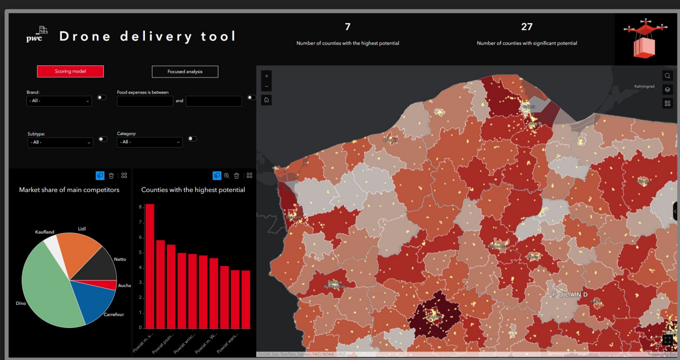
The PwC Drone Delivery Location Finder platform provides invaluable support in assessing the feasibility of implementing drone delivery services in varied environments. By analysing multiple variables relating to regulations, operations, drone platforms, environment and topography, local market and population, as well as other parameters, the platform provides valuable insights into the potential for drone delivery across different sites, regardless of their location.

This tool allows businesses to prioritise geographies, calculate micro market size for each point of sale, and make informed decisions about where to implement drone delivery services. The comprehensive approach ensures that businesses can address the specific needs and dynamics of urban, suburban, rural, and remote areas effectively.

Our tool

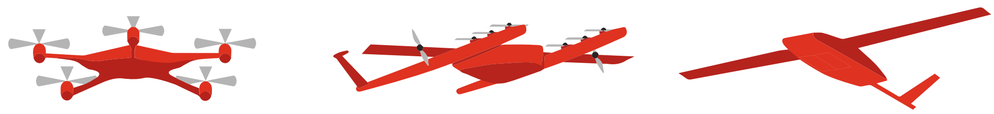
PwC Drone Delivery Location Finder

Understanding which of your stores and warehouses are suitable for drone deliveries is not a simple task. This is why we have developed a **location intelligence platform** that can analyse your existing locations and help you understand the potential for drone delivery across your various sites.



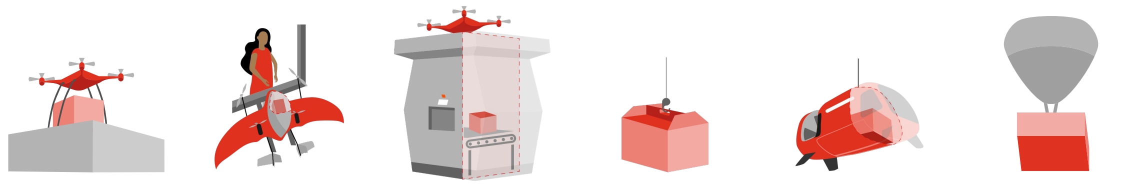
Selecting Key Technologies

THERE are three main types of drone platforms and six types of payload release mechanisms that are most commonly used for drone deliveries, each offering different features, capabilities, and drawbacks. The tables below highlight some of these key features and differences:



	Multirotor	VTOL	Fixed-wing
Manoeuvrability	● ● ●	● ● ○	● ○ ○
Payload	<9kg	<5kg	<2kg
Delivery Range	5-20 km	15-60 km	150-200 km
Cruise Speed	60-70 km/h	80-100 km/h	80-100 km/h
Take-off Requirements	∅ 0.5 m platform	∅ 0.5 m platform	~100 m runway / ~4 m catapult

Table 2.2. Comparison of the most common drone delivery platforms and their typical features.



	Land and drop off	Window frame	Locker	Winch	Winch with droid	Parachute
Best Fit Platform	VTOL / Multirotor	VTOL	Multirotor / VTOL	VTOL	VTOL	Fixed-wing
Operation Complexity	● ○ ○	● ● ●	● ● ●	● ● ○	● ● ○	● ○ ○
Landing Infrastructure	Not required	Window landing dock	On-ground docking station	Not required	Not required	Not required
Typical Delivery Area	Suburban / Rural	Urban / Suburban	Urban	Suburban	Suburban	Rural / Remote

Table 2.3. Comparison of the most common drone delivery payload release mechanisms and their typical features.

Select a drone platform

Selecting the right drone platform and service provider is crucial for effective and safe deliveries. Multirotor drones are ideal for transporting heavier loads over short distances. In contrast, fixed-wing drones can cover long distances, even hundreds of kilometres, but they are suited for lighter packages.

VTOL drones combine the strengths of both types, taking off and landing vertically like multirotor drones while flying longer distances like fixed-wing drones. This versatility makes them suitable for a wide range of applications.

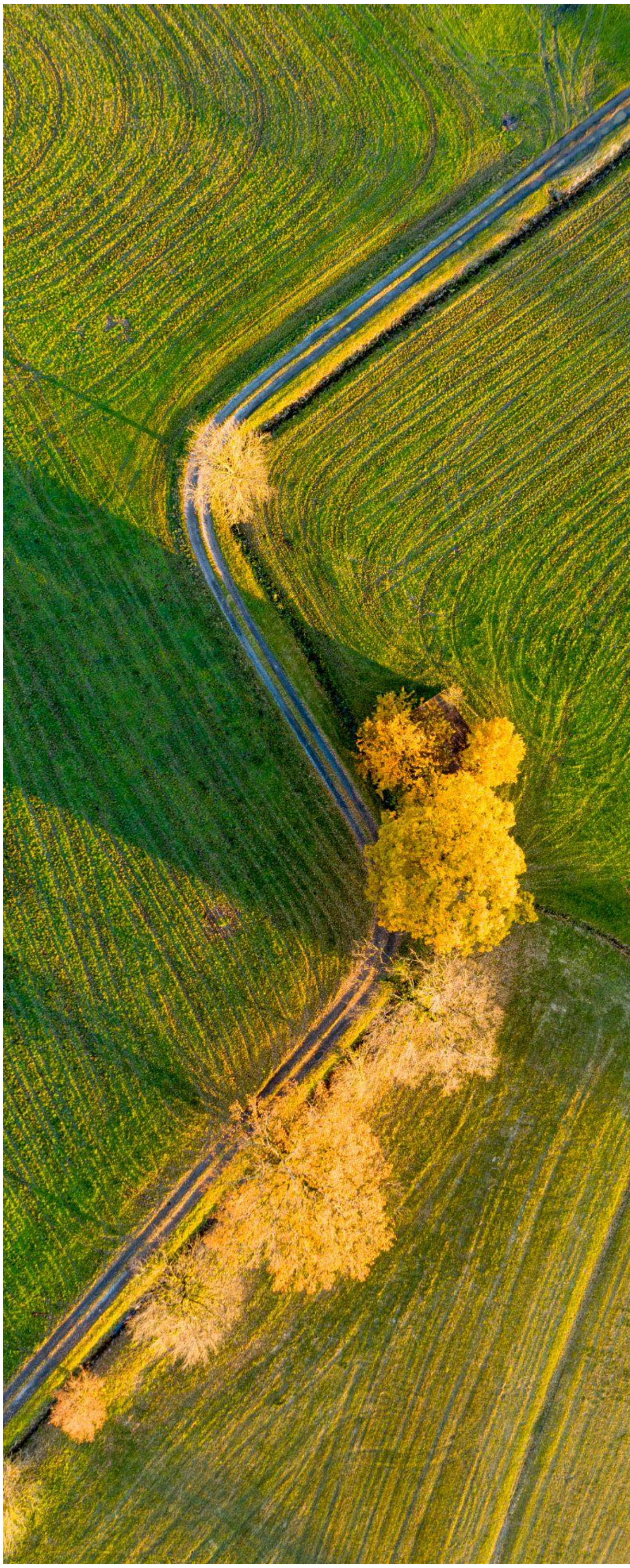
Select a payload release mechanism

The payload release mechanism is a critical factor in drone deliveries. A common system is the winch, which lowers packages to the ground using a tether, allowing delivery without landing. This method reduces noise and avoids direct customer interaction with the drone.

For more precise deliveries, Zipline introduced the "Droid." This device, attached to the end of the tether, uses thrusters and sensors to navigate to the landing spot while the drone hovers higher, further reducing noise.

Other mechanisms involve carrying packages inside the drone and either landing or releasing them from a low altitude. Fixed-wing drones often use parachutes to drop packages, suitable for areas with ample open space.

Urban environments present more challenges for drone deliveries due to dense infrastructure and high population density. Drone delivery companies are exploring various solutions, such as landing on rooftops, using dedicated landing frames installed on windows or balconies, and employing parcel locker systems. All these methods are being tested and piloted to ensure safe and effective urban deliveries.



Create drone loading and dispatching system

Each drone type and technology vendor offers a unique approach to loading and dispatching drones. The choice depends on the specific objectives, challenges, and constraints of each project. Common operating models include:

- **Automated or Semi-Automated Hubs:** These hubs handle loading/unloading, starting and landing, battery swaps, and other tasks. Ideally, they should be located near the point of sales or warehouse
- **Specialised Loading/Charging Docks:** Integrated into the parcel preparation areas as an extension of the warehouse, these docks streamline the loading and charging process
- **Retail Store Rooftops/Parking Lots:** Equipping these areas with landing pads and having dedicated technical staff manually prepare and launch each operation

Shape client journey

Focusing on the user experience is crucial in the delivery process. This includes customer touchpoints, such as how orders are submitted, notifications about delivery progress, and handling customer service requests when errors occur. These elements could be integrated with existing food delivery applications or a dedicated system could be designed for a specific brand.

Consider behind-the-scenes

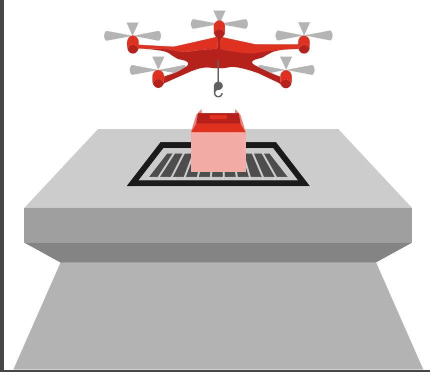
Important behind-the-scenes considerations include the level of autonomy and safety features in the drone delivery system and its integration with existing Unmanned Traffic Management (UTM) systems. This ensures safe orchestration and supervision of multiple simultaneous flights operating within the same airspace.

Ways towards ecosystem automation: drone loading and dispatching

Scenario 1 **Automated or semi-automated hub** for loading/unloading the drone

1 Worker loads the package into a hub

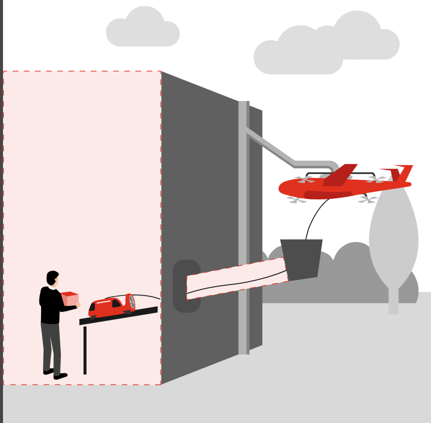
2 Drone autonomously loads the package, takes off and begins flight path



3 Drone delivers the package to the client's location or another hub

Scenario 2 **Loading dock within warehousing area**

1 Worker loads the package into a droid

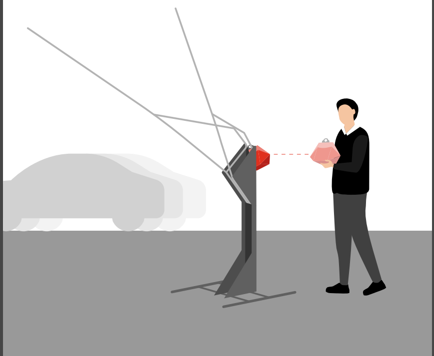


2 Drone autonomously loads the package, takes off and begins flight path

3 Drone arrives to the client's location and releases the package

Scenario 3 **Launchpad from a parking lot**

1 Worker attaches the package to the station



2 Drone flies to the station, lowers the winch, picks up the package and begins flight path

3 Drone arrives to the client's location and lowers the package

Operating Models and Unit Economics

SELECTING the optimal operating model for drone delivery is a complex but crucial decision that integrates various elements discussed previously, including drone platforms, payload release mechanisms, and loading and dispatch systems. This section will focus on how to combine these elements into effective operating models tailored to different environments, business needs, and unit economics.

At its core, the drone delivery process consists of five steps that can be performed in various orders, using different methods and types of infrastructure.

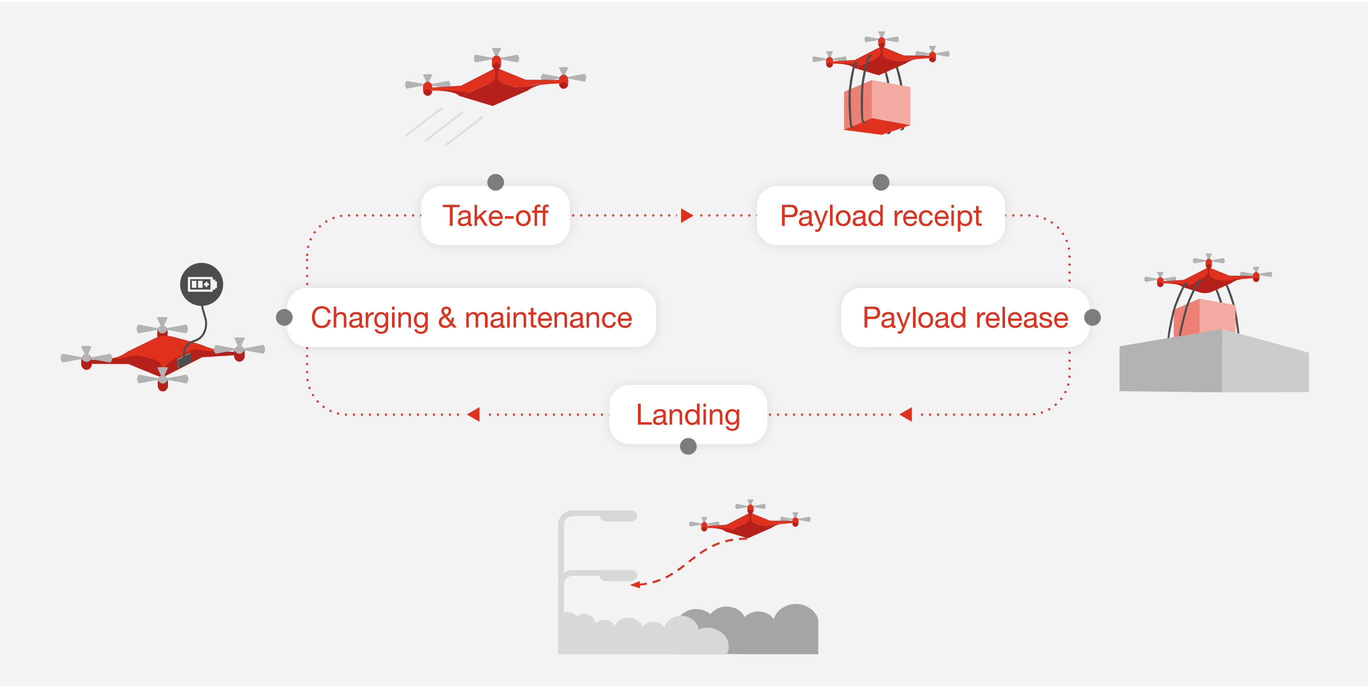


Figure 2.3. Actions performed during drone delivery operations, using the example of a multirotor aircraft.

Common Operating Models

These process steps can be combined in to various operating models including but not limited to:

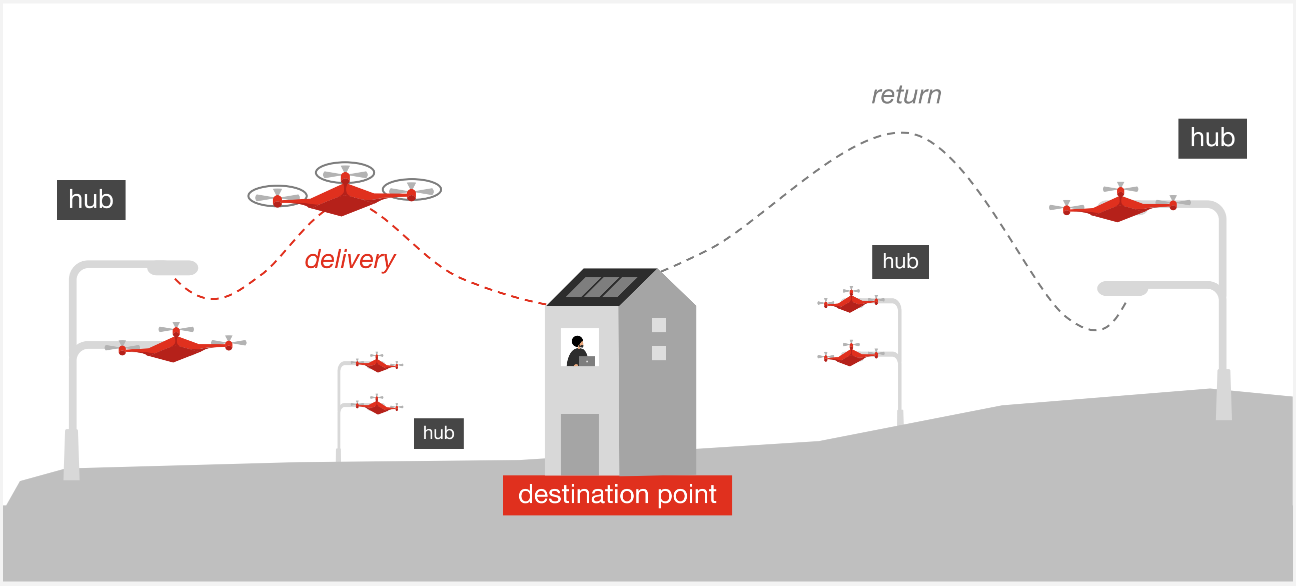
- **Store-to-Door Model**
  Drones pick up orders from stores or restaurants and deliver them directly to customers' doorsteps. This model is practical for urban and suburban areas where businesses are close to residential zones.
- **Hub-to-Door Model**
  Packages are collected at a central hub and delivered directly to customers. This model benefits from centralised operations, making it suitable for suburban and rural areas with fewer delivery points.
- **Locker-to-Locker Model**
  In this model, drones transport packages between lockers, which serve as both the destination and the hub for the next flight. This approach is highly efficient for areas with established locker networks and reduces the need for additional infrastructure.

Regardless of the chosen operating model, drone delivery systems typically use one of two network configurations: point-to-point or hub-and-spoke. These configurations are adapted from traditional logistics systems to suit different areas, distances, and infrastructure.

In a point-to-point network, drones operate from multiple take-off and landing locations, allowing for direct deliveries from various points to customer-chosen destinations. This decentralised model can use shared or private infrastructure. In a hub-and-spoke network, drones take off from a central hub, deliver to designated points, and return to the hub for the next delivery. This centralised approach simplifies operations but requires a strong central hub.

Point-to-point (decentralised) network

With a point-to-point approach, deliveries are made by a drone picking up a parcel from an initial departure point (e.g. pad, dock) where it was prepared, flying to a destination point chosen by the customer to drop off the shipment, and then returning either to the nearest landing point or the landing point where another parcel is ready for pick up. Decentralised drone hub infrastructure can be company-agnostic (shared with others) or private (reserved solely for that service provider).



Pros

+ Coverage of a wider geographic area
+ Possibility for gradual expansion without significant one-time investments
+ Optimised routes and faster delivery
+ Potential for shared drone hub infrastructure

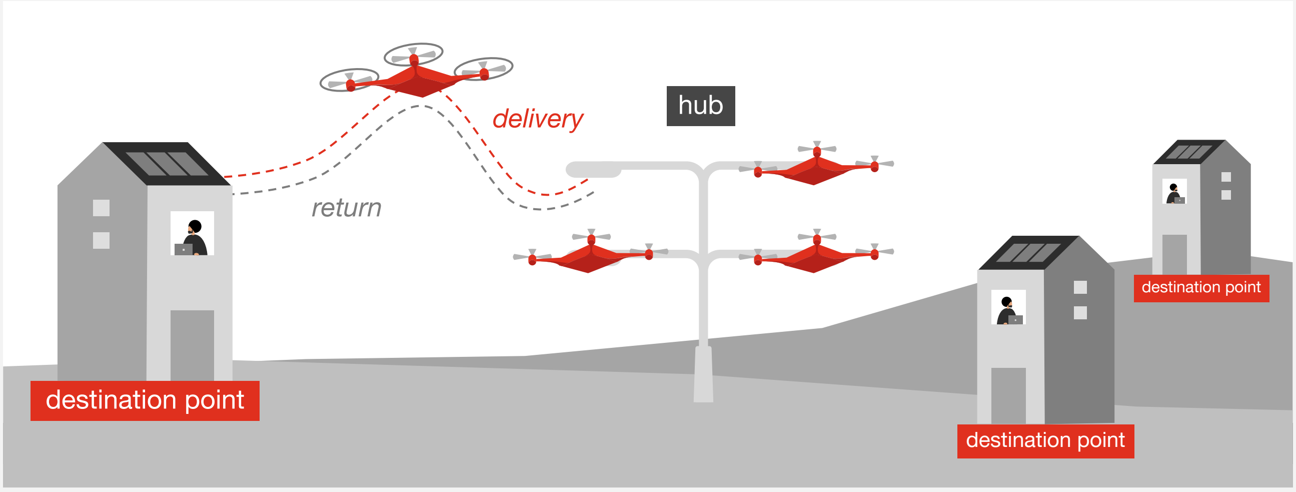
Cons

– Increased operational complexity: drone routing, coordination and management
– Potential for airspace congestion at landing points
– Increased risk of collisions

Figure 2.4. Comparison of the benefits and disadvantages of point-to-point drone delivery network.

Hub-and-spoke (centralised) network

With a hub-and-spoke approach, deliveries always take off from a single point (the hub), and the drone reaches its destination via an assigned air route (the spoke). After the parcel is dropped off, the drone will return to its initial base to pick up the next delivery.



Pros

- Streamlined operations and efficient use of resources
- Simplified drone routing and logistics
- Easier drone maintenance and recharging
- Reduced risk of collisions

Cons

- Delivery range is limited and determined by location of the hub
- Potential for congestion around the central hub
- Higher dependency on a single hub infrastructure creates a single point of failure that can disrupt whole operations

Figure 2.5. Comparison of the benefits and disadvantages of hub-and-spoke drone delivery network.

Pure versions of these network configurations, without additional locations or infrastructure, are likely to be the most convenient and will probably be adopted first. They align well with current delivery schemes, drone platforms, and navigation solutions.

New operating models are being developed to reduce upfront infrastructure costs, such as drone docks and last-mile deliveries to automated parcel machines. There are also efforts to combine UAVs with autonomous ground vehicles, where ground vehicles transport goods to drone take-off points or complete the last-mile delivery from drone landing sites.

Choosing an operational model is a strategic decision that requires a detailed business case, considering revenue forecasts and cost estimates. Tailoring the network type and drone platform to common delivery scenarios in a specific commercial landscape is essential for achieving favourable unit economics.

To assist companies considering the implementation of drone deliveries, we have estimated the cost of drone-powered deliveries based on a third-party service provision model and a hub-and-spoke network configuration. This model assumes no capital investment by retail and logistics companies.

The following table outlines the estimated costs for various delivery distances and capacity utilisation scenarios:

	Capacity utilisation			
Mean Delivery Distance Radius	**25%**	**50%**	**75%**	**100%**
60 kilometres / 37 miles	$19.0	$9.8	$6.7	$5.2
20 kilometres / 12 miles	$6.0	$3.3	$2.4	$1.9
5 kilometres / 3 miles	$3.4	$2.0	$1.5	$1.3

Table 2.4. Estimated drone delivery unit economics in 2034 for hub-and-spoke model.

Capacity utilisation measures how effectively a business uses its installed productive capacity to provide services. In drone delivery, capacity refers to the volume of deliveries the system can handle, and capacity utilisation represents the proportion of actual deliveries performed. High capacity utilisation indicates efficient use of resources, while low utilisation suggests underutilisation or waste of resources.

Table 2.4 presents calculations for four capacity utilisation levels: 25%, 50%, 75%, and 100%.

The unit economics calculations include three main groups of operating expenses (OpEx):

Salaries:
Costs for drone hub personnel

Drone Hardware and Infrastructure:
Costs for initial purchase, maintenance, and replacement

Operating Costs:
Expenses related to battery charging, software, and other operational needs

These calculations are based on a 16/7 operating schedule with over 20 drones per hub. Increasing operating hours and decreasing the delivery distance radius can reduce costs.

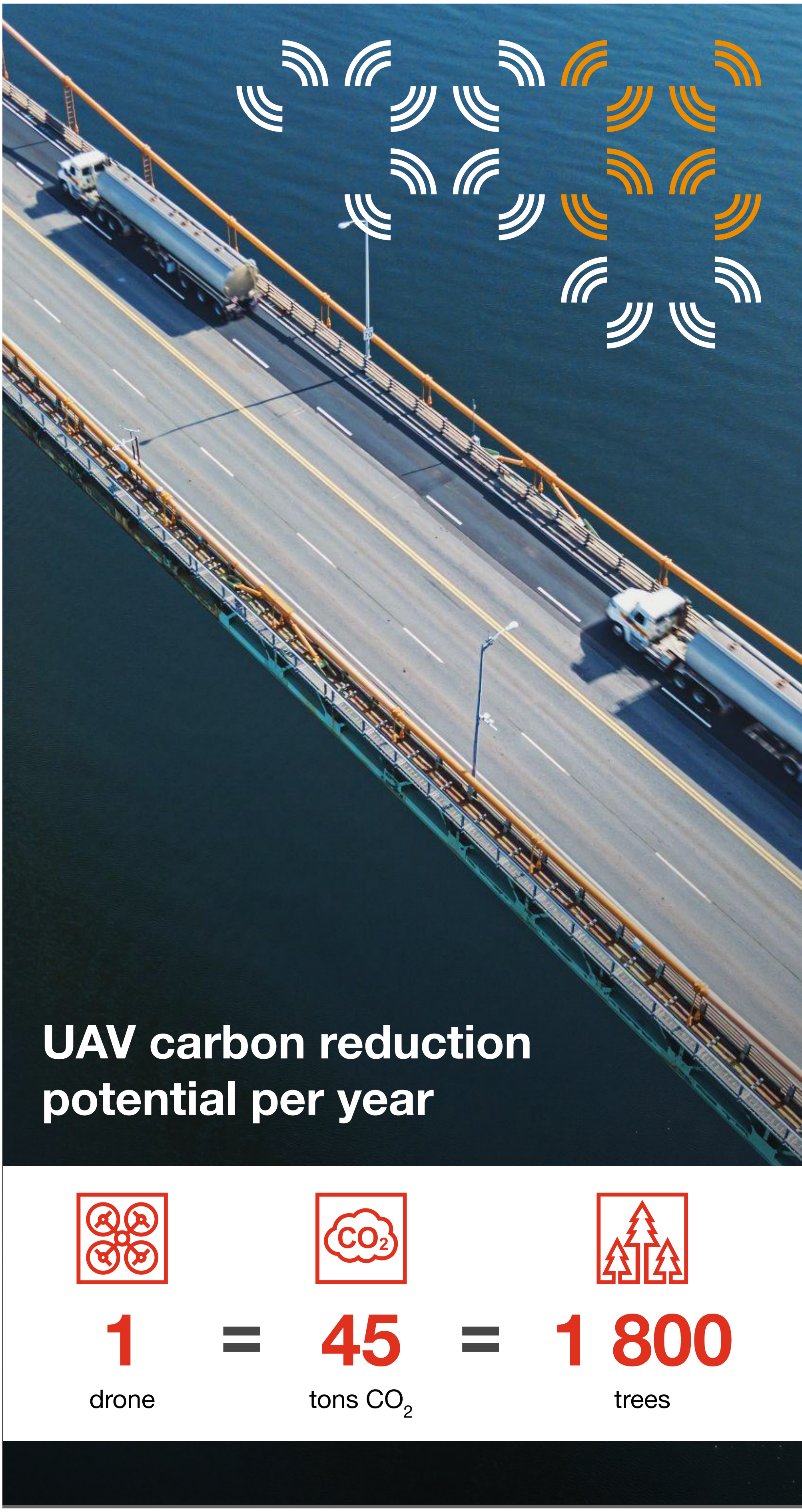
According to our analysis:

- The estimated drone delivery costs vary depending on the mean delivery distance, which affects flight duration and servicing times. Here are the cost estimates:
  - **Rural Deliveries (60 km / 37 mi):** Highest cost at approximately $5.2 per delivery
  - **Suburban Deliveries (20 km / 12 mi):** Estimated at around $1.9 per delivery
  - **Urban Deliveries (5 km / 3 mi):** Lowest cost at about $1.3 per delivery
- The price variation is driven by operational characteristics derived from delivery distance and the technological requirements of drone platforms. More sophisticated technology is needed for distant deliveries, increasing hardware-related expenses.
- The calculations are based on a 10-year projection, considering the expected evolution of drone delivery costs due to regulatory advancements, increased automation, and decreasing prices of drone hardware. We project that unit delivery costs will decrease annually by 5-10%, depending on the operating scenario.
- In 10 years, personnel costs are projected to constitute nearly half of the operational expenses, primarily due to drone pilot salaries. By 2034, a 1:20 pilot-to-drone ratio is anticipated to become the standard (the FAA has already issued such a waiver[8]).

Another important factor not evident from the cost table is that estimated delivery unit costs should be compared with alternatives to assess commercial viability. For example, conventional same-day delivery of prescription medications might cost at least $20 today, excluding surcharges for additional distance. This is particularly relevant for rural areas, where the proportion of older people is higher than in urban and suburban areas. **Drones also eliminate the need for tipping, which is common in many countries, further reducing the total service fee**.

Beyond reducing operating costs, **drone delivery significantly lowers carbon dioxide emissions.** One drone per year can save up to 45 tons of CO_2 emissions* that would otherwise be released by combustion engine vehicles. This is equivalent to the carbon storage potential of 1,800 trees. With that being said, a drone hub with a fleet of 20 aircrafts is the equivalent of 36,000 trees.

From the cost projections and emissions reduction data, it is clear that drones could be an attractive alternative for last-mile delivery. This is not only due to time-saving and client convenience but also because of cost-cutting benefits. This is especially advantageous in economies with high labor costs or difficulties in finding and retaining delivery personnel.



*The following carbon emissions numbers are calculated for a suburban hub-and-spoke model at 100% capacity utilisation. The carbon emissions reduction potential is dependent on the delivery radius and will be higher/lower for longer/shorter distances.

3 Potential Challenges and the Need for Strategic Planning

Challenges and Mitigation Strategies

INCORPORATING drone delivery into existing retail and logistics operations presents numerous challenges for companies. Therefore, understanding these challenges, implementing mitigation measures, and developing a comprehensive implementation strategy is essential.

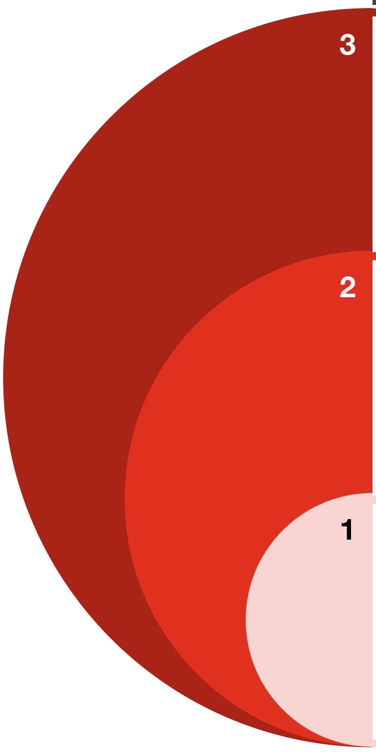
Challenges can be categorised into three levels based on the company's ability to impact them. The chart below shows stakeholders and examples of their impact on drone delivery operations. A more comprehensive list of challenges is described on the following pages.

The innermost circle, 1 **Circle of Control**, includes factors directly within the company's power to manage, such as drone operational procedures, offering and pricing, selection of technology partners, and customer service.

The middle circle, 2 **Circle of Influence**, encompasses areas where the company can exert some control or influence, such as public opinion, perception of drone services, and demand for its services.

Lastly, the outer circle, 3 **Circle of Concern**, involves external factors beyond the company's immediate control, such as national regulations, weather conditions, airspace and air traffic management, market fluctuations, and world events.

By understanding and prioritising these circles, the company can concentrate on areas where it can have the most impact while remaining aware of external factors that might affect operations. This approach allows for a more focused and effective implementation of drone delivery services.



Circle	Stakeholder	Potential Impact
3 **Circle of Concern**	Government	Operational permits Operational standards / requirements
	Competitors	Pricing Customer acquisition
2 **Circle of Influence**	Public	Demand for services
	Partners	Quality of hardware/services
1 **Circle of Control**	Company	Selection of hardware Selection of partners Offering and prices Financial results

Figure 3.1. Key Stakeholders and Examples of Potential Impact on Drone Delivery Operations Presented in Circles of (1) Control, (2) Influence and (3) Concern.

The chart below illustrates the most common bottlenecks that companies may encounter on the way to implementing drone delivery, represented by relevant circles:

1 Circle of Control

2 Circle of Influence

3 Circle of Concern

Figure 3.2. Challenges of Drone Delivery Operations Presented in Circle of (1) Control, (2) Influence and (3) Concern.

Table 3.1 details the most common bottlenecks along with possible mitigations:

Dimension	Outline	Possible Mitigation
Environmental Concerns	Drone may collide with birds	Monitor bird migration routes Chart habitats of birds and avoid those zones Employ UV light to enhance drone visibility to birds[9]
	Noise pollution may impact wildlife	Use quieter propulsion systems Impose flight restrictions in noise-sensitive areas, e.g. nature reserves, national parks Impose time restrictions on flights during sensitive times, e.g. breeding seasons
	Lithium-ion battery waste may contaminate environment	Responsible and optimal usage can prolong battery lifetime and reduce waste Ensure proper battery disposal, reuse or recycle Look for alternative solutions
Social Concerns	Privacy concerns about delivery drones capturing footage without consent	Use technology that does not require a camera Engage with local communities and regulatory authorities to develop mutually acceptable solutions Communicate drone delivery areas and offer an opt-out option[10] Use geofencing to create no-fly zones around sensitive areas, e.g. schools, hospitals Enforce strict privacy policies for data collection and sharing, e.g. activate on-board cameras only during delivery and limit footage storage
	Safety concerns about delivery drones causing an accident or incident	Conduct public awareness campaigns about safe drone operation Conduct thorough risk assessments and safety testing for drone reliability Build flight routes to bypass possible crowds Make every effort to avoid flying over bystanders Use collision avoidance systems and automated emergency procedures Establish a reporting and investigation system for drone incidents
Regulations	Difficulties in obtaining permission to conduct BVLOS / autonomous operations	Partner with vendor which already has all the necessary approvals and authorisations Participate in technology sandboxes, drone delivery programmes and advanced air mobility tests organised by the government Phase in the rollout of drone deliveries, starting with simple delivery scenarios over short distances and then shifting to more complex ones
	Temporary or permanent no-fly or restricted zones may impede drone delivery operations	Consider restrictions before deciding where to locate a drone hub/pad Obtain special permit or exemptions for drone delivery operations in restricted areas Collaborate with aviation authorities and local governments to create designated airspace and corridors for drone delivery

Table 3.1. Examples of Challenges Encountered During Drone Delivery Operations and Possible Mitigations

Final Thoughts & Call to Action

THERE is no doubt that delivery drones have the potential to offer convenient, efficient, and sustainable alternative to conventional last-mile solutions. What is more, numerous successful implementations into operations of B2C retailers, marketplaces, and logistics players have proved that such a delivery option not only helps with customer retention but also creates new markets, therefore expanding the addressable market of their offer and services.

Of course, the introduction of emerging technologies into legacy businesses can be a double-edged sword. When it is done well, it can be very rewarding and open up new avenues for innovation. When it is not done well, it can create further impediments that slow a company's growth. That is why it is so important to tailor all the elements of an aerial delivery services' value chain to a particular business case, the spectrum of the entity's commercial operations, their scale, their customer expectations, and at the same time ensure an appropriate development roadmap.

As the PwC Drone Powered Solutions team, we hope that familiarising yourself with the insights featured in this document will be a catalyst for starting your own drone journey. As a team, we stand ready to assist you and we are looking forward to shaping your success together.

About PwC Drone Powered Solutions

PWC DRONE POWERED SOLUTIONS – Global Centre of Excellence in Drone and Satellite Technologies is the pioneering consulting group dedicated exclusively to implementing drone and satellite technologies for commercial, international development, as well as security, defence and public safety applications.

Since 2015 we have delivered more than 150 projects on 6 continents gathering massive amounts of experience, building unique methodologies and technology solutions.

Being well recognised as global leaders in the drone and satellite industries, our team ensures:

- Strong experience in identifying and assessing disruptive and transformative growth areas, including what is needed to succeed
- Fresh perspective on drone and AAM market with our unique understanding of market needs, drivers and enablers, as well as view on potentials and barriers
- Global scale of presence and scope of activity to give strategic guidance in drone and AAM market with tailored business strategies

Areas of expertise

- Regulations & Strategies
- UTM / U-Space
- Drone Delivery
- Air Taxis
- Mapping & Inspections
- C-UAS & Defence, Security and Public Safety
- ESG & Drones for Good
- Satellites & Space

Client profiles

- National and Local Governments
- Public entities
- CAA, ANSP, Airlines and Airports
- Large Enterprises
- Private Sector Companies
- Defence and Law Enforcement
- Development Institutions
- NGOs

Glossary, Sources and Acknowledgments

Table of Terms and Acronyms Used

Term or Acronym	Term and Definition
AAM	Advanced Air Mobility: new concept of air transportation of goods (drone delivery) and people (air taxis) in controlled and uncontrolled airspace utilising emerging aerial technologies, such as alternative energy-powered, remotely piloted, autonomous, or vertical take-off and landing aircraft.
CoE	Centre of Excellence: a team, a shared facility or an entity that provides leadership, best practices, research, support, or training for a focus area.
CAA	Civil Aviation Authority: Government authority responsible for regulations related to civil aviation (including UAS).
CAGR	Compound Annual Growth Rate: The annualised average rate of growth between two given years, assuming growth takes place at an exponentially compounded rate.
FAA	Federal Aviation Administration: The transportation agency of the U.S. government which regulates all aspects of civil aviation in the country.
B2C	Business to Consumer: This refers to the business model of selling directly to customers, bypassing any middlemen.
BVLOS	Beyond Visual Line of Sight: This refers to unmanned aerial vehicles who make flights that are operated beyond the line of sight of the human pilot.
Delivery range	Alternatively referred as delivery radius - the maximum distance between drone take-off location and delivery location.
Drone	In this report, when we mention drones, we are specifically referring to autonomous aerial vehicles (UAS/UAVs/RPAS). If we are discussing other types of uncrewed or autonomous vehicles, we will clearly specify it in the text.
OpEx	Operating Expenditure: This refers to ongoing costs incurred by an organisation for operating the company. This are typically short-term in nature.
UAV/S	Unmanned Aerial Vehicle/System: This refers to an aircraft that is piloted remotely via remote control or an onboard computer.
UTM	Unmanned Traffic Management: This refers to an air traffic management system designed to coordinate and regulate flights from drones and other unmanned aircraft.
VTOL	Vertical Take-Off and Landing: This refers to an aircraft that can take-off and land vertically, without needing a runway.

Sources

1	Beer, Eliot. "More than a gimmick? Alphabet's Wing makes record 50k drone deliveries in Q1". Website: Text/HTML, The Stack, 22 April 2022. https://www.thestack.technology/wing-drone-delivery-50k-deliveries/?amp=1
2	Wing Team. "The potential of drone delivery in enhancing patient care." Website: Text/HTML, Wing, 5 September 2023. https://blog.wing.com/2023/09/drone-delivery-enhancing-patient-care.html
3	Xu, Wang. "Meituan's drone food deliveries on the rise." Website: Text/HTML, China Daily, 19 September 2023. https://www.chinadaily.com.cn/a/202309/19/WS6508e4fca310d2dce4bb66a8.html
4	Plaza, Juan. "Faster, Greener, Cheaper, Quieter, and Safer: Manna Drone Delivery and the Reality of Drone Deliveries in Ireland." Website: Text/HTML, Commercial UAV News, 10 April 2023. https://www.commercialuavnews.com/drone-delivery/faster-greener-cheaper-quieter-and-safer-manna-drone-delivery-and-the-reality-of-drone-deliveries-in-ireland
5	Weckler, Adrian. "Irish drone company aims for one million deliveries by end of the year." Website: Text/HTML, Irish Independent, 7 March 2024. https://www.independent.ie/business/irish-drone-company-aims-for-one-million-deliveries-by-end-of-the-year/a1665876702.html
6	M. Narkus-Kramer, "Future demand and benefits for small-autonomous unmanned aerial systems package delivery", AIAA Aviation Technology, Integration and Operations Conference, Colorado, US 2017. https://arc.aiaa.org/doi/epdf/10.2514/6.2017-4103
7	Link, Jeff, and Dave, Paresh. "Amazon's Drone Delivery Dream Is Crashing." Website: Text/HTML, Wired, 4 April 2023. https://www.wired.com/story/crashes-and-layoffs-plague-amazons-drone-delivery-pilot/
8	McNabb, Miriam. "20 Drones, 1 Pilot: Matternet's New Waiver Could Change the Economics of Drone Delivery." Website: Text/HTML, Dronelife, 13 February 2023. https://dronelife.com/2023/02/13/20-drones-1-pilot-matternets-new-waiver-could-change-the-economics-of-drone-delivery/
9	Parry, Wynne. "Lighting May Reduce Fatal Airplane-Bird Collisions." Website: Text/HTML, Livescience, 10 July 2012. https://www.livescience.com/21497-aircraft-bird-collisions.html
10	DroneVideos.com. "Amazon's Drone Delivery Service May Scan Your House and Backyard to Find More Things to Sell You!" Website: Text/HTML, DroneVideos.com, 5 October 2017. https://dronevideos.com/amazons-drone-delivery-service-may-scan-your-house-and-backyard-to-find-more-things-to-sell-you/?_page=133

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This report was prepared by a team led by:	**Agnieszka Gajewska** *Partner, Global Government & Public Services Leader*
	Aleksander Buczkowski *Director, PwC Drone Powered Solutions*
The team is grateful for the support and contributions provided by:	**Tomasz Kłosowicz** *Senior Manager, PwC Drone Powered Solutions*
	Anhelina Kamenska *Senior Consultant, PwC Drone Powered Solutions*
	Róża Wilczek *Senior Consultant, PwC Drone Powered Solutions*
	Daniel Abadie *PwC Drone Powered Solutions*
	Jan Kryca *founder of Arda Group LLC*
	Tomasz Dąbek *Senior Advisor*

Contacts

Agnieszka Gajewska

Partner
Global Leader Government & Public Services

+48 517 140 537
agnieszka.gajewska@pwc.com

Aleksander Buczkowski

Director
PwC Drone Powered Solutions

+48 503 781 024
aleksander.buczkowski@pwc.com

Tomasz Klosowicz

Senior Manager
PwC Drone Powered Solutions

+48 519 504 273
tomasz.klosowicz@pwc.com