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Flying into the future

The potential benefits of small package drone delivery in Ireland

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This report was prepared for Wing by Accenture in February 2023. The amounts in this report are estimated and specified in 2022 euros.

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BENEFITS FOR **BUSINESSES** BY 2033

Drones are expected to **grow retail sales by €395 million.** This equates to 10 million additional transactions in the grocery, food takeaway, pharmacy and household items sector[1].

Reduce **business delivery costs** by up to **€136 million** per year.[2] Delivery costs for some items such as takeaway could fall by up to **75-85%.**

Expand the reach of businesses by up to **4x as many consumers** by bringing more households into range.

BENEFITS FOR **CONSUMERS** BY 2033

Save **31 million hours for customers** by replacing customer pick-up journeys. Delivery times will be **50-60%** faster than today.

Save consumers **€115 million** per year in **reduced delivery costs.** Delivery costs for some items such as takeaway could fall by up to **75-85%.**

More choice for consumers, providing access to up to **4x as many merchants** within their delivery range.

BENEFITS FOR **SOCIETY & ENVIRONMENT** BY 2033

Reduce traffic congestion by **480 million vehicle kilometres**, of which 287 million will be from arterial roads.

Reduced traffic on roads will result in **60 fewer accidents each year**, making roads safer.[3]

Reduce **CO_2 emissions** by **28,000 tonnes** due to fewer motor vehicle trips, equivalent to the carbon storage of **close to 830,000 trees.**

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1 This report focuses on retail transactions, defined as food takeaway, pharmacy, grocery and household items. It is expected that 7-9% of total transactions in these sectors could be delivered by drone.
2 Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs
3 'Road accidents' are defined as collisions resulting in injuries
Source: Accenture.
Note that all amounts shown are in euros.

Executive summary

With the fastest growing economy in the European Union that hosts tech innovator-giants such as Google, Amazon and Uber, Ireland has quickly established itself as a global innovation hub – and drone delivery is no different. In late 2022, the European Commission adopted a European Drone Strategy 2.0 which set out the vision for large scale commercial drone operations across the European Union ('EU'). This provided the backdrop for drone delivery demonstrations and trials in Ireland – with several drone delivery providers offering consumers quick, cost-effective deliveries of groceries, takeaway food and other household items in suburbs north of Dublin.

Drones have the potential to transform retail delivery around the world. Flying above the traffic, drones can quickly and cost-effectively deliver small packages of food, medicine and other household items, saving businesses and consumers time and money while also helping to reduce congestion, greenhouse gas emissions and accidents on our roads.

Drones are expected to have an important role to play in "last-mile" delivery – that is, the transport of products from the store to the home. Last-mile delivery is one of the costliest segments of the supply chain, accounting for approximately 28% of the total cost of retail transactions, either through delivery fees or the time spent by consumers picking up their goods. Ireland consumers incurred a total of €8.5 billion in last-mile transport costs in 2022.

Last-mile delivery can be challenging in Ireland, particularly in Dublin where logistics providers face congested city roads. Consumers are doing more of their shopping online, supercharged by the COVID-19 pandemic, but still face limited on-demand delivery options, particularly for smaller packages where the relative cost of traditional delivery remains restrictively high. The cost and time taken for items to be delivered in Ireland not only limits the range of products available to consumers at home; businesses are also limited in their ability to reach customers who either need or demand home delivery.

Drones could be a cost-effective solution for small items needing to travel distances of 1 to 10 km. Based on these criteria, drones could deliver up to 7-9% of retail transactions (including takeaway, pharmacy, groceries and household items) by 2033 across most of Ireland. Drones will support businesses to be more competitive, providing greater choice and convenience for customers, while also reducing the total number of motor vehicle journeys.

Road transportation accounts for 18% of Ireland's greenhouse gas emissions and replacing some of those journeys with delivery drones could have a significant environmental impact. By using drones to deliver 7-9% of retail transactions, we could expect more than 28,000 fewer tonnes of CO_2 being emitted per year by 2033 – equivalent to the carbon storage of close to 830,000 trees.

Exhibit 1

The impact of drone delivery was analysed across three areas

Benefits for business

Drone delivery could result in several important benefits for businesses:

- **Expanding market reach.** Drones are one of the fastest modes of last-mile delivery, with the ability to travel at speeds over 110 km/h. For some types of transactions, this additional speed allows businesses to offer instant or same-day delivery to customers in a wider geographical area. The delivery radius for restaurants, for example, could increase from an average of 5 km currently to 10 km with 2033 drone technology.[4] For example, consider a restaurant located in Ashtown, Dublin, where drone delivery could bring an additional 20,000 households into delivery range.[5]
- **Reducing delivery costs.** Businesses, including food outlets, incur costs as part of providing delivery to customers. These costs include fees to delivery service providers as well as the cost associated with performing deliveries themselves. These costs make it unprofitable in some circumstances for businesses to offer last-mile delivery at all, despite a growing customer preference for online shopping and delivery. The lower cost of drone delivery could result in a saving of up to €136 million in delivery costs to businesses by 2033.[6]
- **Generating increased sales.** By reducing delivery costs and increasing convenience, drone delivery will make it easier and less costly for consumers to purchase items. As a result, consumers will be able to purchase more items, or possibly opt for higher-value items. These effects combined are expected to generate up to an additional €18,000 a year for a retail business or €395 million in additional sales by 2033.[7] This is approximately 10 million additional transactions. Of this, over €100 million could accrue to small and medium sized businesses.[8]
- **Enabling more businesses to deliver.** Drones could allow more businesses to offer

4 Current range of 5 km based on the average Deliveroo and Just Eat delivery radius in various locations in Dublin, Galway and Cork, estimated based on furthest restaurant delivery available on 19th January 2023.
5 Potential increase in household estimate based on population of Ashfield. Cherry Orchard and Drumcondra with average household size of 2.75 people per household. CSO Census (2022).
6 Assumes retailers receive a reduction in delivery costs proportional to the reduction in the underlying cost of delivery due to drones.
7 Active enterprises (excluding micro businesses) from CSO Business in Ireland 2016: Small and Medium Enterprises.
8 Small and medium businesses (excluding micro businesses) in retail are estimated to contribute 25.6% of valued added to the economy. Source: CSO Business in Ireland (2016), Small and Medium Enterprises.

last- mile delivery, giving them a new way to reach customers. This could allow more specialised businesses to thrive and encourage new businesses to engage in e-commerce. Quicker delivery will play a role in supporting quality control of items (for example, keeping chilled items cold and warm items hot).

Importantly, the business benefits outlined in this report exclude the profits generated by any third-party drone delivery providers. Instead, we focus on the benefits for retailers that partake in drone delivery, whether they do so in-house or via an outsourced drone service provider.

Benefits for consumers

Drone delivery has the potential to generate significant benefits for consumers. These include:

- **Improving quality of life for homebound people.** Drones could deliver a wider range of food, medicines and other products to elderly, those living with a disability, or homebound people for whom visiting shops and restaurants may be difficult or impossible.
- **Saving time.** Drones travel faster than all other forms of last-mile delivery and have the potential to shorten delivery times by 50-60%.[9] Further, for suitable transactions (which are described in Section 2), drone delivery reduces the need for consumers to travel to pick up their items. By eliminating up to an estimated 42 million 'pick-up' journeys by 2033, drone delivery has the potential to save consumers 31 million hours, which is worth €384 million.[10]
- **Reducing delivery fees.** As drones cost less to operate than current delivery methods, businesses will be able to charge lower delivery fees to consumers for certain types of deliveries. Delivery costs for some items, such as takeaway food, could fall by up to 90%. This could save households up to €115 million by 2033.[11]
- **Expanding product variety.** Because the speed of drones allows retailers to offer instant or same-day delivery to a larger geographical area, customers would have a wider range of products to choose from. Increased delivery ranges are expected to provide consumers with up to 4x as many vendor options.

Benefits for society and environment

By reducing the number of motor vehicle journeys taken in fulfilling last-mile deliveries around Ireland, drone delivery has the potential to reduce emissions and make Irish roads safer.

- **Reducing the number of motor vehicle journeys.** By replacing traditional forms of delivery for certain types of transactions, drone delivery can reduce the number of motor vehicle journeys on Irish roads. Preliminary estimates suggest that drone delivery could result in 480 million fewer motor vehicle kilometres on Irish roads in 2033. The majority of these avoided kilometres are on arterial or local roads, supporting reduced congestion in local communities.
- **Reducing greenhouse gas emissions.** Lightweight commercial drones produce fewer emissions per package delivered than today's road vehicle delivery options. Flying a drone emits the equivalent of about 25 grams of greenhouse gas when delivering a small package, compared with the 296-728 grams emitted by delivery trucks. Items that are personally picked-up by a purchaser via car emit 4,600 grams of greenhouse gas per package. By replacing these more polluting methods, drone delivery could eliminate about 28,000 tonnes of greenhouse gas emissions by 2033, equivalent to the carbon storage of close to 830,000 trees.[12]
- **Reducing road accidents.** Drone delivery is forecasted to reduce motor vehicle kilometres by 480 million each year by 2033,

9 Accenture Analysis
10 Source: Accenture Transport Cost Model.
11 Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs.
12 Greenhouse gas to carbon storage using EPA equivalency calculator (2018). Available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator, Assumes of 20-30 trees per acre.

resulting in close to 60 fewer accidents on Irish roads.

The last mile is a costly challenge

"Last-mile" delivery from the store to the home is one of the most costly segments of the retail supply chain. Most of the last mile is accounted for either by consumers taking the time to pick up their own goods (around 97% of all transactions) or by paid delivery services (around 3% of all transactions).

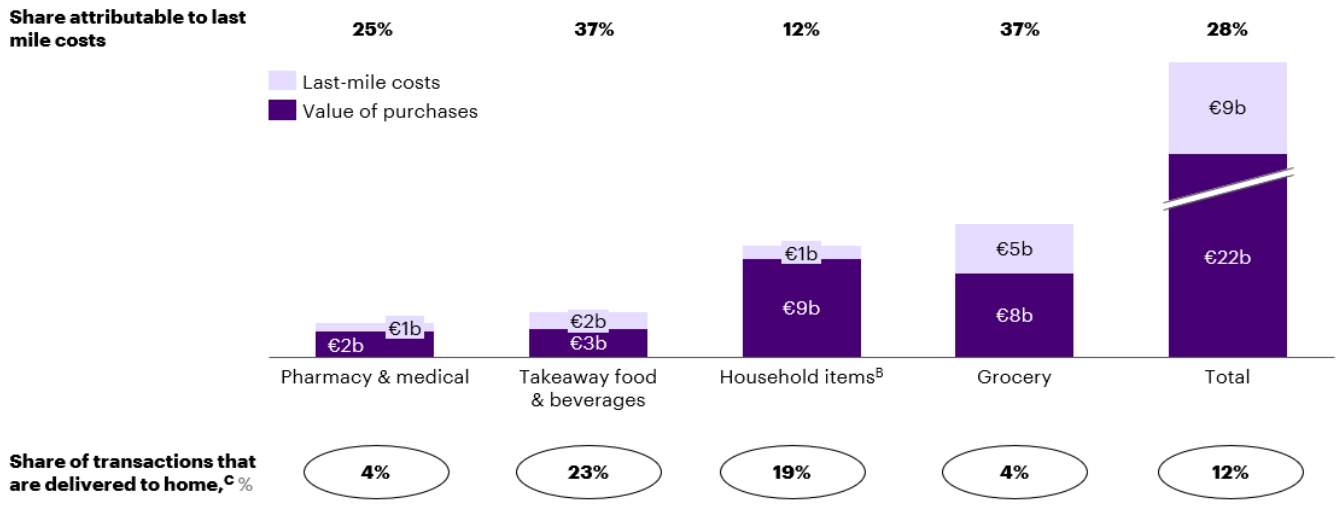
Consumers who pick up their own goods incur costs of time as well as a range of other potential expenses such as fuel, parking and other vehicle costs. Products delivered by retailers or delivery services can incur both explicit fees (such as the additional cost of delivery paid by the consumer) as well as implicit delivery costs (such as costs that are absorbed by the retailer or passed onto the restaurant). As shown in Exhibit 2, the cost of last-mile delivery can account for up to 37% of the total cost of the item, which comes either from delivery fees or the time of consumers picking up their goods.

Exhibit 2

The cost of last mile delivery and pick-up was over €9 billion in 2021, which represents 28% of the total value of retail trade in Ireland

Total value of retail trade in Ireland, including last-mile costs[A]

€B, 2021



A Excludes food consumed on-premise at restaurants/cafes.
B Includes hardware and home goods, clothing & footwear, department stores and ecommerce retailing.
C Delivery percentages are typically calculated based on 2022 data, to abstract from the influence of lockdowns throughout 2020 and 2021. Other transactions are picked up instore by customers.
Source: IBISWorld Industry Reports (2022), Bord Bia–The Irish Food Board (2022), Accenture Transport Cost Model; Accenture analysis.

Drone delivery is gaining momentum globally

Investment in drone technology has grown exponentially, driven in part by retail and logistics giants seeking to improve their operations and in part by technology companies hoping to provide third-party drone delivery services to other businesses.

Whilst the COVID-19 pandemic generated significant economic uncertainty and brought many industries to a halt, the commercial drone market remained relatively unaffected. In fact, the ability of drones to provide contactless delivery for consumers likely contributed to the resilience of the industry.

The shift toward drone delivery in Europe is already underway. In late 2022, the European Commission adopted a European Drone Strategy 2.0 which set out the vision for large scale commercial drone operations across the European Union. This provided the backdrop for drone delivery demonstrations and trials in Ireland – with several drone delivery providers offering consumers quick, cost-effective deliveries of groceries, takeaway food and other household items in suburbs north of Dublin with the approval and oversight of the Government of Ireland and Irish Aviation Authority ('IAA').

Drones will have an important role to play in last-mile delivery

Drone technology has the potential to become an important part of Ireland's delivery sector, particularly in fulfilling 'last-mile' deliveries.[13] In this report, drones are expected to replace current delivery methods where:

- **Item and location satisfy physical limitations.** Based on our analysis of external literature, we expect drones to carry a maximum weight of 2.5kg and travel at top speeds over 110 km/h for a total round-trip distance of 20 km by 2033.[14]
- **Delivery is time-sensitive in nature** (needed either instantly or on the same day) and
- **Drones are a cost-effective way of transporting the item**, given the physical limitations and required delivery time. For example, deliveries that are not required until the next day (or later) can be transported more cheaply by traditional forms of delivery (e.g. parcel vans) due to the potential for economies of scale.

The result of applying these criteria (as shown in Exhibit 3) is that drones are most likely to be used for small item deliveries made on an instant or same-day basis. For these time-sensitive transactions such as food and medicine delivery, drones are significantly less expensive (€1.85 per delivery compared to €16.30 for consumers)[15] and faster than other methods (more than twice as fast compared with current methods of instant delivery such as Deliveroo). Standard, less urgent deliveries will likely still be fulfilled by road vehicles (including potentially autonomous ones) by 2033. These vehicles can achieve a lower average estimated cost per delivery than drones when economies of scale can be achieved (i.e. when standard parcel deliveries are grouped together and delivered along a route).[16]

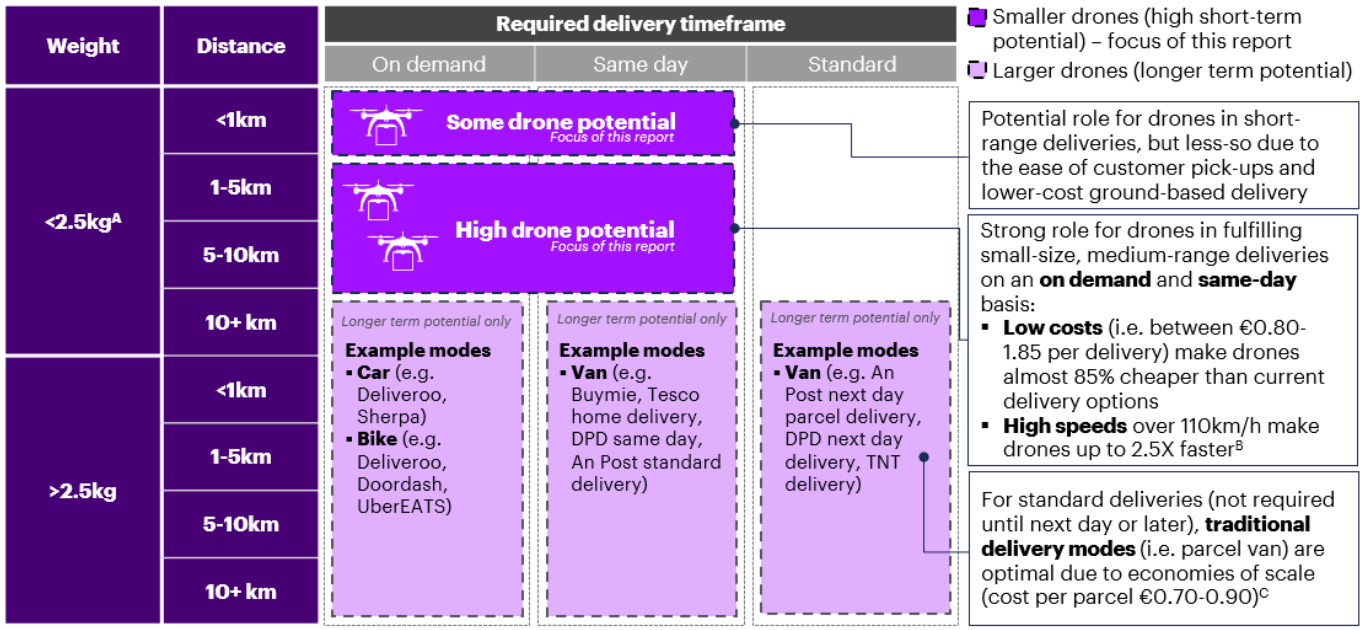
13 'Last-mile' deliveries include transporting an item to the customer's location from the retailer (if close) or local distribution centre.
14 The 20 km round-trip range allows drones to deliver packages at up to a 10 km radius but not beyond. While large drones could service larger distances and carry heavier packages, these aircraft were not considered as part of the study due to their different cost structure and the potential emergence of cheaper alternatives for longer-range delivery (e.g. autonomous road vehicles).
15 Cost for 5-10 km instant delivery compared with private car, which we have assessed as the most economical option.
16 McKinsey (2016), Parcel delivery – the future of last mile.

Exhibit 3

Drones are promising candidates for fulfilling small orders within the same day

Current modes of delivery

Approximately 97% of transactions are picked up, the rest are delivered using a range of methods



A Assumes a maximum payload of 2.5kg and maximum range of 10km (20km round trip) for last-mile drone technology.
B Assumes a 10 km journey where a private car takes 20 minutes and a drone takes 8 minutes.
C Delivery costs refer to transport costs related to labour, fuel and depreciation. See appendix for details and assumptions.
Source: Accenture analysis

It should be noted that larger drone technology has the potential to serve greater distances and heavier packages in the future. However, the focus of this study is on lightweight commercial drones that travel shorter distances due to greater certainty around the feasibility and economics given the operational status of these currently in Ireland.

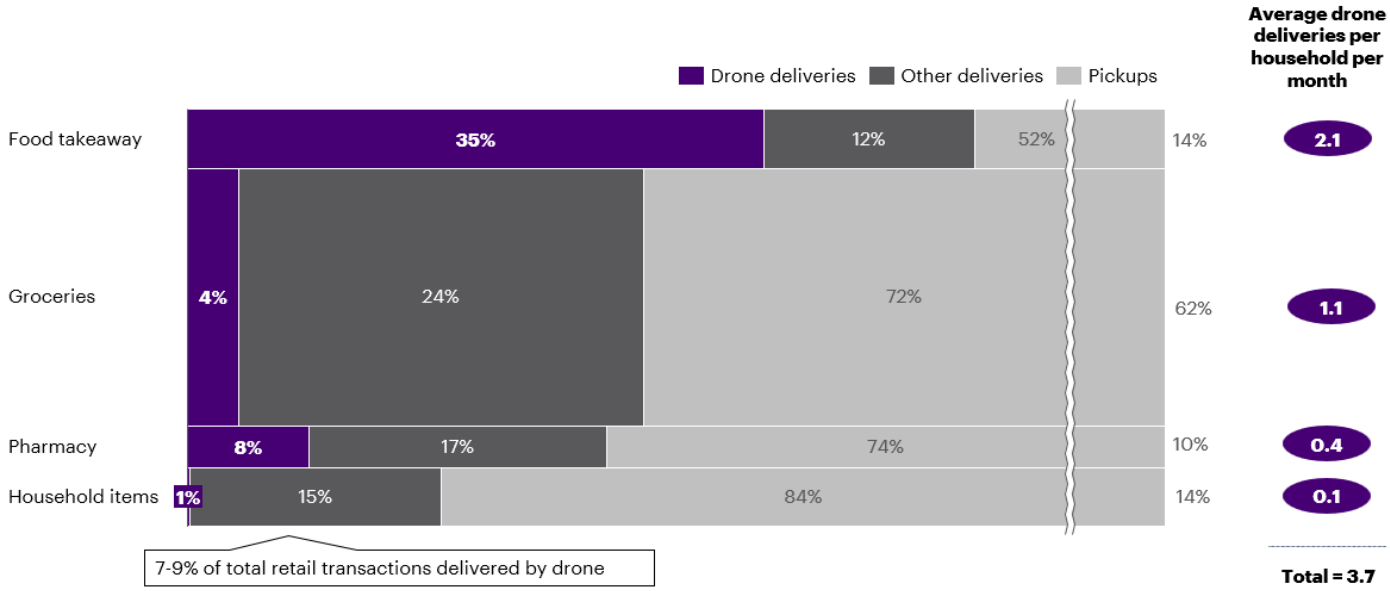
Further, for the benefits described in this report to be obtained, it is essential, as with any new technology, that sensible regulation exists to protect consumers and the community. In Ireland, the IAA manages drone registration and provides guidance for operating and flying drones to ensure public safety, privacy and regulates drone noise levels. The IAA follow drone regulatory frameworks and rules recommended by the European Union Aviation Safety Agency which are implemented in member and non-member states throughout Europe.

Exhibit 4

By 2033, drones could deliver up to 7-9% of retail transactions and over 25% in some categories (e.g. takeaway)

Share of 2033 retail transactions by mode of delivery[A,B,C,D]

% of retail transactions in 2033, by sector



A In most categories, drones are expected to replace half of today's deliveries where the transaction meets size and distance restrictions and is time-sensitive (instant or same-day), except for takeaway where the expected replacement rate is 75% due to the typically small size and instant nature of these purchases. A lower rate of replacement (by approximately half) is expected for deliveries within 1-5km of home due to ease of customer pickup and the potential emergence of low-cost ground-based delivery options. Drones are also expected to replace ~20-30% of pickups that meet size, distance and time-sensitivity criteria.
B A slightly higher share of deliveries in pharmacy & medical are serviced by drone because the transactions are more likely to satisfy drone weight restrictions than grocery or household items.
C Includes convenience stores, which have a smaller average purchase weight than supermarkets.
D These transactions only represent the total for the 69.6% of the Irish population we estimate will live in a region suitable for drone deliveries by 2033.
Source: IBISWorld, The Irish Food Board; Accenture analysis.

Drones could deliver more than one in three takeaway food orders and up to 7-9% of retail transactions by 2033

In 2022, Ireland households made over 880 million retail transactions, including groceries, pharmacy goods, takeaway food and other household items. Around 3% of those purchases were delivered to customers, while the remainder were picked up by customers travelling to the retailer's outlet.

The delivery landscape in 2033 will be different. Based on recent economic growth, Ireland households will make an estimated 1.2 billion transactions and a greater share of these will be delivered. Takeaway delivery could reach almost 50% of total takeaway sales by 2033, with external estimates for online deliveries in other product categories ranging from 20-45%.[17]

Drones will play an important role in this shift toward online delivery. It is estimated that drones could deliver up to 7-9% of retail transactions by 2033 (Exhibit 4). There is significant variation by product category, with the greatest contribution of drones coming from takeaway food and beverages (due to the time-sensitive nature of takeaway food and small package sizes) and grocery (due to the high overall volume of purchases by Irish households).

17 Based on various sources including Morgan Stanley, Pharmafile. See Appendix for details.

Benefits for business

Expanding market reach

Drones can help businesses reach more customers. The current average radius of food delivery in Ireland, for example, is only about 5 km.[18] Road delivery vehicles are too slow to deliver food to customers much further than 5km without impacting food quality (keeping hot food hot and chilled food chilled).

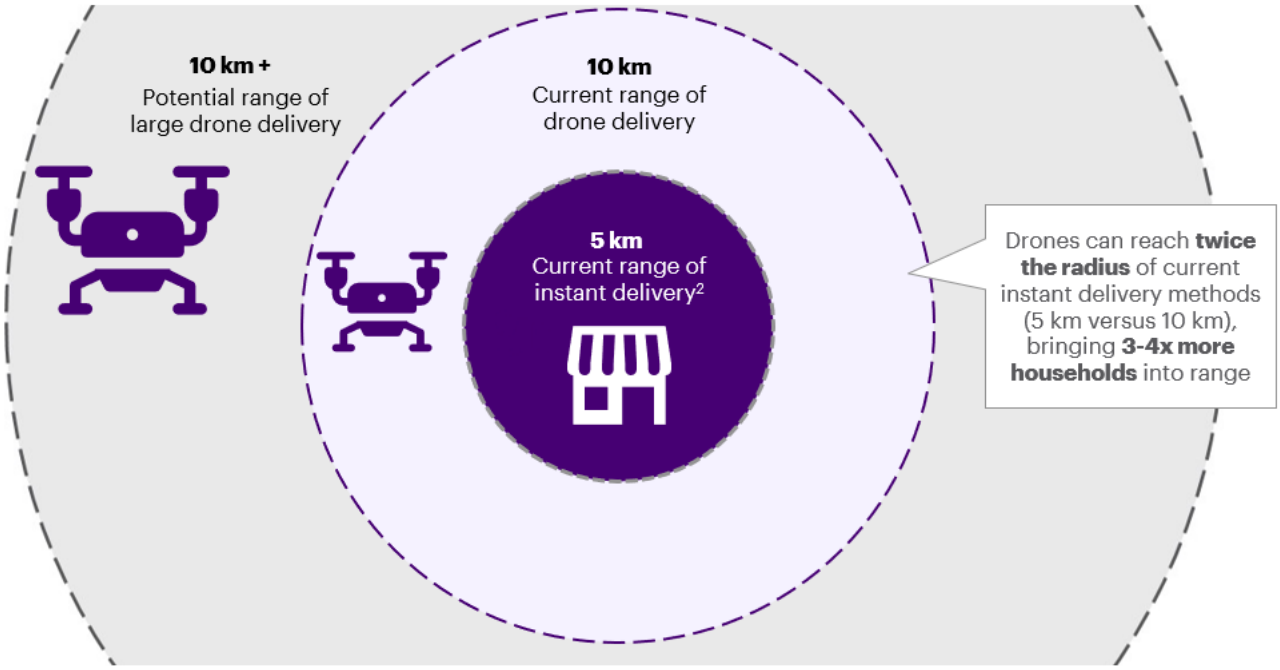
But drones can deliver a package 10 km in less time than it takes a car to drive 5 km, so the effective range doubles. Doubling the range can more than double the market each business can reach. For example, doubling the range to 10 km more than doubles the number of households within range of a restaurant based in cities such as Dublin, Galway and Cork.[19]

Even within today's delivery range, drones can help businesses better serve their customers where speed matters, such as food and pharmaceuticals. Today an 'instant' delivery van takes about 15-25 minutes to complete a 10 km trip. A drone can cover the same distance in less than 6 minutes, or more than 60% faster.[20]

Exhibit 5

Drones can double the reach of instant delivery relative to current methods, bringing 3-4x more households into range

Range of current and future instant delivery methods[A]



A current range of 5 km based on the average Deliveroo and Just Eats delivery radius in various locations in Dublin, Ireland, estimated based on furthest restaurant delivery available.

18 Current range of 5 km based on the average Deliveroo and Just Eat delivery radius in various locations in Dublin, Galway and Cork, estimated based on furthest restaurant delivery available on 19th January 2023.
19 Household estimate based on population of Ashfield. Cherry Orchard and Drumcondra and average household size of 2.75 people per household according to the 2022 Census, CSO.
20 Average van speed 40 km/h, average drone speed 100 km/h.

Reducing delivery costs

Delivery costs represent a significant expense for businesses, especially in cases where delivery is time sensitive. Currently, restaurants pay an average of 28% of each order value to online delivery service providers.[21] Further, for other items, same-day parcel delivery alone can cost over €45 (with a share of these costs borne by the retailer in some cases).[22] These costs could make it unprofitable for some businesses to offer last-mile delivery at all, despite a growing customer preference for online shopping and delivery.

Drone delivery costs are expected to be up to 86% less expensive than existing methods of on-demand and same-day delivery. Even after factoring in the likely savings for customers, businesses could save almost €136 million in fees by 2033.[23]

Generating increased sales

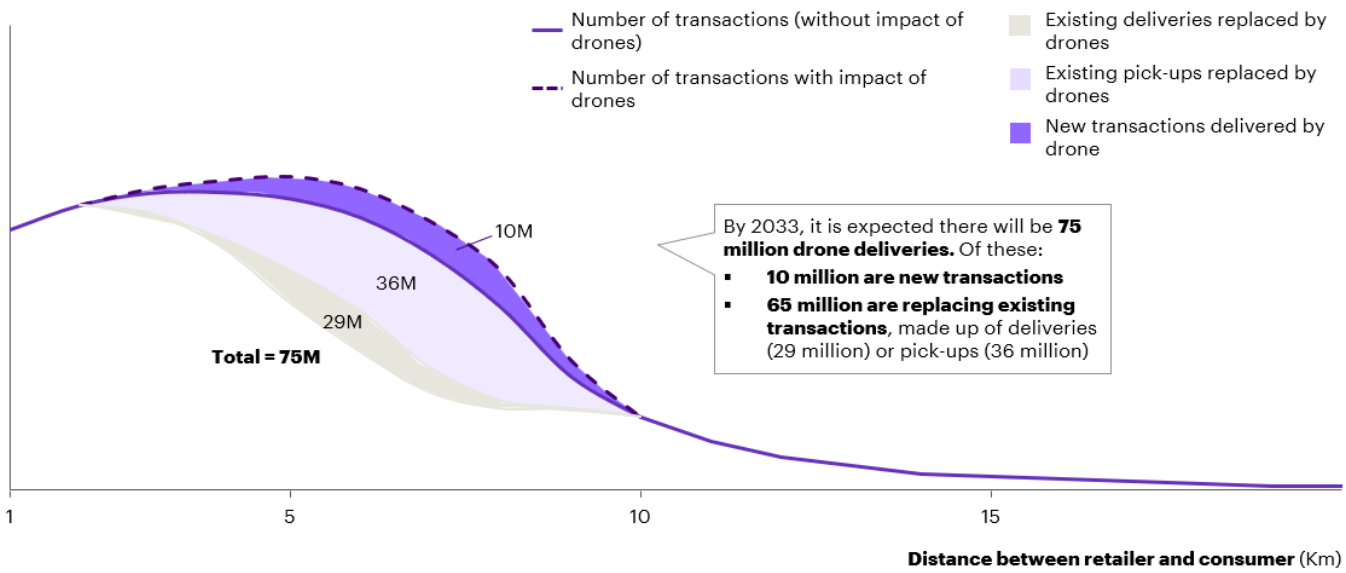
As explored in the consumer benefits section, drones will save customers time and money. That cuts the effective cost of retail purchases, so consumers will make additional or higher-value purchases. Furthermore, low value perishable goods (such as a cappuccino or fresh juice) are much more appealing when delivery is quick and cheap. It is expected that consumers are more likely to purchase these types of instant snacks when drone delivery is available. While the value is hard to estimate precisely, drone delivery could generate nearly 10 million additional annual retail transactions by 2033, translating to a sales uplift of €395 million. This benefit could be as high as €18,000 per relevant retail business.[24] Over €100 million, or just over a fourth of these benefits, is likely to be accrued by small and medium sized businesses.[25]

Exhibit 6

In 2033 there will be 75 million drone deliveries of which 10 million will be new transactions due to lower cost, greater range and increased convenience

Transactions by distance between home and retailer[A]

Retail transactions (indexed)



A Illustrative axis, retail transactions and distance between retailer and consumer are indicative.
Source: Accenture analysis.

21 Based on 2022 average from restaurant commission pricing of UberEats, Just Eat and Deliveroo.
22 Based on 2022 pricing of private ClickaCourier delivery and Copenhagen Economics (2016), Principles of e-commerce delivery prices.
23 Assumes retailers receive a reduction in delivery costs proportional to the reduction in the underlying cost of delivery due to drones.
24 Active enterprises (excluding micro businesses) from CSO Business in Ireland 2020 data.
25 Small and medium business (excluding micro businesses) are estimated to contribute 25.6% of valued added to the economy. CSO (2020), Business in Ireland 2020.

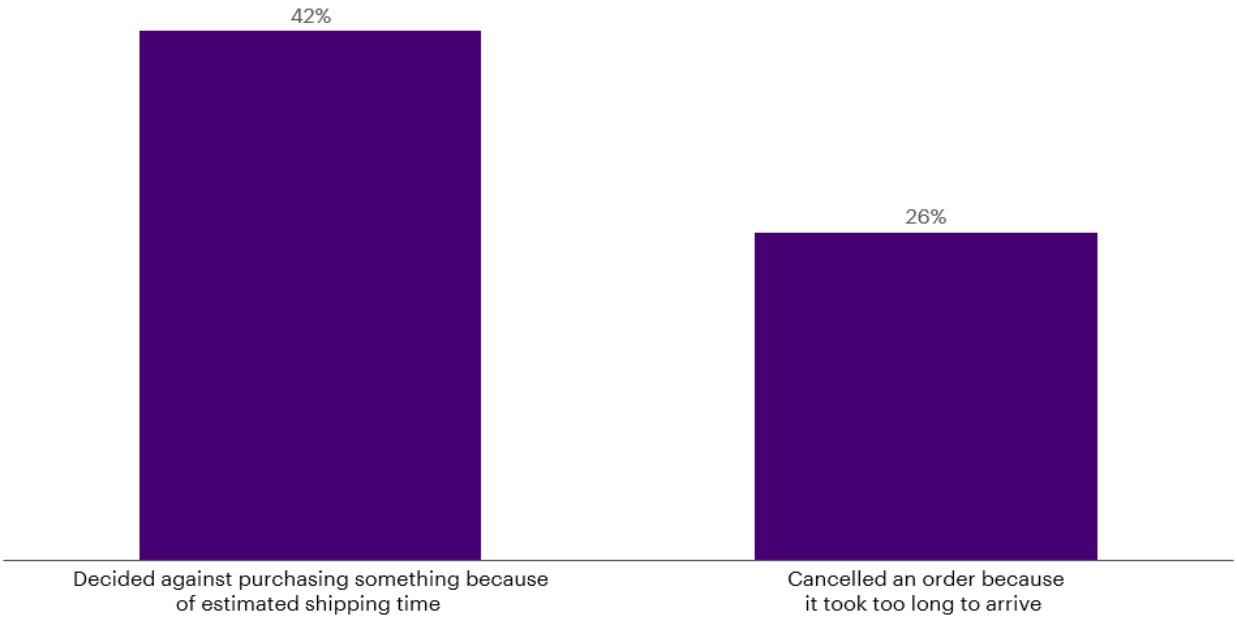
Many consumers have stated deterrence to buying online due to potential delivery delays. In a recent survey by Morning Consult, 42% of individuals decided against online purchases due to expected wait times with a further 26% cancelling existing orders that took too long to arrive.[26] Drone delivery would provide businesses with fast tracked delivery options for small items.

Exhibit 7

Slow deliveries create frictions, reducing propensity to purchase online

A survey of online shoppers shows the impact of slow delivery

% of survey respondents



Source: Morning Consult (2021) Supply chain disruptions limit consumer spending.

Enabling more businesses to deliver

When a business can reach more customers, it can serve smaller customer groups that are not well served today. For example, an outstanding takeaway restaurant that specialises in some regional cuisine could thrive when it can access a larger market. While the benefit is difficult to quantify, some businesses will be able to cut costs and increase profits by scaling up to serve such niches.

As discussed earlier in this section, businesses may be unable to offer last-mile delivery due to the cost of delivery methods available today. This is less of a problem for larger brands that typically have access to lower-cost delivery due to their scale. Drones could be a convenient, affordable option for new businesses to participate in last-mile delivery and engage in e-commerce. This would facilitate a more productive, competitive business environment.

26 Morning Consult (2021). Supply chain disruptions limit consumer spending.

Benefits for consumers

Reaching underserved populations

The availability of accessible drone delivery services could present significant benefits for people with disabilities, elderly people and vulnerable populations who are otherwise homebound. While delivery does not replace the need for more inclusive public spaces and services, drones could provide an additional way for homebound people to independently purchase items from the comfort and safety of their homes.

More than 400,000 people live alone in Ireland, of which nearly 40% are over 65.[27] Additionally, over a third of those aged over 65 live with chronic disease or a disability with many needing assistance for core activities according to statistics from the European Commission.[28] Drone delivery could play a role in serving these populations and improving their quality of life.

Saving time

Drones travel faster than all other forms of last-mile delivery, at top speeds of over 110 km/h based on current small-drone technology. Drones are also not affected by traffic congestion and can thus deliver products much faster than other ground vehicles, particularly around peak hours. As a result, drones could reduce delivery times for on-demand deliveries by up to 60% by 2033.

Further, drone deliveries can save people time by replacing close to 42 million customer pick-up journeys by 2033. As noted earlier, the last mile accounts for a large proportion of total cost of retail purchases when we factor in the time taken for customers to drive to the shops, make their transactions and bring their purchases home. By replacing customer pick-ups, drones could save consumers 31 million hours by 2033 or up to 45 minutes per trip via drone. This is valued at €384 billion after taking into account the value of time for customers completing these pick-up journeys.

Additionally, drone deliveries give consumers greater control of their deliveries. The traditional experience of ordering a product and being uncertain of its arrival time will be replaced with live tracking that is accurate to a matter of seconds.

Reducing delivery fees

Current delivery fees paid by consumers on instant and same-day delivery can be very high, ranging from close to €4 for a food delivery to close to €45 for a courier delivery for consumers.[29] In many cases where delivery is not an option, such as a trip to the grocery store to pick up bread, milk, or an extra ingredient that was forgotten during a larger shop, the time cost of picking up an item is also significant. Drones provide an option for consumers who want affordable on-demand or same-day delivery. By 2033, drones are expected to be up to 90% less expensive than current methods of on-demand delivery[30]. Even if only half of those savings are passed onto consumers, drones could save households a total of €115 million in delivery fees by 2033.[31] Using drones to reduce the cost of delivery can enable consumers to spend less on delivery and more on the products they want.

Expanding product variety

Drones can increase the variety and range of on-demand products available to consumers. Consumers could access three to four times the number of retailers that are currently available to them. The potential increase in range and choice is most salient in the case of food delivery, where delivery is time is sensitive and current delivery ranges are restricted.

Today, consumers can typically order food from select restaurants within a 5 km radius.[32] For example, a consumer based in Ashtown, Dublin has access to around 850 restaurants through a food delivery app. Drone delivery can broaden this to a 10km radius, which can provide access to up to four times as many vendor options. For a Ashtown customer this would mean access to Cherry

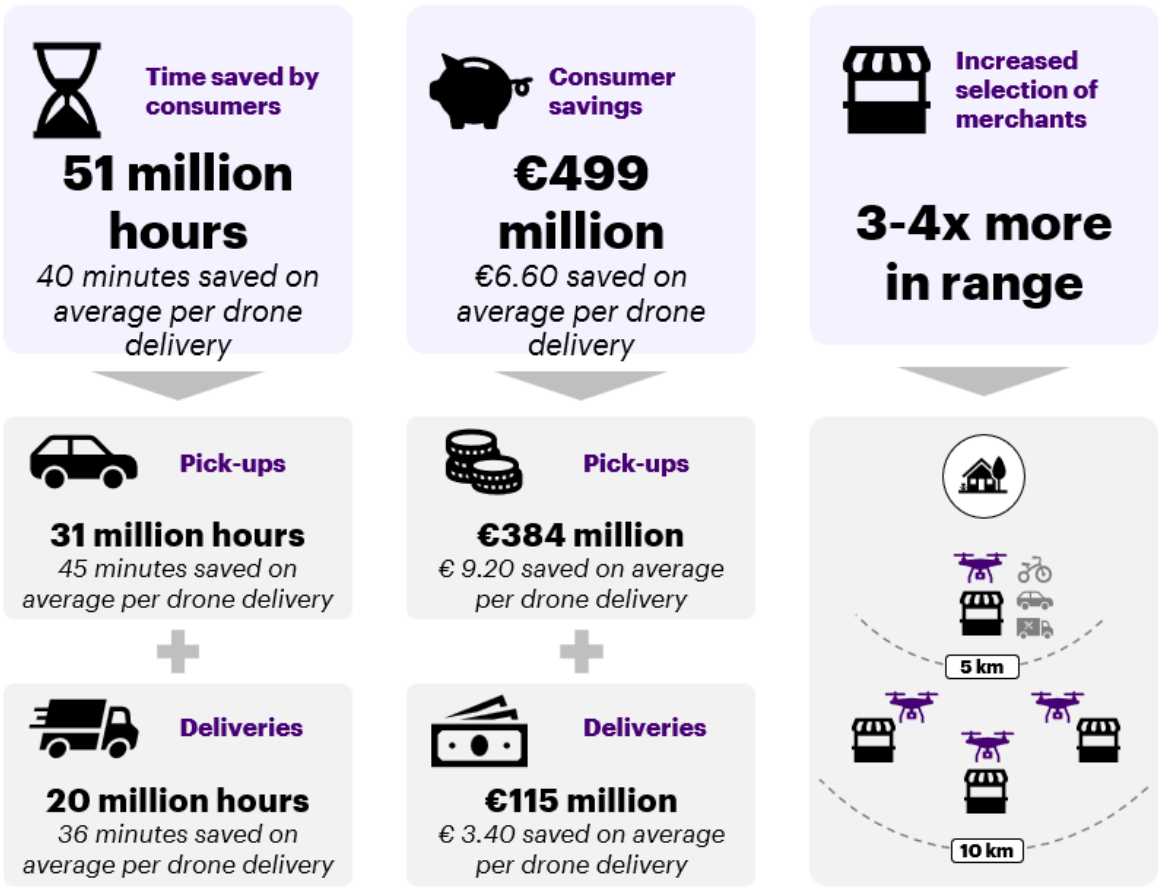
27 Health Policy and Technology (2020), The COVID-19 pandemic in Ireland: An overview of the health service and economic policy response
28 European Commission (2019), State of Health in the EU Ireland Country Health Profile 2019
29 Uber Eats, ClickACourier van delivery and An Post (2022) pricing.
30 Based on a round trip of 12-15km. See appendix for full details.
31 Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs.
32 Current range of 5 km based on the Deliveroo and Just Eat delivery radius in 2022 in Dublin, estimated based on restaurants available In Ashtown, Cherry Orchard and Drumcondra. Illustrative only.

Orchard, extending their options to a further 300 vendors and to Drumcondra with a further 1000 vendors. Quickly, consumers can see their options expanding, improving choice and convenience.

In addition to increasing the physical range of products currently available for delivery, consumers are likely to benefit from further product diversity. Drones are likely to encourage new retailers to engage in delivery services and enable existing retailers to further specialise their products.

Exhibit 8

Consumers could save over 51 million hours and nearly €500 billion by opting for drone delivery and have up to 4x more merchants to choose from



Benefits for society and the environment

Reducing congestion

Irish consumer habits are shifting, with preference for home delivery on the rise. Without action, this shift in preferences comes with an inherent increase in motor vehicle-based delivery methods, resulting in more congestion on Ireland's roads – from main highways down to suburb roads.

Because delivery vehicles are large and heavy, they can disproportionately disrupt other road users. Parking and access to loading areas often delay and inconvenience other commuters and pedestrians. Delivery-related congestion in high-density areas has only increased in the era of ridesharing and food delivery. This is particularly true in large shopping complexes where delivery drivers compete for parking, increasing congestion and reducing available parking for shoppers. Drones have the potential to reduce kilometres travelled on roads and therefore the levels of congestion experienced by people using the roads.

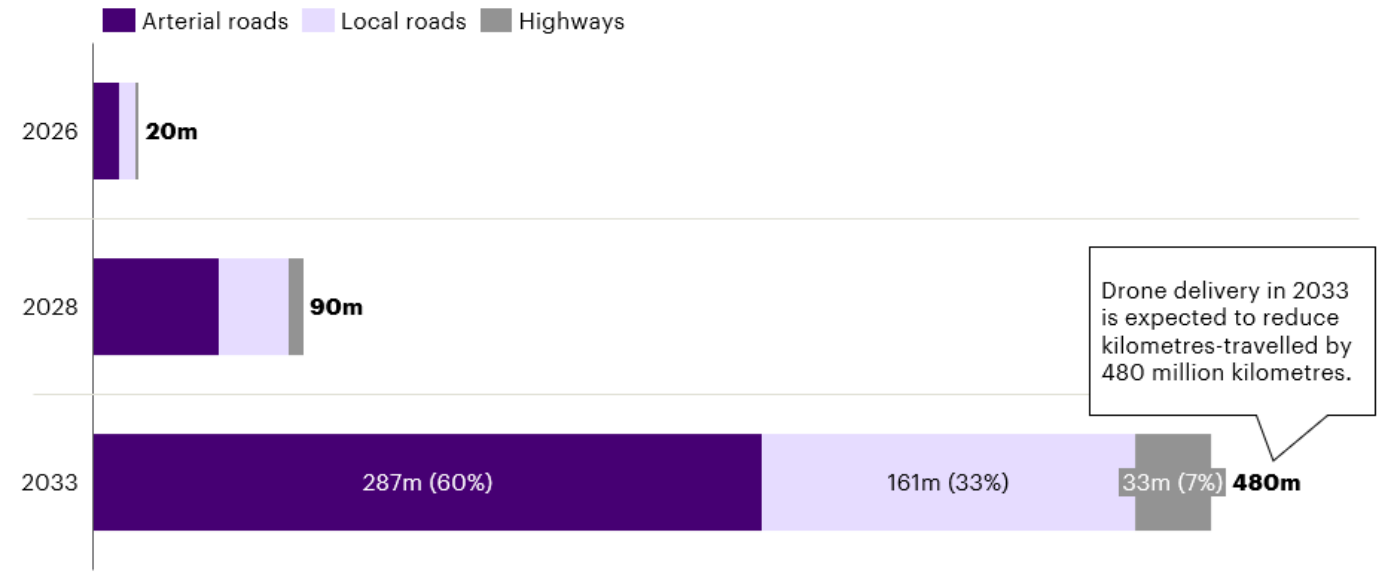
By serving 7-9% of retail transactions,[33] drones can eliminate 480 million vehicle kilometres, materially reducing the number of vehicles on roads, thus reducing congestion and its associated greenhouse gas emissions. As shown in Exhibit 9, the majority of avoided vehicle-kms (287 million) are on arterial roads – high-capacity urban roads that are susceptible to congestion. Over 160 million kilometres will be avoided on local roads, improving air quality and reducing congestion in local streets and neighbourhoods.

Exhibit 9

Drone delivery could reduce vehicle road travel by 480 million kilometres by 2033

Reduction in motor vehicle usage due to drone delivery

Reduced motor vehicle usage, millions of kilometres, by year



Source: Accenture analysis

[33] This report focuses on retail transactions, defined as food takeaway, pharmacy, grocery and household items. It is expected that 7-9% of total transactions in these sectors could be delivered by drone.

Reducing emissions

There is an urgent need for countries to lower their greenhouse gas emissions, which, if left at current levels, could have devastating effects on the world. The United Nations' Intergovernmental Panel on Climate Change has warned that several hundred million more people could face climate-related risks and poverty unless annual carbon emissions are halved by 2033.[34] As of 2022, we are not on track to limit global warming to 1.5 degrees Celsius and greater action is needed.[35]

Ireland emits 11.6 tonnes of greenhouse gasses per capita each year, one of the highest per capita rates in Europe.[36] Transport accounts for over 18% of Ireland's emissions. Drones are more environmentally friendly than alternative delivery methods – producing >95% fewer emissions for a single delivery than that of a car picking up an order from the store. Academic studies (results shown in Exhibit 10) found that small, lightweight commercial drones cause the emission of 25 grams of greenhouse gas per last-mile delivery, versus 296-728 grams for delivery trucks or vans, after accounting for the economies of scale that these trucks can achieve by delivering multiple packages along their route. Personal pick-ups via car – which we forecast will account for about 76% of transactions in Ireland by 2033 – are the worst polluters, emitting an average of 4,600 grams of greenhouse gasses per trip.[37] By using drones to fulfil 7-9% of retail transactions, Ireland could reduce its greenhouse gas emissions by nearly 28,000 tonnes by 2033, offsetting the emission of close to 830,000 trees.[38]

Contributing to low-carbon supply chains

Delivery vehicle CO_2 emissions are forecasted to increase 32% by 2030.[39] As consumers turn to e-commerce more and more and expect their orders to arrive faster than ever, the last-mile delivery sector faces significant challenges in sustainably scaling up for the task. In the regions of Ireland that we forecast could benefit from drone delivery, we predict that drones will account for 24% of deliveries by 2033. By replacing these deliveries with near-zero-carbon drone deliveries, drones have the potential to single-handedly negate the anticipated increase in CO_2 emissions due to increased deliveries.

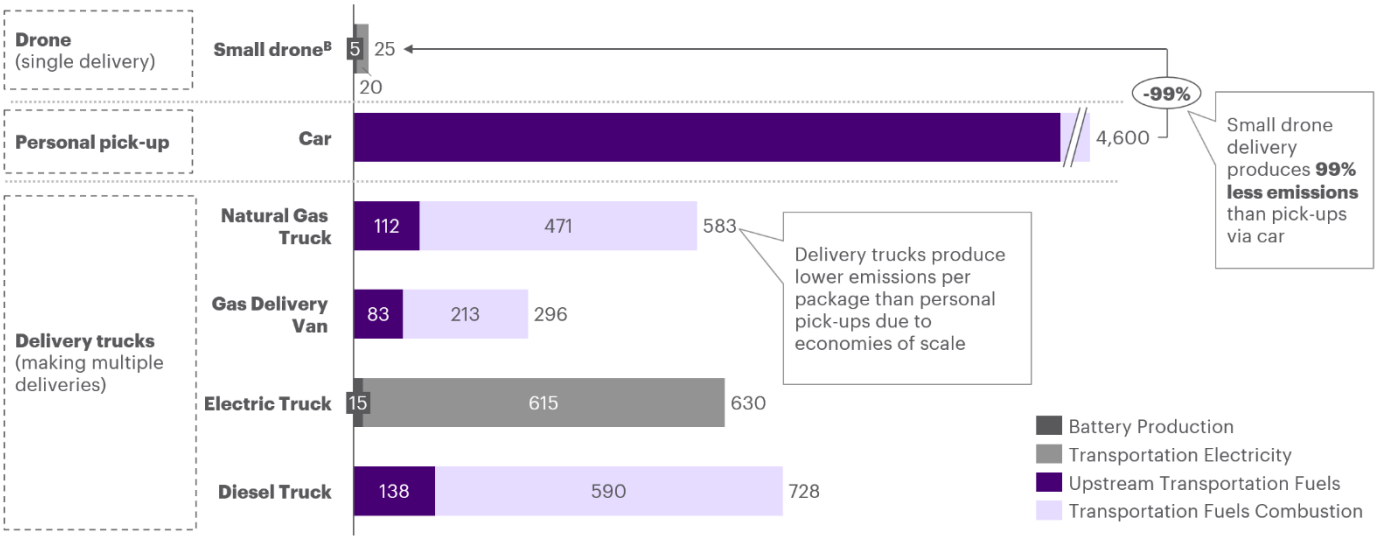
34 IPCC (2018), Global Warming of 1.5°C.
35 IPCC (2022), Opening Speech COP27 November 2022.
36 CSO (2022), Environmental Indicators Ireland 2022.
37 While a shift to renewable energy would reduce these costs, it would also reduce emissions from drones. Modelling of carbon emissions per delivery obtained from Stolaroff et al. (2018), "Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery", Nature Communications 9: 409. The estimates used in this paper exclude the fixed warehousing component (we consider the marginal emissions per vehicle trip only). The authors argue that a drone network requires more warehousing than other delivery modes.
38 Greenhouse gas to carbon storage using EPA equivalency calculator (2018). Available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator, Assumes of 20-30 trees per acre.
39 World Economic Forum: The Future of the Last-Mile Ecosystem (2020)

Exhibit 10

Drones create ~99% lower emissions than deliveries by car and are cleaner than other delivery options

Marginal environmental impact per package delivered by mode of delivery[A]

Grams of CO_2 equivalent per delivery, 'last-mile' only



A Example is based on a small quadcopter drone. Large drones exert more CO_2 per km, however small lightweight commercial drones are the focus of this analysis.
B Excludes fixed emissions (such as those associated with warehousing) – it should be noted that a drone network may require more warehousing than a traditional delivery network (as argued by Stolaroff et al, 2018). Battery production is included as the battery incurs wear with each delivery.
Source: Stolaroff et al. (2018). Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. Nature Communications 9: 409.

Reducing road accidents

There are almost 150 people killed each year on roads in Ireland with over 4,100 injury collisions of which nearly 1,200 are seriously injured.[40,41] Drone delivery service could replace 480 million vehicle-kilometres of road-based deliveries and pick-ups. This could result in close to 60 less injury-inducing collisions and 20 fewer serious road accidents resulting in severe hospitalisation and/or death. Road accidents impose significant human and economic costs on the Irish community, with the economic cost of road crashes estimated by economists to be as high as €1.15 billion, or 0.3% of GDP.[42]

40 RSA (2022). 13% rise in road deaths recorded in 2022
41 RSA (2021). Serious and Minor Injury Road Crashes Drop by a Quarter in 2020
42 International Transport Forum. (2020). Ireland

Appendix – detailed methodology

Constructing a scenario for the future role of drone delivery

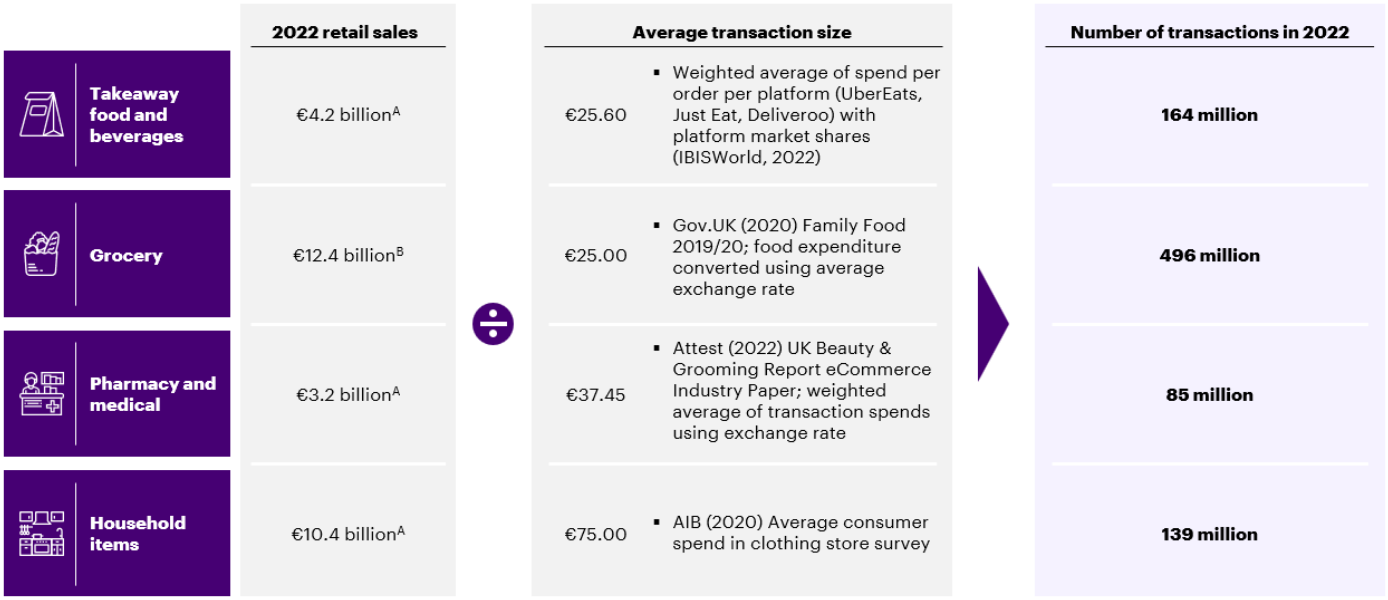
The first step in estimating the benefits of drone delivery is understanding the number and types of deliveries that might be undertaken by drones by 2033. This was done by sizing last-mile delivery in 2022, extrapolating it to 2033 and dividing it up into transactions of different characteristics based on a range of assumptions and data inputs. These transactions were further broken into those which are delivered today (versus picked up by customers) and how that might change by 2033. Assumptions were then made about the potential uptake of drones by 2033.

Sizing the last-mile delivery sector

The first step in sizing last mile delivery was understanding the number of transactions today and how those might grow by 2033. For each retail category (see Exhibit 11), we began with total retail sales sourced from IBISWorld and The Irish Food Board. To obtain the number of transactions, the average order value for each retail category was applied.

Exhibit 11

Estimating the number of transactions in base years (2021-23)



A Relevant industry report revenues from IBISWorld
B Bord Bia – The Irish Food Board (2022). Irish Grocery Retail Market Overview

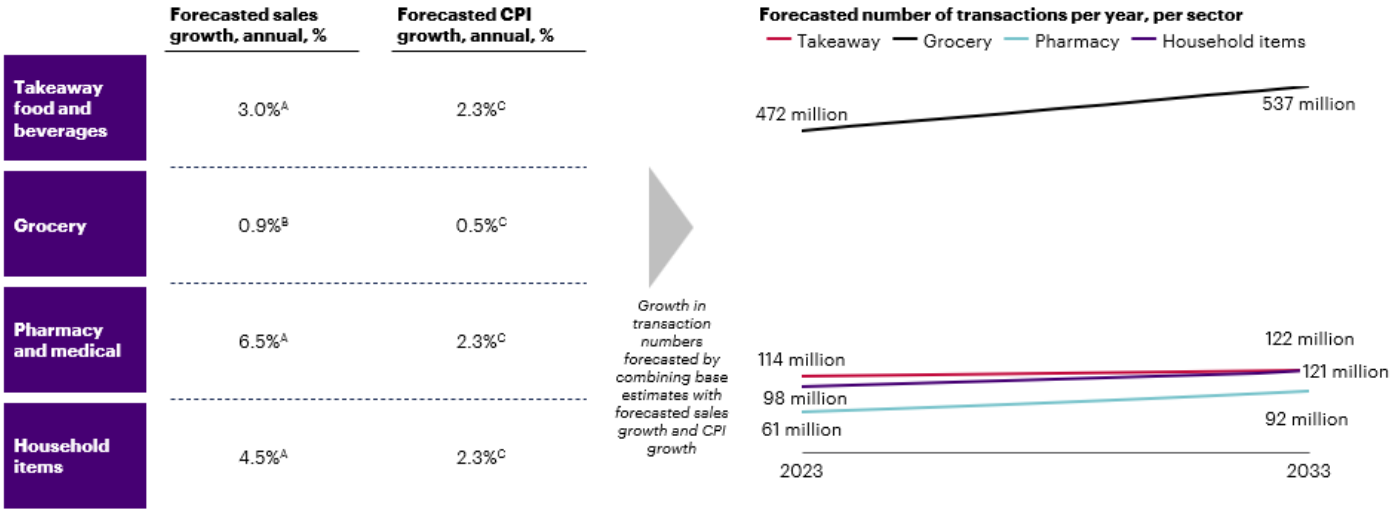
The number of transactions was then grown to 2033 volumes using a real GDP growth rate forecast. To achieve this, nominal sales growth estimates were sourced for each of the four target sectors (Exhibit 12) and CPI growth projections per sector were sourced from European Central Bank. Growth in transaction numbers can then be estimated with the following equation:

$$Transactions(year) = Transactions(2021) \cdot \left(1 + \left(sales_{growth} - CPI_{growth}\right)\right)^{year-2021}$$

Where $sales_{growth} - CPI_{growth}$ represents sector growth in real terms (accounting for higher prices per item). Transient inflation increases were factored into the model to account for relatively high inflation rates seen in 2022 and 2023.

Exhibit 12

Forecasting the number of transactions per sector through to 2033



A Sourced from Mordor Intelligence industry reports.
B Sourced from Central Statistics Office on Retail Sales Index July 2022
C ECB (2022) HICP macroeconomics projections; Forward-looking CPI projections for 2025 applied from 2023-2033 with Total HICP applied for takeaway, pharmacy and household items sectors whilst HICP food applied for grocery sector

The number of transactions were then divided across three axes:

- Distance between merchant and customer
- Time sensitivity of the purchase (how quickly the item is required, i.e. on-demand, same day or standard)
- Size distribution of the transactions

The assumptions and inputs used to disaggregate the transactions are given in Exhibit 13. The time sensitivities and size distribution of transactions were varied by sector to account for variation in transaction behaviour (i.e., consumers are generally more likely to purchase a larger weight of items from a grocery store than they would in a takeaway order).

Exhibit 13

Distance, time sensitivity and size assumption or transactions

Distance assumptions

Distance from outlet, %	% of households
<1KM	10%
1-5KM	60%
5-10KM	25%
>10KM	5%

Required delivery timeframe assumptions (% of orders)

Product category	Instant	Same day	Standard
Takeaway food & beverages	100%	N/A	N/A
Grocery	20%	60%	20%
Pharmacy and medical	33%	33%	33%
Household items[A]	2%	20%	78%

Size distribution of transactions

Takeaway food and beverages	Small (<2.5kg)	85%	▪ 2.5kg payload assumed to capture 80 to 90% of today's food delivery
	Medium (2.5-6kg)	10%	
	Large (>6kg)	5%	
	Total	**100%**	
Grocery	Small (<2.5kg) *(Top-up)*	40%	▪ 2.5 supermarket visits per week (from Torchmedia, 2007) – assume one is weekly shop and other 1.5 are top-ups (distributed evenly between small and medium) ▪ Convenience stores included in this category, and have smaller purchase sizes, so share of small transactions increased slightly to 40%
	Medium (2.5-6kg) *(Top-up)*	30%	
	Large (>6kg)	30%	
	Total	**100%**	
Pharmacy and medical	Small (<2.5kg)	80%	▪ 80% of items assumed to be small
	Medium (2.5-6kg)	15%	
	Large (>6kg)	5%	
	Total	**100%**	
Household items	Small (<2.5kg)	45%	▪ Based on distribution of transactions between different subcategories within household items (e.g., furniture, electrical, hardware, etc.), and the share of each that is likely to be heavy, medium or light
	Medium (2.5-6kg)	45%	
	Large (>6kg)	10%	
	Total	**100%**	

A Shares from McKinsey (2016) Parcel delivery – the future of the last mile.
Source: Previous Accenture estimations; Torchmedia (2007) Supermarket Insights, Finder 2022 Supermarket Insights; previous Accenture estimates for Wing; Google maps analysis.

Once estimates were obtained for the number and types of transactions, it was necessary to break these down further into those that are delivered versus those that are picked up. For this we used a range of external inputs, as shown in Exhibit 14.

Exhibit 14

Estimating the share of relevant transactions that are delivered[A]

A 'Relevant transaction' refers to transactions eligible for drone delivery, i.e. small (<2.5kg) with a pick-up/delivery distance up to 10km.

The resulting dataset is a rich breakdown of transactions – for both today and 2033 – by weight, distance, time-sensitivity and current mode (delivery versus pickup). That is, for each cell in the matrix in Exhibit 15, we form a detailed view of the number of transactions that are delivered versus picked up in 2022 and 2033.

	2022		2033	
Takeaway food and beverages	22.5%	IbisWorld (2022). Restaurants and Takeaways in Ireland	46%	Previous Accenture estimates; existing growth and market estimates of online takeaway and delivery (Morgan Stanley 2018)
Grocery	4%	The Irish Times (2021). Online grocery shopping still to take off in Irish market. Statistics sourced from Kantar industry report	30%	Previous Accenture estimates; engagement with industry experts. Market estimate and historic growth (Bankwest 2018). Delivery market estimate using predicted growth (Nielson 2018, Woolworths 2018, Livewire 2018)
Pharmacy and medical	4%	IbisWorld (2022). Dispensing Chemists in Ireland	28%	Previous Accenture estimates; current market and anticipated growth (ABS 2017, Pharmafile 2016). Estimated delivery and growth (Australia Post 2018)
Household items	15.5%	J.P. Morgan (2021) 2020 E-commerce Payments Trends Report: Ireland	29%	Previous Accenture estimates; current market and historic growth (Australia Post 2018). Current online sales and expected growth (Australia Post 2018, UBS 2018)

Exhibit 15

A dataset was constructed that provides a detailed breakdown of current and future retail transactions

Number of transactions by type

Weight	Distance	Required delivery timeframe		
		On-demand delivery	Same day	Standard
<2.5kg	<1km			
	1-5km			
	5-10km			
	10+ km			
>2.5kg	<1km			
	1-5km			
	5-10km			
	10+ km			

For each cell in this table, the dataset contains the number of transactions, split by:

- Retail product category
- Whether the transactions are delivered or picked up by the customer

These figures were forecast for years between 2023 and 2033 based on current sales values and estimated growth rates.

Source: Accenture analysis.

The final step for forecasting the size of the drone delivery sector involved estimating the proportion of residents that would be in range for large-scale commercial drone delivery operations. To estimate this, we used CSO urban and rural classifications. Urban areas are categorised as cities, satellite urban towns and independent urban towns (Table 1) with this proportion of Ireland's population taken as feasible for drone operations. The resultant proportion of the population eligible based on this definition was 69.6%.

Table 1

Urban area definitions

	Type	Definition
Urban Areas	Cities	Towns/settlements with populations greater than 50,000
	Satellite Urban Towns	Towns/settlements with populations between 1,500 and 49,999 where 20% or more of the usually resident employed population's workplace address is in the 'Cities'
	Independent urban towns	Towns/settlements with populations between 1,500 and 49,999 where less than 20% of the usually resident employed population's workplace address is in the 'Cities'

Source: CSO (2019), Urban and Rural Life in Ireland, 2019

This method was used to give a general estimation only and does not represent commercial strategies nor plans for drone delivery operators. It is likely that more areas could be serviced if commercial-scale drone delivery is a viable option, as is the case that regions proportioned as viable may not be serviced by drone delivery.

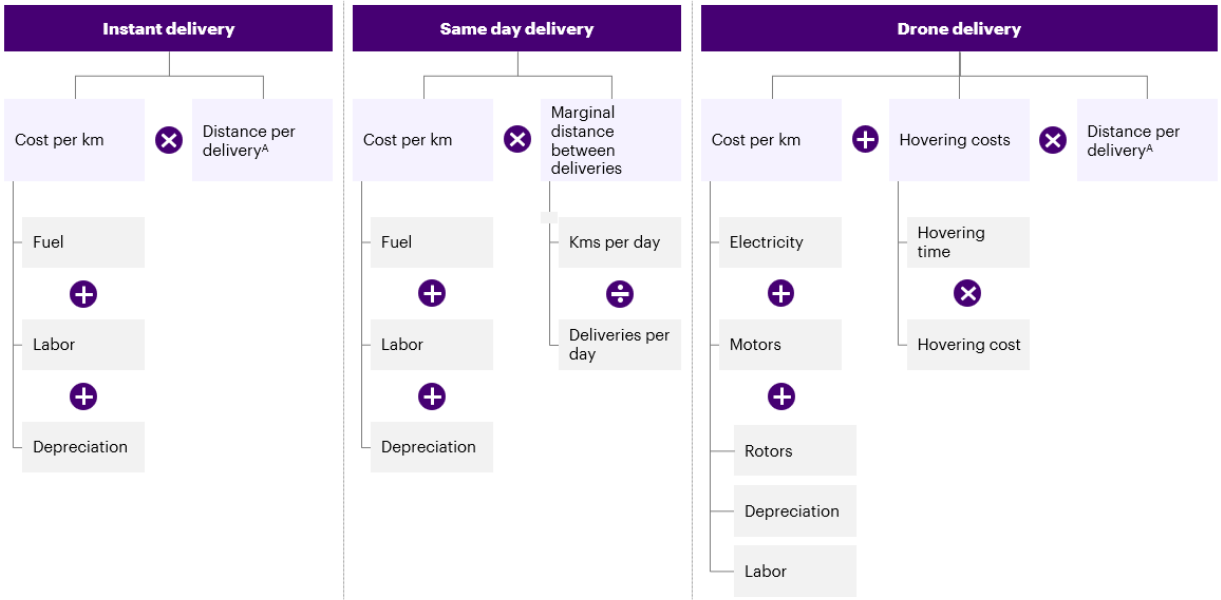
Estimating the change in delivery costs

Estimating the cost of current and future delivery modes

Delivery costs of vans, cars, bikes and drones were considered in this report and defined as the marginal cost related to the transportation of products. For current modes of delivery, this includes labour, depreciation and fuel expenses. For drone delivery, a bottom-up view of drone costs was estimated to consider component costs such as the motor, rotor, batteries, labour and electricity (see Exhibit 16). The marginal delivery cost was calculated for all four modes across each distance category and three delivery periods (instant, same day and next day). Accenture's cost saving estimates are consistent with other external views (see Exhibit 17).

Exhibit 16

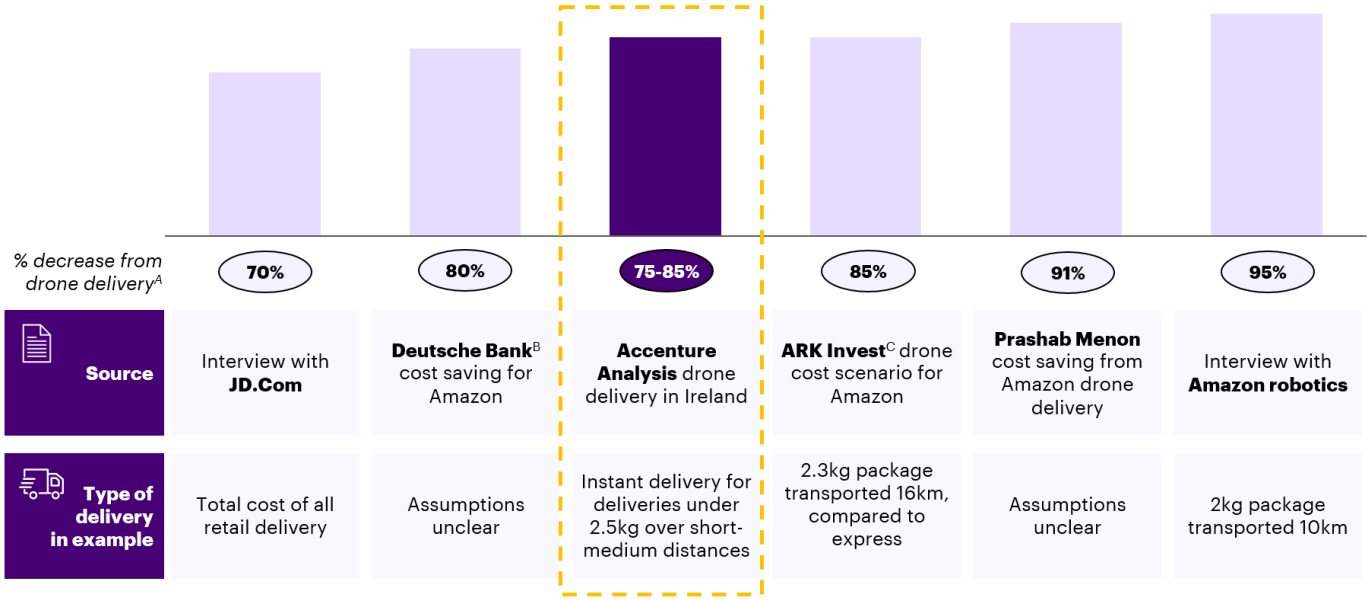
Estimating the cost of instant, same day and drone delivery



A Distances were calculated for each distance category: <1km, 1-5km, 5-10km, >10km.
B Estimated delivery distance equal to return of each distance category.

Exhibit 17

The estimated drone cost savings are consistent with external views



A Cost saving estimates have been collected from desktop research. Assumptions are not always clear and vary by source of analysis.
B Cost saving from a combination of delivery automation, drones and robots.
C Labour costs are a high share of potential drone delivery costs, 60%.
Source: Desktop research; ARK Invest; Business Insider; University of California Berkeley; Ivey Business Review.

Estimating the cost of instant delivery

Cost modelling for instant delivery used a different method to same-day and next-day delivery. Instant delivery calculations assumed that food delivery and private couriers only deliver one parcel at a time. These deliveries are often point to point and the estimated marginal cost is the distance between the point of origin and destination. Thus, the distance travelled per delivery is similar to drones, making the cost comparison straightforward. To account for road design and traffic, a discounted average delivery speed was assumed for current methods of delivery.

Assumptions related to speed, distance and route activities were tested with industry experts. The high-cost nature of point-to-point delivery meant that instant delivery costs were significantly higher than same-day and next-day deliveries. This is consistent with market price estimates from Deliveroo, Just Eats, Uber Eats, ClickaCourier and An Post.

Estimating the cost of same-day and standard delivery

To ensure an accurate cost comparison with drone delivery, same-day and next-day delivery, cost calculations considered economies of scale and optimised delivery routes. Modes that use route delivery have a different marginal cost structure to instant, point-to-point deliveries, where the marginal cost per delivery is the cost between the previous drop and the next drop, as opposed to the cost from point of origin to point of destination. Given the scale and efficiency of the standard parcel delivery sector, conservative assumptions were made to factor in high economies of scale. This was done by varying the marginal distance per delivery across each different distance length. The further the delivery destination was from the point of origin (i.e. shop or parcel depot), the greater the additional distance per parcel.

Table 2

Inputs and sources for calculating current delivery costs

Area	Metric	Source
Marginal cost of delivery	Fuel Costs	▪ Ireland unleaded and diesel prices (December 2022) ▪ Care Ireland, CarZone, CarBuyersGuide, Donedeal - Mercedes Sprinter (2020) and Toyota Corolla (2018)
	Labour costs	▪ Indeed (2022). Salary for An Post van driver and van drivers
	Labour (pick up) costs	▪ CSO (2021) Earnings and labour costs
	Depreciation costs	▪ Care Ireland, CarZone, CarBuyersGuide, Donedeal - Mercedes Sprinter (2020) and Toyota Corolla (2018) ▪ Revenue Irish Tax and Cuts Wear and Tear for Claim for Car Expenses & Capital Allowances
	Trip speed	▪ Industry expert interviews
Distance of marginal trip	Distance travelled per trip by vehicle	▪ CSO (2021) Road Traffic Volumes for goods and average total vehicles
	Parcels per day	▪ Accenture analysis ▪ Industry expert interviews

Estimating the cost of drone delivery

The novel nature of drone delivery has made it relatively difficult to determine potential costs. To solve for the shortage of available information, drone costs referenced in this report represent a bottom-up approximation of the individual components of a drone. To ensure the potential of drones is realistic, conservative estimates of package load, range speed and overall cost were used to calculate the potential marginal cost of drone delivery across different distances.

Table 3

Inputs and sources for calculating drone delivery costs

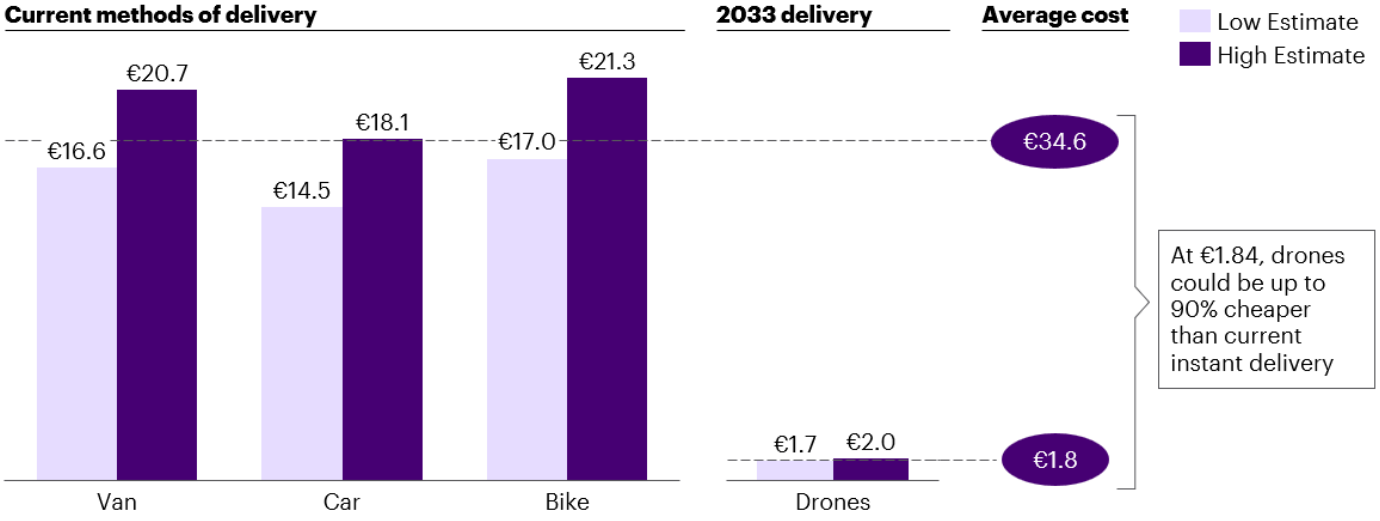
Area	Metric	Source
Marginal cost of delivery	Electricity and battery costs	▪ Jenkins et.al (2017) Forecast of commercial UAS package delivery market ▪ Industry expert interviews
	Motor costs	
	Rotor costs	
	Depreciation costs	
	Labour costs	▪ Salary Expert (2022). Average salary of drone pilot
Operation trip assumptions	Hovering time	▪ Jenkins et.al (2017) Forecast of commercial UAS package delivery market ▪ Industry expert interviews
	Speed	
	Flight time	
	Trip per day	

Exhibit 18

At €1.84 per trip, drones could be 90% cheaper than current instant delivery

Cost of instant delivery methods

€ per additional trip for delivery 5-10km from point of origin[A]



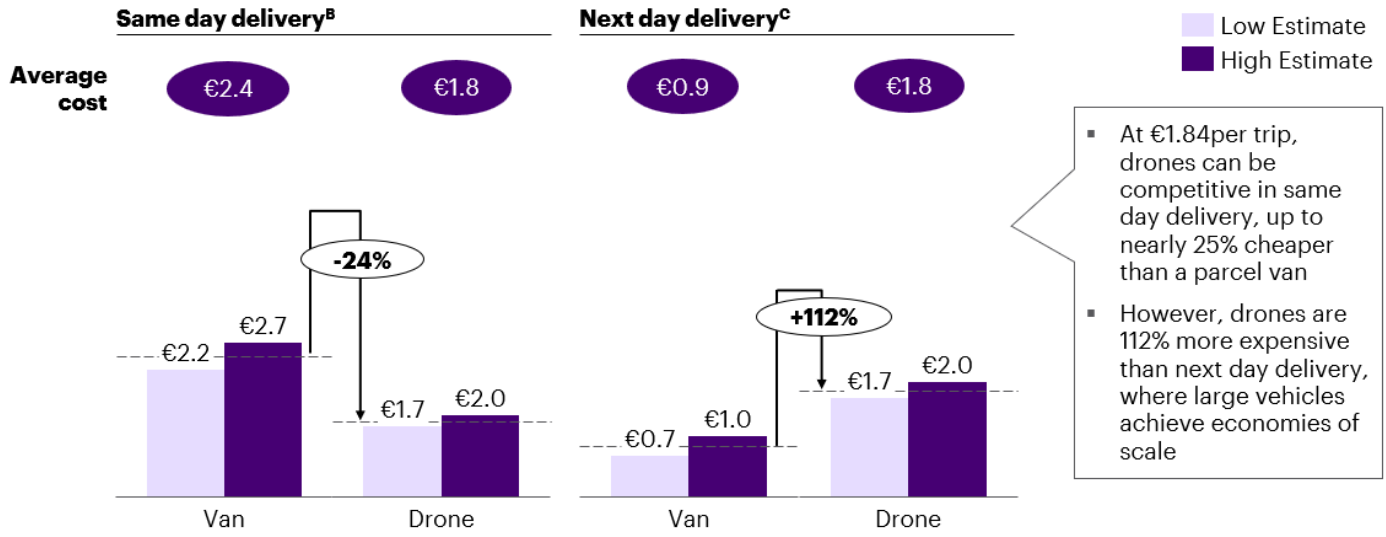
A Assumes an instant delivery return trip of 12-15 km
Source: Accenture analysis

Exhibit 19

Drones become less affordable when competing with large vehicles that gain economies of scale from delivering multiple parcels

Cost of same day and next day delivery

€ per additional trip for delivery 5-10km from point of origin [A]



A Assumes an instant delivery return trip of 12-15 km
B Assumes additional delivery distance on existing route is 1-1.2 km per delivery
C Assumes additional delivery distance on existing route is 0.4-0.6 km per delivery
Source: Accenture analysis

Establishing a reasonable scenario for uptake

For each cell in Exhibit 15, it was necessary to form a view on the potential uptake of drone delivery by 2033. Educated assumptions were made about the share of current deliveries and pickups that could be migrated to drone delivery. Different assumptions were made for each retail category to reflect their different suitability for drone delivery (for example, uptake is expected to be higher for takeaway given it is currently the primary use case for Wing drone delivery trials). The result of these assumptions is provided in Exhibit 20. Note that assumptions were made at a more detailed level and are aggregated to this level for presentation.

We arrived at estimates for adoption between 2022 (the base year of the forecasts) and 2033 (the final year) by fitting an innovation adoption curve to existing drone delivery data (2019-21; 2022 extrapolated) and the target forecast by 2033. This resulted in the adoption rates shown in the left-hand-side of Exhibit 21, this adoption curve suggested a peak uptake rate in early-2031, practically this meant that we anticipate 5.3% of 2033 adoption rates by 2026 and 20.5% of 2033 adoption rates by 2033. The adoption of drone delivery does not just include consumer adoption rates (as innovation adoption rates for software products would likely be accelerated compared to hardware adoption), this analysis implicitly takes into account:

- Varying regulatory adoption timeframes from federal, state/territory and local governments.
- Varying adoption timeframes for businesses hosting drone delivery services / partnering with providers.
- Varying adoption rates by consumers, once drone delivery is available in their local region.

Exhibit 20

Assumptions were made about the potential uptake of drone delivery for the relevant transaction types

Assumed percentage of transactions delivered by drone by 2033

Weight	Distance	Required delivery timeframe		
		On-demand delivery	Same day	Standard
<2.5kg	<1km	10-15%	4-6%	
	1-5km	30-35%	8-12%	
	5-10km	24-28%	8-12%	
	10+ km			
>2.5kg	<1km			
	1-5km			
	5-10km			
	10+ km			

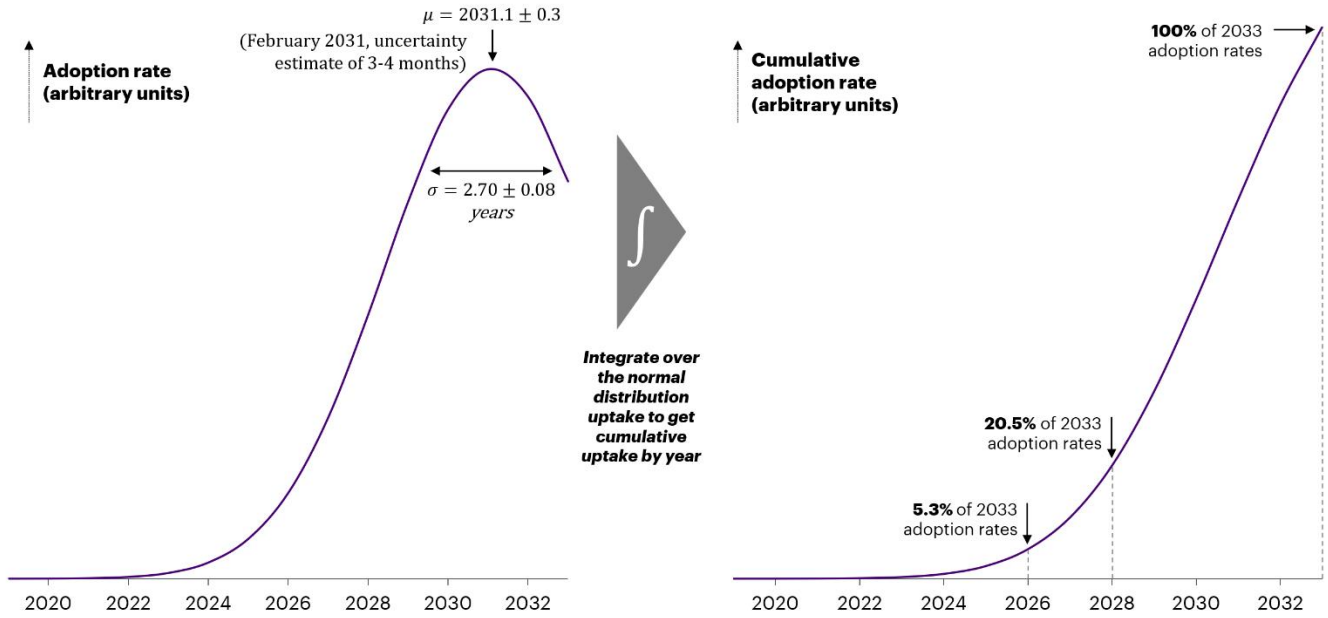
Factors influencing the share of deliveries undertaken by drone include:

- **Distance:** Very close transactions are less likely to be delivered due to ease of pickup
- **Time sensitivity:** Drone uptake is higher for instant transactions due to the higher speed and lower cost of drones versus other methods of instant delivery
- **Mix of current delivery modes:** Delivered transactions are more likely to be replaced by drone than pickups as the latter requires a bigger behaviour change from consumers

Source: Accenture analysis.

Exhibit 21

An adoption curve was estimated by fitting drone adoption data to a normally distributed tech adoption rate curve[A,B,C]



A Drone adoption data from 2019-22 was sourced / estimated from various public sources, including Wing news media.
B Adoption curves are assumed to have similar shapes for the fours sectors analysed in this report.
C The basis for the normal distribution adoption rate is the Rogers' Innovation Adoption Curve which approximates the diffusion of new technologies.

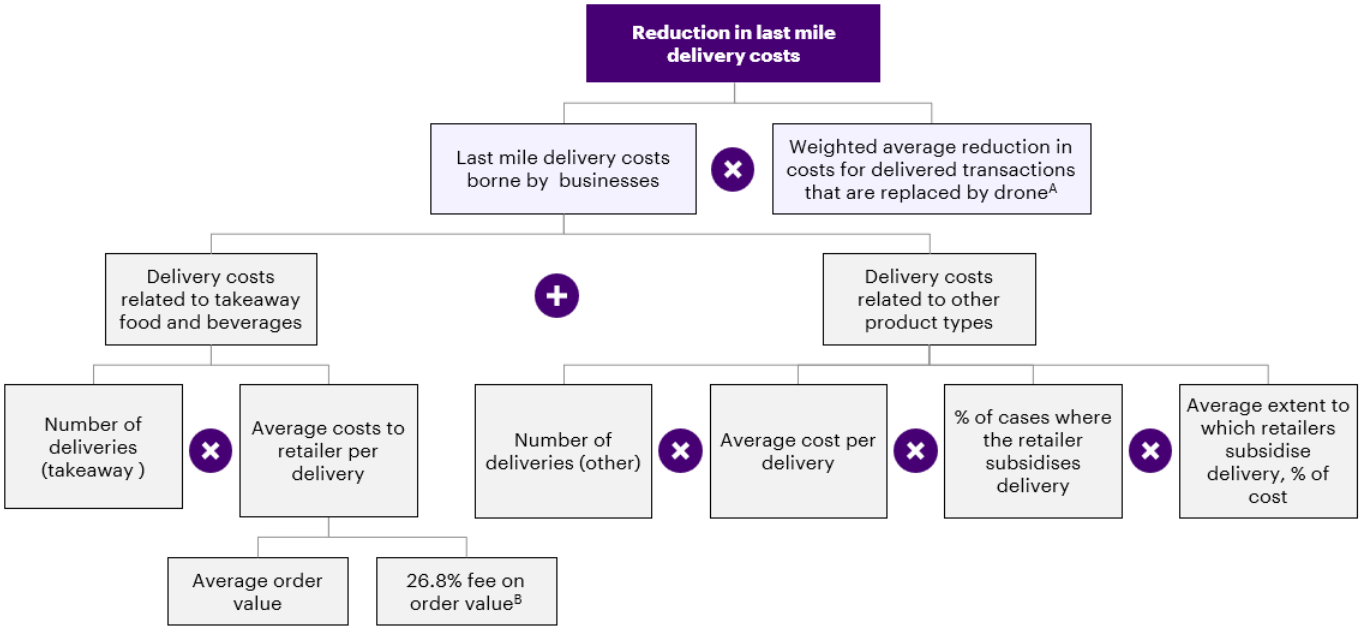
Estimating benefits for businesses

Reducing delivery costs

Using the cost estimation derived earlier for drones versus current modes of delivery, the potential reduction in delivery costs to businesses was estimated as shown in Exhibit 22. The estimated reduction is the product of the weighted average reduction in delivery costs and last mile delivery cost borne by businesses. The business borne metric is calculated using average fees incurred by businesses for delivery costs related to takeaway versus other product items (grocery, pharmacy, household items). Takeaway was calculated separately as a higher proportion of transactions are delivered in this sector relative to the other sectors.

Exhibit 22

Calculating the reduction in last-mile delivery costs for businesses



A It is assumed that retailers receive a cost increase that is proportional to the decrease in the underlying cost of delivery.
B Weighted average of takeaway delivery platforms by fee structure (%) and market share Ireland.

Table 4

Inputs and sources for calculating reduction in delivery costs

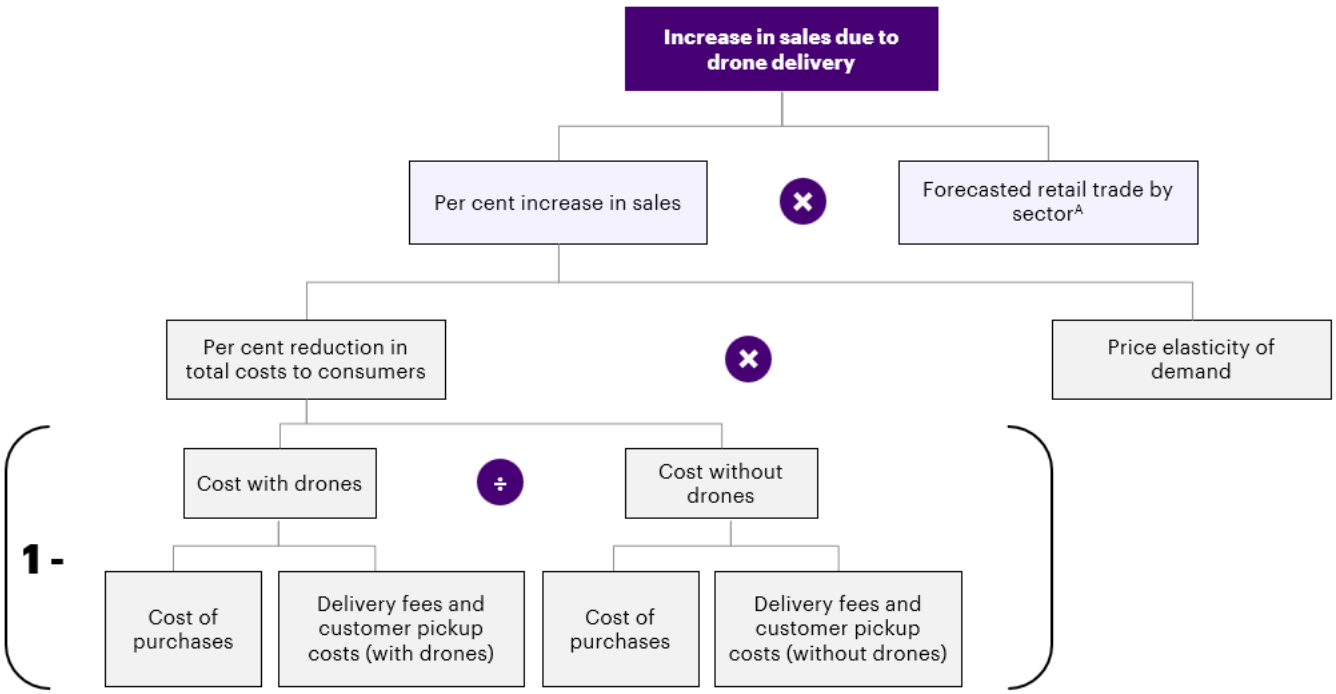
Area	Metric	Source
Weighted average reduction in costs for delivered transactions that are replaced by drone	Weighted average cost reduction (%)	▪ Estimated using the results obtained in earlier sections of this appendix (cost of drones, cost of current methods of delivery and current mix of transaction types)
Last mile delivery costs borne by consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last-mile sector by 2033)
	Number of deliveries (other)	▪ As above, but for non-takeaway transactions
	Average cost per delivery	▪ Obtained from earlier analysis of the cost of delivery for each mode of transport, combined with the current mix of transaction types
	% of cases where the retailer subsidises delivery and amount of subsidisation	▪ Analysis of mystery shopping data presented in Copenhagen Economics (2016), Principles of e-commerce delivery prices

Generating more sales

Reducing costs to consumers (via lower delivery fees and pick-up travel costs) has the potential to generate more transactions that would otherwise not have occurred. This effect was estimated as in Exhibit 23.

Exhibit 23

Calculating the increase in total sales due to less expensive and more convenient delivery



A Includes takeaway but excludes meals consumed at restaurants.

Table 5

Inputs and sources for calculating the increase in sales

Area	Metric	Source
2022 total retail trade	Total retail trade in 2022 (€M)	▪ Number of relevant industries from IbisWorld (2022) and Irish grocery retail market numbers from Bord Bia – The Irish Food Board (2022)
Per cent increase in sales	Cost of purchases	▪ Relevant industry reports for Ireland from IbisWorld for pharmacy, takeaway and household items (2022) ▪ Irish grocery retail market from Irish Grocery Retail Market Overview (2022) by Board Bia Ireland
	Delivery fees and customer pickup costs with drones	▪ Obtained from earlier analysis (see "Estimating the change in delivery costs" in this appendix)
	Delivery fees and customer pickup costs without drones	▪ Obtained from earlier analysis (see "Estimating the change in delivery costs" in this appendix)
	Price elasticity of demand	▪ Elasticity of 0.7, based on: – Supermarkets elasticity of 0.6, obtained from Andreyeva (2010) The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food. American Journal of Public Health (AJPH) – Adjusted upwards slightly to reflect other product categories (takeaway and household items) that are likely to be more price-elastic than groceries ▪ This elasticity was considered conservative, because we do not measure the intangible value placed on increased convenience and greater choice, which would also have a positive impact on transaction activity.

Expanding market reach

A key benefit of drones for both retailers and consumers is the expansion of delivery range. To quantify this benefit, the report investigated how an increase in delivery range could impact retailers and consumers.

To understand the retailer benefit, various Ireland regional and metro locations were selected with average delivery ranges observed using online food delivery websites. This analysis indicated that the average maximum distance of food delivery was approximately 5 km. Using CSO Census 2022 data, it was possible to estimate the population within the current delivery radius and the potential increase if the delivery radius was expanded to 10 km. This was converted to households using the CSO average size estimate of 2.75 persons per household.

Table 6

Inputs and sources for calculating expansion of market reach

Area	Metric	Source
Households available in delivery range for various metro and regional locations in Ireland (for example Ashwood, Dublin)	Current range of restaurant delivery	▪ Delivery radius of Deliveroo and Just Eat for various locations (2022)
	Number of current and potential households in range	▪ Census population to relevant suburb locations, CSO Census (2022) ▪ Census of population: Private household, CSO Census (2016)

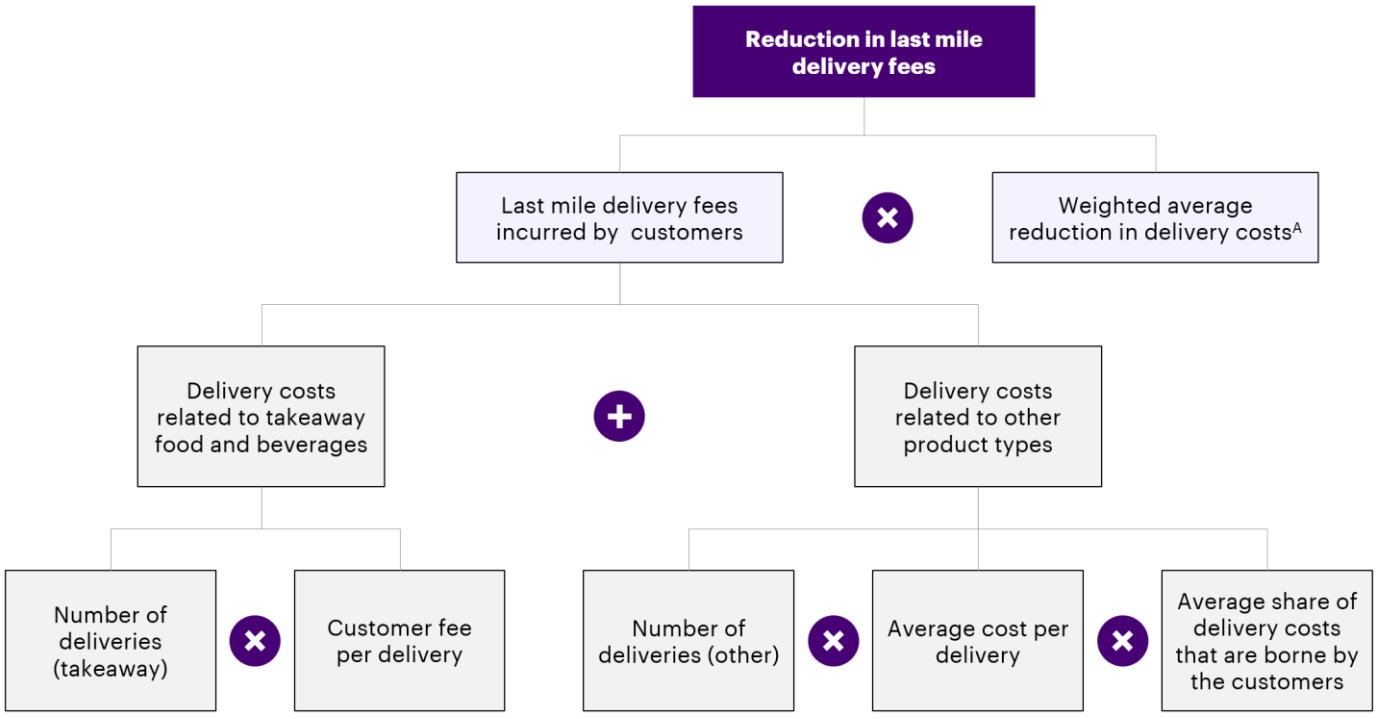
Estimating benefits for consumers

Reducing delivery fees

The potential reduction in delivery fees to consumers is calculated by multiplying the last mile delivery fees incurred by consumers by the weighted average reduction in delivery costs (Exhibit 24). Takeaway delivery costs were considered separately as a higher proportion of deliveries take place in this sector relative to other sectors such as grocery.

Exhibit 24

Calculating the reduction in last mile delivery fees for consumers



A It is assumed that consumers receive a reduction in delivery fees that is proportional to the reduction in underlying costs.

Table 7

Inputs and sources for calculating consumer delivery fee savings

Area	Metric	Source
Weighted average reduction in costs for delivered transactions that are replaced by drone	Weighted average cost reduction (%)	▪ Estimated using the results obtained in earlier sections of this appendix (cost of drones, cost of current methods of delivery and current mix of transaction types
Last mile delivery costs borne by consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last mile sector by 2033)
	Number of deliveries (other)	▪ As above, but for non-takeaway transactions
	Average cost per delivery	▪ Obtained from earlier analysis of the cost of delivery for each mode of transport, combined with the current mix of transaction types
	% of cases where the retailer subsidises delivery	▪ Analysis of mystery shopping data presented in Copenhagen Economics (2016), Principles of e-commerce delivery prices
	Average share of delivery costs that are borne by the customer (% of cost)	▪ Analysis of mystery shopping data presented in Copenhagen Economics (2016), Principles of e-commerce delivery prices

Saving time

The potential reduction in delivery fees to consumers was estimated using the approach shown in Exhibit 24.

Estimating delivery times for each mode of transportation

This paper estimated and compared delivery times across delivery modes (van, car, bike, drone) and periods (instant, same day and next day). This analysis focused on last-mile instant delivery.

Delivery distances were matched to four typical categories (less than 1 km, between 1-5 km, between 5-10 km and over 10 km). The speed assumptions necessary to calculate time taken per delivery were estimated for each mode of delivery using research and industry expert interviews.

Table 8

Inputs and sources for calculating delivery times

Area	Metric	Source
Current vehicle speeds	Average speed of instant delivery	▪ Industry expert interview, ClickACourier ▪ Accenture analysis
	Average speed of same day delivery	▪ An Post, ClickACourier, Buymie ▪ Industry expert interview
Drone delivery speeds	Average speed of trip by deliver distance	▪ Industry expert interview ▪ Accenture analysis

Estimating the reduction in delivery times for consumers

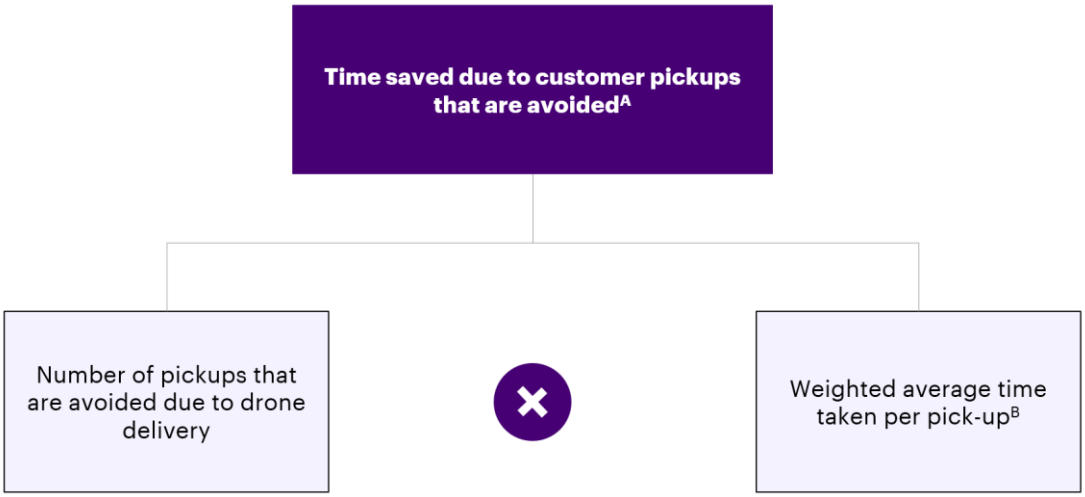
The reduction in delivery times was calculated as the weighted average difference in delivery times between drones and current delivery modes for relevant transaction types (see above for sources). For example, for instant deliveries (which are currently delivered using ground transportation, e.g. by Deliveroo), the weighted average delivery time savings is around 50-60%.

Estimating the time savings due to replacing customer pick-ups

The time saved by replacing customer pick-up journeys was estimated using the approach shown in Exhibit 25.

Exhibit 25

Calculating time saved due to pickups that are avoided due to drone delivery



A This was converted to euro terms using the average earnings per person
B Weighted by pick-up journey distance.

Expanding product variety

A similar method to "Expanding market reach" was used to estimate the potential range expansion benefits to consumers. This involved selecting several test locations and observing how many restaurants were within delivery range. Other locations were then chosen 10km away in differing directions with restaurant count observed. Range increases were found and averaged to potentially three to four times more restaurant options with increased delivery range.

For example, Ashfield in Dublin was profiled to understand the expected number of food restaurants available to consumers with drone delivery services. Using Deliveroo and Just Eat, restaurants within the standard delivery range were counted. Additional, potential restaurants were observed 10km away from Ashfield, being Cherry Orchard and Drumcondra. The potential additional restaurants available to Ashfield residents via drone delivery (which have a larger delivery range) was over four times greater than the current delivery range based on traditional instant delivery. Other locations were profiled in this way and an average, more conservative, estimate of 3-4x greater consumer choice was found.

Estimating benefits for society and environment

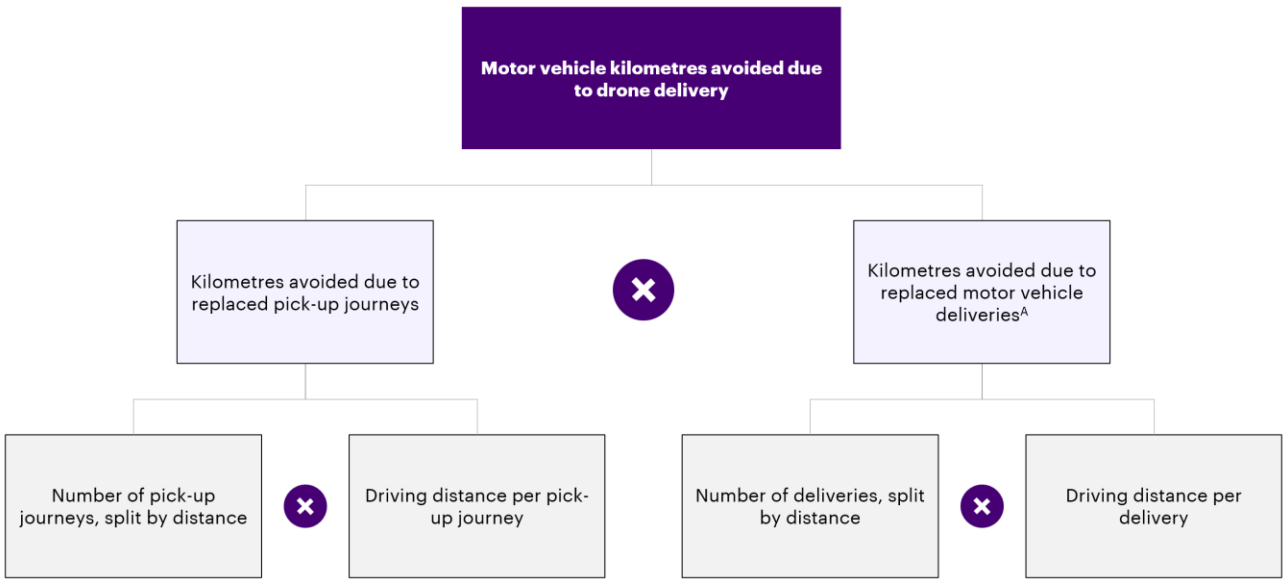
Societal benefits encompass a broad range of benefits, including some indicators that are difficult to measure or attribute directly to drone delivery such as lives saved by emergency medical delivery and boosts in innovation. As such, this report estimates the environmental and safety benefits from drone delivery that directly result from having fewer motor vehicles on the road. While other benefits are often not conducive to comprehensive quantitative measurement, they are important contributions that can be observed and described.

Motor vehicle kilometre reductions from drone delivery

We estimated the number of motor vehicle kilometres avoided on the roads by taking a weighted average of the trip distances avoided (pick-ups and deliveries), multiplying by the average return trip distance.

Exhibit 26

Calculating motor vehicle kilometres avoided due to drone delivery



A Implicitly excludes delivery types where bicycles are most prominent / cost-effective, e.g. <1km takeaway deliveries.

Congestion reduction by road type

We estimated the reduction of congestion by multiplying proportion of road type for varying travelling distances (Exhibit 27) and vehicle kilometre reduction on roads (Exhibit 26). This produced vehicle-kilometre reduction values by road type. Exhibit 27 was built from desktop research on road type travel proportions. This was further refined for distances travelled from road type analysis of varying journeys to local grocers via Google maps.

Exhibit 27

Apportioning motor vehicle km reduction per road type

Proportion of road type by vehicle travelling distance[A,B], %

Distance	Road type		
	Suburban	Arterial	Highway
<1km	65%	35%	0%
1-5km	45%	50%	5%
5-10km	20%	70%	10%

A Based off Department of Transport, Tourism and Sport (2018) Managing the Regional and Local Road Network estimates of Ireland road type.
B Adjustments made to reflect metro cohort journey to grocer through Google Map road type analysis.
Source: Accenture analysis.

Emissions reduction from drone delivery

The potential emissions reduction from drone delivery is the difference between emissions avoided due to the reduction of motor vehicles on roads and the additional emissions produced by drones. Emissions avoided was calculated using the total last-mile distance travelled by motor vehicles that would be replaced by drone delivery, multiplied by the emissions per km by vehicle type (namely cars and light commercial vehicles). Additional emissions produced by drones was estimated in the same way, by using the rate of emissions per trip from drone delivery, as estimated from literature values (Stolaroff et al. (2018)).

Emissions per km (also known as emission intensities) for vehicles was estimated using data published from the European Environment Agency (EEA) which documents 2020 rates of average emissions of carbon dioxide (CO_2) for new cars and vans. Emission intensities were then forecasted through to 2033, assuming that the fleet of Irish vehicles complies with current EU6 emissions standards by 2033, the results of this forecast are shown in Exhibit 28.

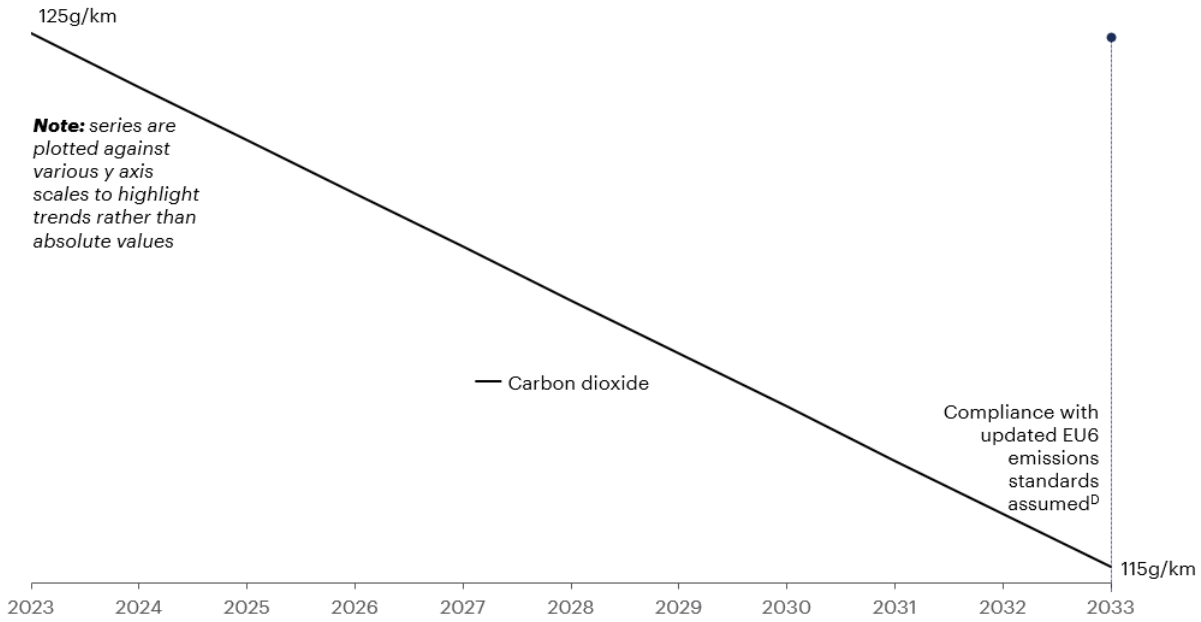
Once modelled estimates for motor vehicle km reductions and forecasts for emission intensities were obtained, we calculated the total reduction in CO_2 emissions using the method shown in Exhibit 29. One additional variable in the model was the subtraction of anticipated electric vehicle (EV) uptake from the emission reduction estimates. From Sustainable Energy Authority of Ireland (SEAI) estimates, we assumed a ~20% EV uptake in 2022 and a ~47.5% EV uptake by 2033, which effectively scales down model. This produces a conservative estimate for emissions avoided, because for CO_2 in particular, a significant fraction of the electricity used to charge EV will likely be generated from non-renewable means with an associated carbon footprint.

Exhibit 28

Forecasted emissions intensity for internal combustion engine vehicles

Emissions intensity per km average over internal combustion engine fleet

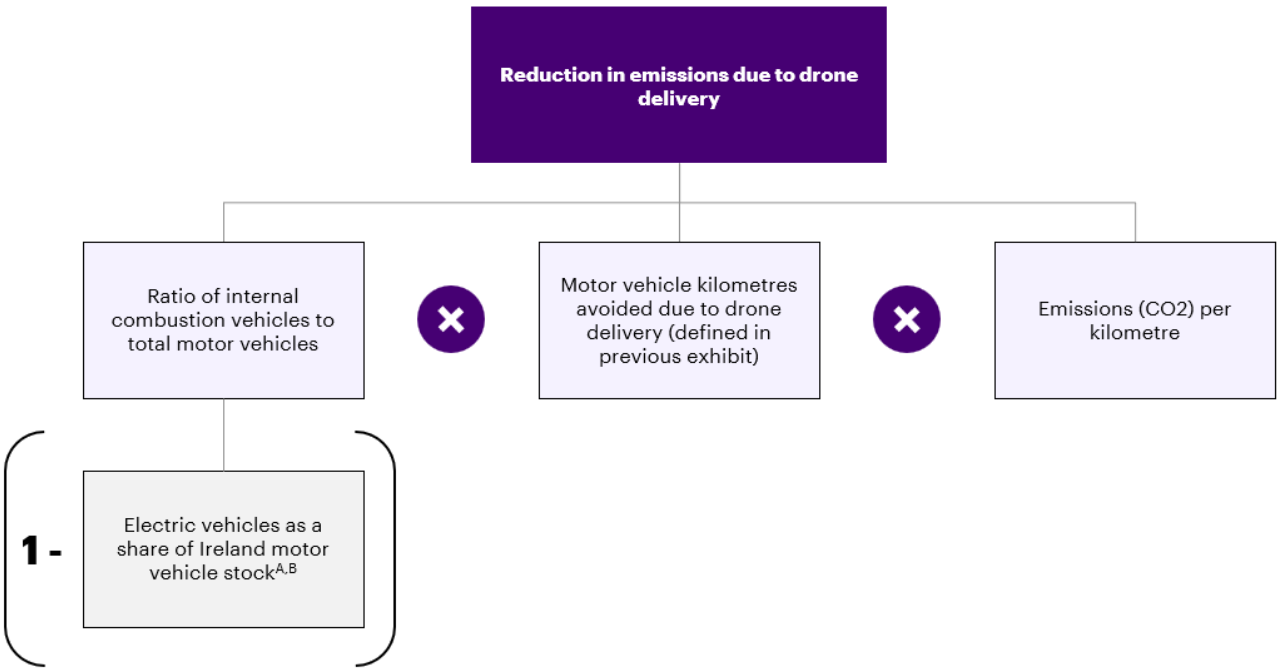
Emissions, grams per km



A Series are presented as averages across the entire fleet, which means that 2033 figures are primarily composed of a distribution of vehicles manufactured between ~2023 and 2033.
B Assumes that the composition of internal combustion engine vehicles continue their current trend of 80% petrol / 20% diesel.
C The base year of these forecasts is 2020, emissions intensities were estimated using a range of sources including European Environment Agency estimates of emission intensities.
D These forecasts are only for internal combustion engine vehicles, i.e., we exclude electric vehicles from these averages.

Exhibit 29

Calculating emissions reduction due to drone delivery



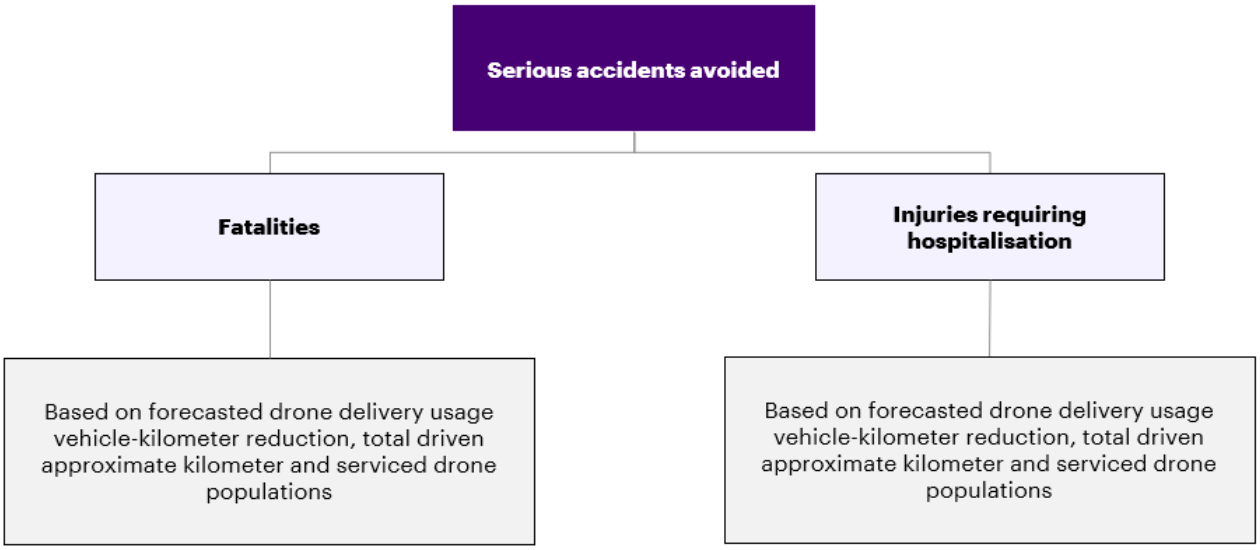
A Taken from Sustainable Energy Authority of Ireland, which estimate ~20% in 2022 and ~40% in 2030 and a near-linear increase between 2022 and 2033.
B Our estimates are conservative as we assume that electric vehicles are charged using low-carbon/renewable electricity sources.

Accidents avoided from drone delivery

The potential number of accidents avoided by drone delivery due to fewer vehicles on roads is calculated by using the current rate of accidents per km multiplied by the reduction in distance travelled by road vehicles including bicycles. This estimate is likely to be conservative as road accidents and crashes have proven to be underreported in official data. The method for these estimations are shown in Exhibit 30.

Exhibit 30

Estimating serious accidents avoided due to reduced motor vehicle usage[A]



A Car related injury (2020) and fatalities numbers (2022) sourced from Road Safety Authority Ireland

Table 9

Inputs and sources for calculating societal benefits

Area	Metric	Source
Emissions reduction from drone delivery	Total emissions from motor vehicles by vehicle type	▪ European Environment Agency (EEA) CO_2 performance emissions of new passenger cars and vans (2020)
	Estimated total emissions by 2033	▪ Emissions intensity limits sourced from updated EU6 regulations (2020), assumes that the majority of internal combustion vehicles on the roads comply with EU6 standards by 2033
	Electric vehicle uptake	▪ Taken from Sustainable Energy Authority of Ireland (SEAI), which estimate ~20% in 2022 and ~40% in 2030
	Total distance travelled by motor vehicles by vehicle type	▪ CSO (2021) Road Traffic Volumes for goods and average total vehicles
	Emissions per trip for drone delivery and other methods	▪ Stolaroff et al. (2018) Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery
Road accidents prevented from drone delivery	Total number of road crashes	▪ Fatal accident data from RSA (2022 data), total injury collisions (serious and non-fatal hospitalisations) from RSA (2020 data)
	Total distance travelled by vehicle type	▪ CSO (2021) Road Traffic Volumes for goods and average total vehicles
Road vehicles avoided from drone delivery in distance travelled	Primary mode of transport for delivery and pick-up by consumer type (distance from retailer, package size, timeliness of delivery)	▪ Accenture analysis ▪ Industry expert interviews
	Average distance travelled per trip by consumer and vehicle type	▪ Accenture analysis ▪ Google maps (2022) ▪ Refer to cost of delivery analysis in this appendix
	Average number of trips replaced by drone delivery by consumer type	▪ Relevant industry reports for Ireland from IBISWorld for pharmacy, takeaway and household items (2022) ▪ Irish grocery retail market from Irish Grocery Retail Market Overview (2022) by Board Bia Ireland ▪ Accenture modelling and analysis

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