Submission to Review of the Air Navigation (Aircraft Noise) Regulations 2018 - Remotely Piloted Aircraft

To whom it may concern,

Please find attached two research reports produced by the strategy & economics consultancy AlphaBeta that provide insight into the potential benefits of drone delivery. The reports quantify selected benefits for businesses, consumers and society in the ACT and Qld of using small drones in a delivery context. The types of benefits quantified include:

- Reduction of delivery costs in the order of 80-90% relative to current ground-based methods (saving money for consumers and businesses),
- Allowing merchants to reach 4x as many consumers by bringing more households in to range (and similarly, allowing households to receive delivery from 4x as many merchants),
- Improving convenience with delivery times that are 60-70% faster than current methods, and
- Replacing ground vehicle journeys, which can reduce congestion, improve road safety and lower emissions.

While the work was conducted for the ACT and Qld, the results are also relevant to other geographies.

We would recommend that these benefits are considered in the review, alongside other factors being investigated.

Kind regards
Callum

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FASTER, GREENER AND LESS EXPENSIVE

THE POTENTIAL IMPACT OF DELIVERY DRONES IN THE AUSTRALIAN CAPITAL TERRITORY

NOVEMBER 2018

Prepared by AlphaBeta for Wing

αlphaβeta

strategy x economics

Important Notice on Contents – Estimations and Reporting

This report has been prepared by AlphaBeta for Wing. All information in this report is derived or estimated by AlphaBeta analysis using both proprietary and publicly available information. Where information has been obtained from third party sources and proprietary research, this is clearly referenced in the footnotes.

The amounts in this report are estimated and specified in 2017 Australian dollars. Where conversion rates have been used, these are stated in the footnotes.

αlphaβeta

strategy x economics

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CONTENTS

Drones will deliver benefits to ACT businesses, consumers and communities

BENEFITS FOR LOCAL BUSINESSES

Grow retail sales in the ACT by

$30-40 million

of which **$10-15 million** could accrue to **small businesses** in the ACT in 2030

Reduce delivery costs for businesses by up to

$12 million

per year by 2030.* Delivery costs for some items such as prepared meals could fall in the long term by up to

80-90%

Expand the reach of merchants by up to

4x as many consumers

by bringing more households into range

BENEFITS FOR CONSUMERS

Save

3 million hours

for consumers in 2030 by replacing customer pick-up journeys, as well as **delivery times** that are

60-70% faster

than today's methods

Save consumers

$5 million

per year in **reduced delivery costs by 2030**.* Delivery costs for some items such as takeaway food could fall over the long term by up to

80-90%

Expand choice for consumers by giving them access to up to

4x as many merchants

by bringing more retailers within delivery range of their home or workplace

BENEFITS FOR SOCIETY

Reduce traffic congestion by replacing

35 million

vehicle kilometres

each year. This could also avoid up to **70 road accidents** each year

Reduce annual **CO_2 emissions** by

8,000 tonnes

due to fewer road vehicle deliveries. This is equivalent to the carbon storage of **250,000 trees**

* Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs

1

EXECUTIVE SUMMARY

Drones have the potential to transform retail around the world, and the ACT is at the forefront of this change, with regional trials demonstrating how delivery drones can bring a wider range of products within rural and suburban consumers' reach. 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 the road.

The ACT is at the forefront of global drone technology. As one of the first global delivery hubs for Wing, the ACT has had drones deliver thousands of food, drink, pharmaceutical and household items from local businesses to suburban homes, demonstrating the feasibility of and consumer appetite for drone delivery in Australia.

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 most costly segments of the supply chain, accounting for 15 to 20% of the total cost of retail transactions in the form of delivery fees or the time spent by consumers picking up their goods. The ACT incurred a total of $1.1 billion of last-mile delivery costs in 2017.

Last-mile delivery is particularly challenging in Australia, where logistics providers face congested city roads at one extreme and sparsely populated countryside at the other. Consumers are doing more of their shopping online, but still face limited delivery options compared with those available overseas, where "same-day" delivery services are more common.[1]

The cost and time taken for items to be delivered in Australia not only limits the range of products available to consumers at home; local 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 urgently. Based on these criteria, drones could deliver up to 4-6% of household purchases in 2030 in the ACT, helping to make local businesses more competitive, providing greater choice and convenience for customers, while also reducing the total number of motor vehicle journeys in the region.

Road transportation accounts for 69% of the ACT's greenhouse gas emissions (compared with only 16% nationally), and replacing some of those journeys with delivery drones could have a significant environmental impact. By using drones to deliver 4-6% of its household purchases, the ACT could reduce the number of accidents on its roads, as well as carbon emissions by about 8,000 tonnes a year – equivalent to the carbon absorbed by 250,000 trees.

[1] SmartCompany (2017), "The last mile: Why Australian shoppers won't see same-day delivery from Amazon for years to come"

EXHIBIT 1

The impact of drone delivery in the ACT was analysed across three areas

The nature and size of each of these types of benefits is explored below.

Benefits for local businesses

Drone delivery could result in several important benefits for ACT businesses:

- **Expanding market reach.** Drones travel faster than all existing forms of last-mile delivery, reaching a maximum speed of 120 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 2030 drone technology.[2] For a restaurant located in central Canberra, this could bring an additional 50,000 households into range.[3]
- **Reducing delivery costs.** ACT businesses, including food outlets, incur costs as part of providing delivery to customers. These costs include fees to delivery service providers (e.g. Uber Eats or Australia Post), as well as the cost associated with performing deliveries themselves. These costs make it unprofitable for some 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 $12 million to businesses by 2030.[4]
- **Generating increased sales.** By reducing delivery costs and increasing convenience, drone delivery will make it easier and less costly for consumers to purchase items in the ACT. As a result, consumers will be able purchase more items, or switch to higher-value items. These effects combined are

[2] Current range of 5 km based on the current Uber Eats and Deliveroo delivery radius on 8 October 2018 in the ACT, estimated based on the furthest restaurant delivery destination available from Canberra central.
[3] Potential increase in households estimated by count of households within 5 km radius of Canberra central compared with count of households within 10 km radius. ABS Census (2016)
[4] Assumes retailers receive a delivery cost reduction that is proportional to the reduction in underlying costs due to drone delivery.

expected to generate up to an additional $12,000-$16,000 a year for a retail business or $30-40 million in additional sales for the whole of the ACT in 2030.[5] Of this, $10-15 million could accrue to small businesses in the ACT.

- **Enabling more businesses to deliver.** Drones could allow more local businesses to offer last-mile delivery, giving them a new way to reach customers. This could allow more specialised businesses to thrive, and encourage and enable new businesses to engage in e-commerce.

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 in the ACT. These include:

- **Improving quality of life for homebound people.** Drones could deliver a wider range of food, medicines and other products to elderly, disabled, or otherwise 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 60-70%. 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 an estimated 4-5 million 'pick-up' journeys in 2030, drone delivery has the potential to save consumers 3 million hours, which is worth $70 million if valued at today's average earnings.[6] Rapid drone delivery enables consumers to have greater control over their time, knowing for certain that a delivery will arrive within a short time interval.
- **Reducing delivery fees.** In 2017, ACT consumers paid an estimated $30 million in last-mile delivery fees on transactions within the ACT.[7] Because 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 80-90%. This could save ACT households a total of up to $5 million in 2030.[8]
- **Expanding product variety.** Because the speed of drones allows retailers to offer instant or same-day delivery to a larger geographical area, customers in the ACT would thus have a wider range of products to choose from. An ACT suburb that currently receives delivery from 50 restaurants could expand their reach to over 150 food outlets via drone – a three-fold increase.[9]

Benefits for society

By reducing the number of motor vehicle journeys taken in fulfilling last-mile deliveries in the ACT, drone delivery has the potential to reduce emissions and make ACT 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 ACT roads. Preliminary estimates suggest that drone delivery could result in 35 million fewer motor vehicle kilometres on ACT roads in 2030.
- **Reducing greenhouse gas emissions.** Small 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

[5] Relevant businesses defined as food and store-based retailers, based on 2017 business counts from the ABS.
[6] Average earnings per person of $23 per hour, based on $34 average earnings for those employed in the ACT, adjusted for employment-to-adult-population ratio of 68%.
[7] Includes fees for last-mile transport only and does not include transactions sent from outside of the ACT.
[8] Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs.
[9] Restaurant count based on the number of restaurants available on Uber Eats and Deliveroo, accessed from Yarralumla on 8 October 2018. Potential increase in restaurants based on the number of restaurants and cafes currently delivering within a 10 km radius of Yarralumla.

package.[10] By replacing these more polluting methods, drone delivery could eliminate about 8,000 tonnes of greenhouse gas emissions by 2030, equivalent to the carbon storage of around 250,000 trees.[11]

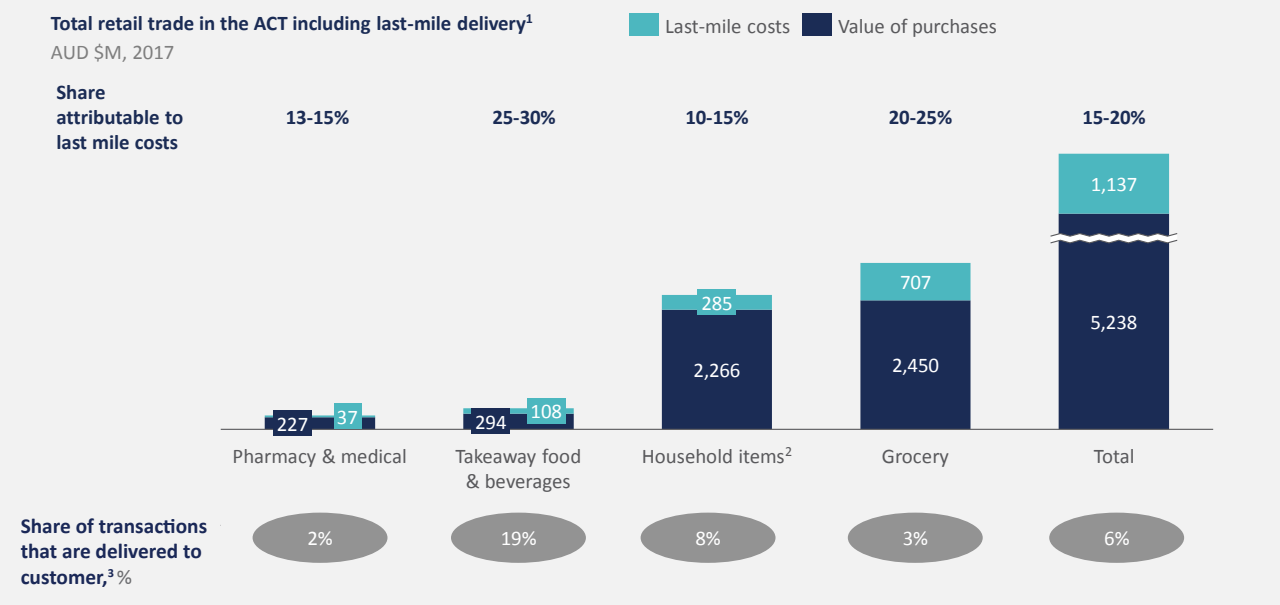
- **Reducing road accidents.** In 2016 there were 7,911 motor vehicle accident on ACT roads.[12] This represents two accidents for every million kilometres travelled by motor vehicles. If drone delivery is able to reduce the number of motor vehicle journeys by 0.6% by replacing road-based deliveries and pick-ups, this could result in 70 fewer accidents on ACT 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 94% of all transactions) or by paid delivery services (around 6% 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). The average cost of last-mile delivery can account for 15-20% 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 (or pick-up) was ~$1.1bn in 2017, which represents 15-20% of the total value of retail trade in the ACT



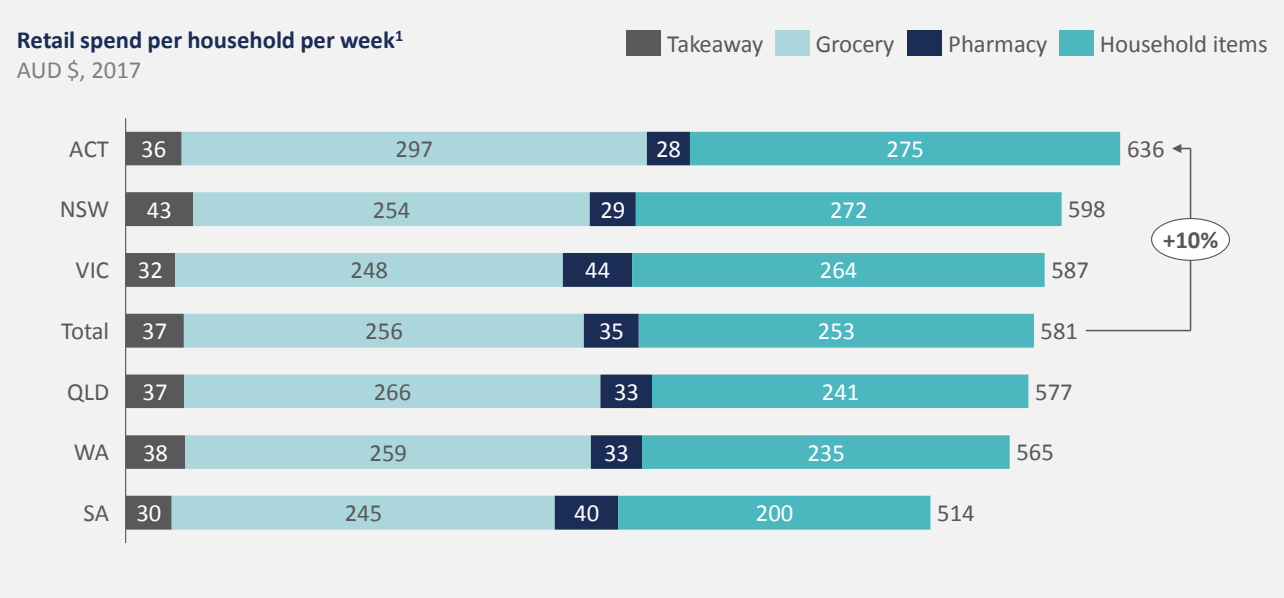
1 Excludes food consumed on-premise at restaurants/cafes
2 Includes household goods, clothing & footwear, department stores, newspapers/books, other recreational goods and other retailing
3 Other transactions are picked up instore by customers
SOURCE: ABS Retail Trade (2017), AlphaBeta Transport Cost Model

[10] 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)
[11] This is otherwise expressed as 8,000 MT CO_2e.
[12] ACT Government (2016), ACT Road Crash Report

The ACT has the largest retail spend per household in Australia. In the ACT last year delivery cost amounted to around $1.1 billion. By reducing delivery costs, drones have the potential to create massive value for both retailers and consumers.

EXHIBIT 3

ACT households spend more on retail than any other state, at $636 per household per week – 10% above the national average



1 Excludes food consumed on-premise at restaurants/cafes but includes takeaway. Number of households based on 2017 population and 2016 household sizes by state. Excludes NT and TAS due to their smaller populations and lower data quality. The NT also has a high retail spending per household, at $635.66 per week versus $635.73 for the ACT
SOURCE: ABS Retail Trade (2018), ABS Census (2016)

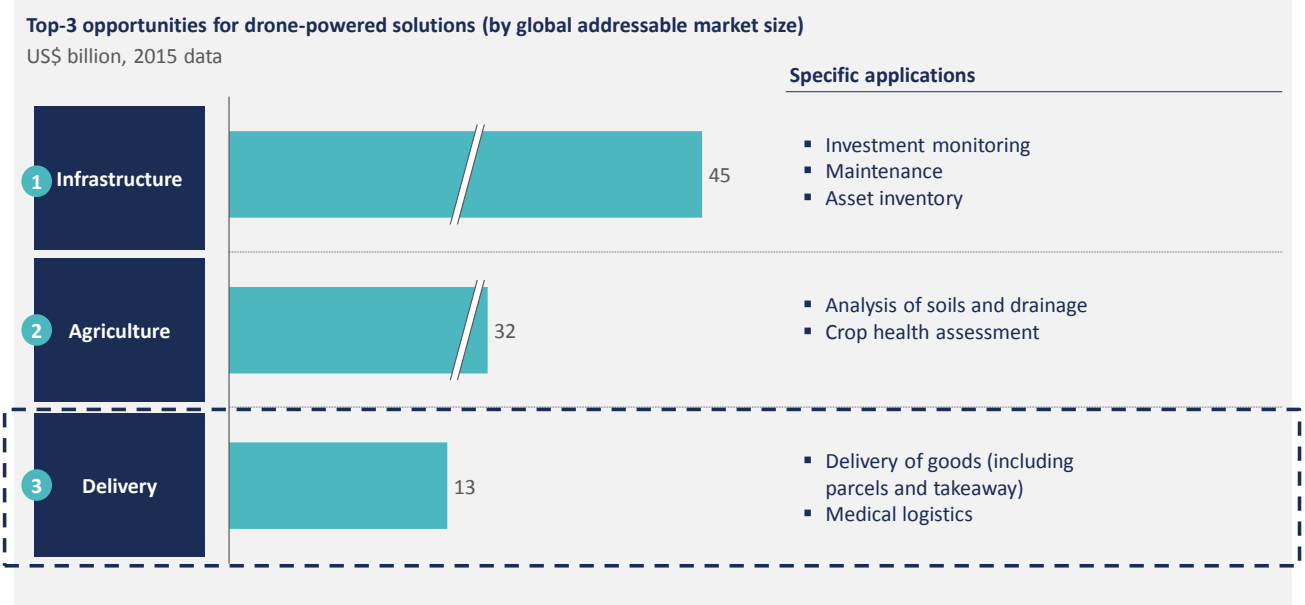
Drone delivery is gaining momentum globally

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. Enterprises globally purchased almost three million drones in 2017, up 39% from 2.15 million in 2016.[13] Further, the global market opportunity for commercial applications of drone technology is estimated at US$127 billion, with drone delivery being the third-largest component (see Exhibit 4).[14]

[13] Gartner (2016), *Forecast: Personal and Commercial Drones, Worldwide, 2016*
[14] PwC (2016), *Clarity from Above*

EXHIBIT 4

Delivery is predicted to be one of the top-three commercial applications of drone technology globally



SOURCE: PwC (2016) Clarity from above

The shift toward drone delivery is already underway. Global technology companies such as Alphabet's Wing, Amazon, and start-ups such as Flirtey, Zipline and Flytrex are either using drones for delivery today or conducting advanced trials of the technology. Here in the ACT, Wing has completed about 2,500 deliveries of beverages, food, pharmacy and household items to selected areas, with the approval and oversight of the ACT government and Civil Aviation Safety Authority (CASA).

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

Drone technology has the potential to become an important part of Australia's delivery sector, particularly in fulfilling 'last-mile' deliveries.[15]

In this report, drones are assumed 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 a maximum speed of 120 km/h for a total round-trip distance of 20 km in 2030.[16]
- **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 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.

[15] 'Last-mile' deliveries include transporting an item to the customer's location from the retailer (if close) or local distribution centre

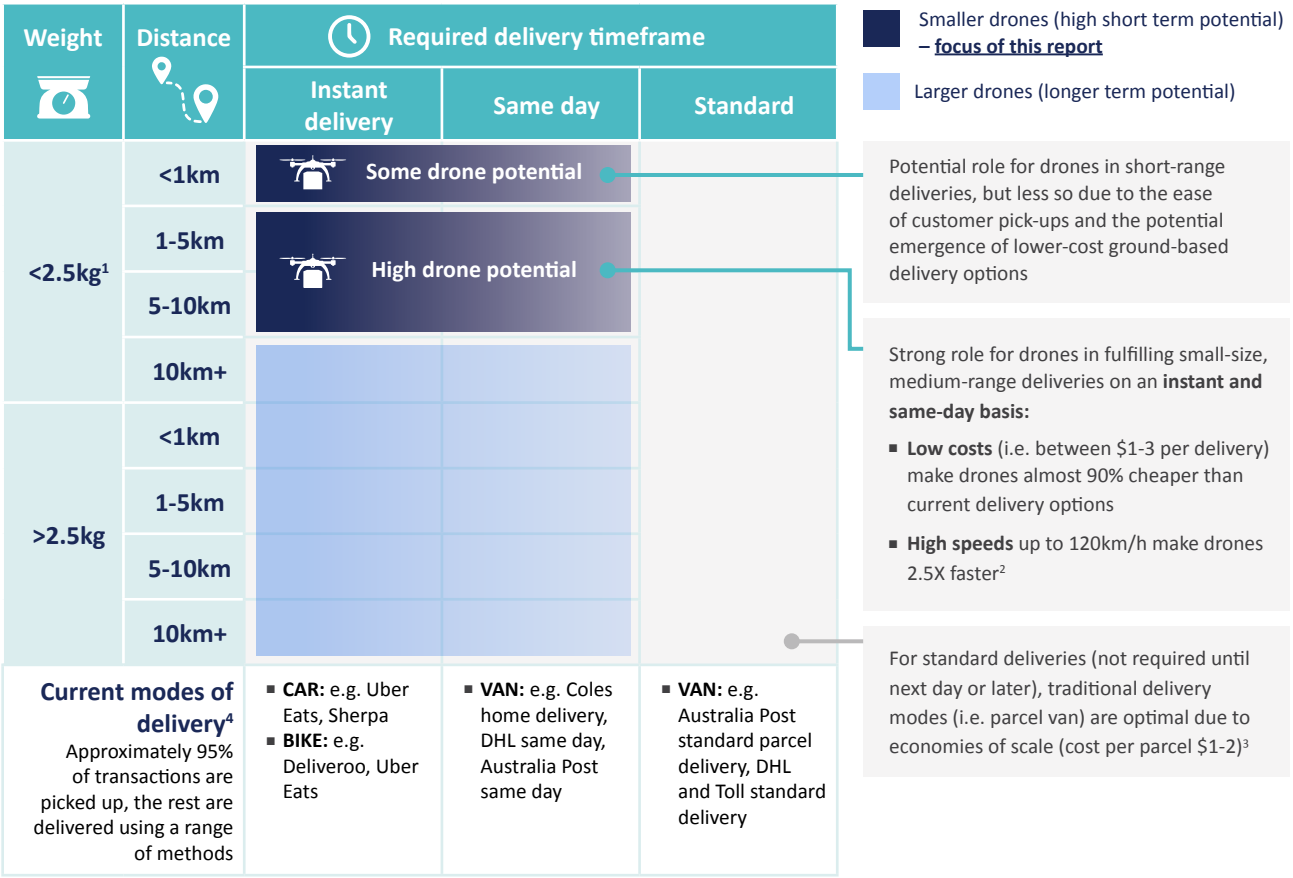
[16] The 20 km round-trip range allows drones to deliver packages at up to a 10 km radius but not beyond. While large drones could service larger distances and carry heavier packages, these aircraft were not considered as part of the study due to their different cost structure and the potential emergence of cheaper alternatives for longer-range delivery (e.g. autonomous road vehicles)

The result of applying these criteria (as shown in Exhibit 5) 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 ($1-3 per delivery compared to $14-17)[17] and faster than other methods (more than twice as fast compared with current methods of instant delivery such as Uber Eats). Standard, less urgent deliveries will likely be fulfilled by road vehicles (including autonomous ones) by 2030. 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).[18]

EXHIBIT 5

There is a strong role for drones in fulfilling small deliveries on an instant and same-day basis

Role for drones by transaction type



1 Assumes a maximum payload of 2.5kg and maximum range of 10km (20km round trip) for last-mile drone technology
2 Assumes a 10 km journey where a private car takes 20 minutes and a drone takes 8 minutes
3 Delivery costs refer to transport costs related to labour, fuel and depreciation. See appendix for details and assumptions
4 This list of example delivery modes is non-exhaustive.
Source: AlphaBeta analysis

[17] Cost for 1-5 km instant delivery compared with van, car and bike.
[18] McKinsey (2016), *Parcel delivery – the future of last mile*

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 small drones due to greater certainty around the feasibility and economics of small-drone delivery.

Drones could deliver more than one in four take-away food orders, and up to 4-6% of all purchases in the ACT by 2030

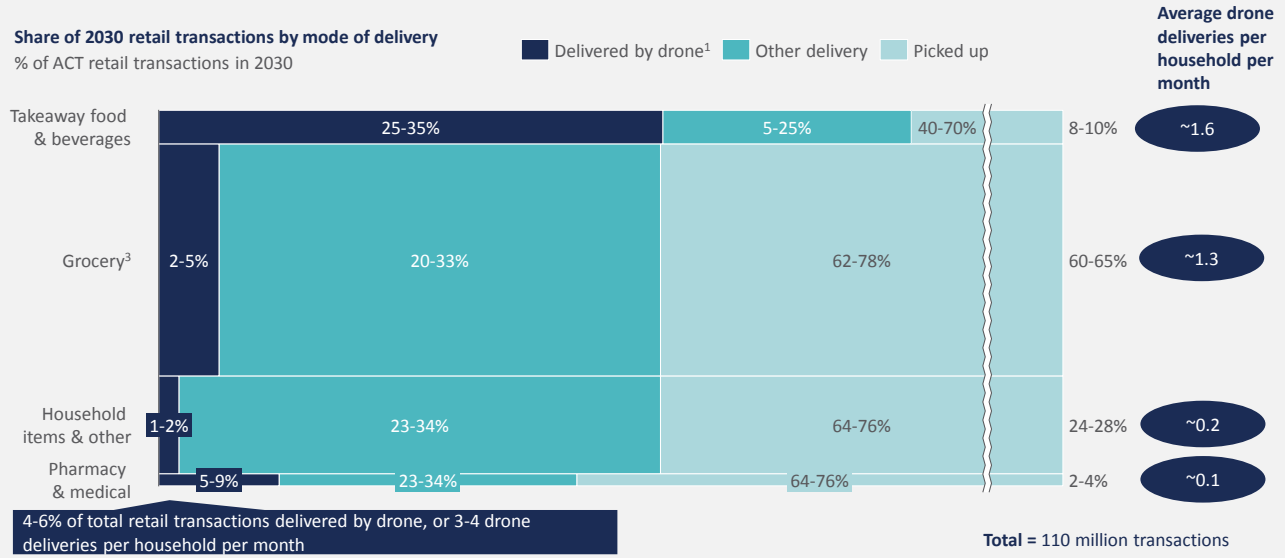
In 2017, ACT households made an estimated 90 million retail transactions, including groceries, pharmacy goods, takeaway food and other household items. Around 6% of those purchases were delivered to customers, while the remainder were picked up by customers travelling to the retailer's outlet.

The delivery landscape in 2030 will be different. Based on recent economic growth, ACT households will make an estimated 110 million transactions, and a greater share of these will be delivered.[19] Takeaway delivery could reach 40-50% of total takeaway sales by 2030, with external estimates for online deliveries in other product categories ranging from 20-35%.[20]

Drones will play an important role in this shift toward online delivery. It is estimated that drones could deliver up to 4-6% of household purchases in 2030 (Exhibit 6). 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 ACT households).

EXHIBIT 6

In 2030, drones could deliver up to 4-6% of retail transactions, and up to 25-35% in some categories (e.g. takeaway)



1 In most categories, drones are assumed 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 assumed 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 assumed 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 assumed to replace ~20-30% of pickups that meet size, distance and time-sensitivity criteria. These are assumptions only and the above represents an example scenario rather than a prediction of future uptake
2 A higher share of deliveries in pharmacy & medical serviced by drone because the transactions are more likely to satisfy drone weight restrictions than grocery or household items
3 Includes convenience stores, which have a smaller average purchase weight than supermarkets
SOURCE: ABS Retail Trade, AlphaBeta analysis

[19] Based on a conservative forecast GSP growth rate for the ACT of 2% p.a. from 2017-30 (which is assumed to be lower than recent growth since 2009 of 3.0% p.a. due to the rising share of services in Australia's GDP)
[20] Based on various sources including Morgan Stanley, Bankwest, Australia Post. See Appendix for details.

2

BENEFITS FOR LOCAL BUSINESSES

Expanding market reach

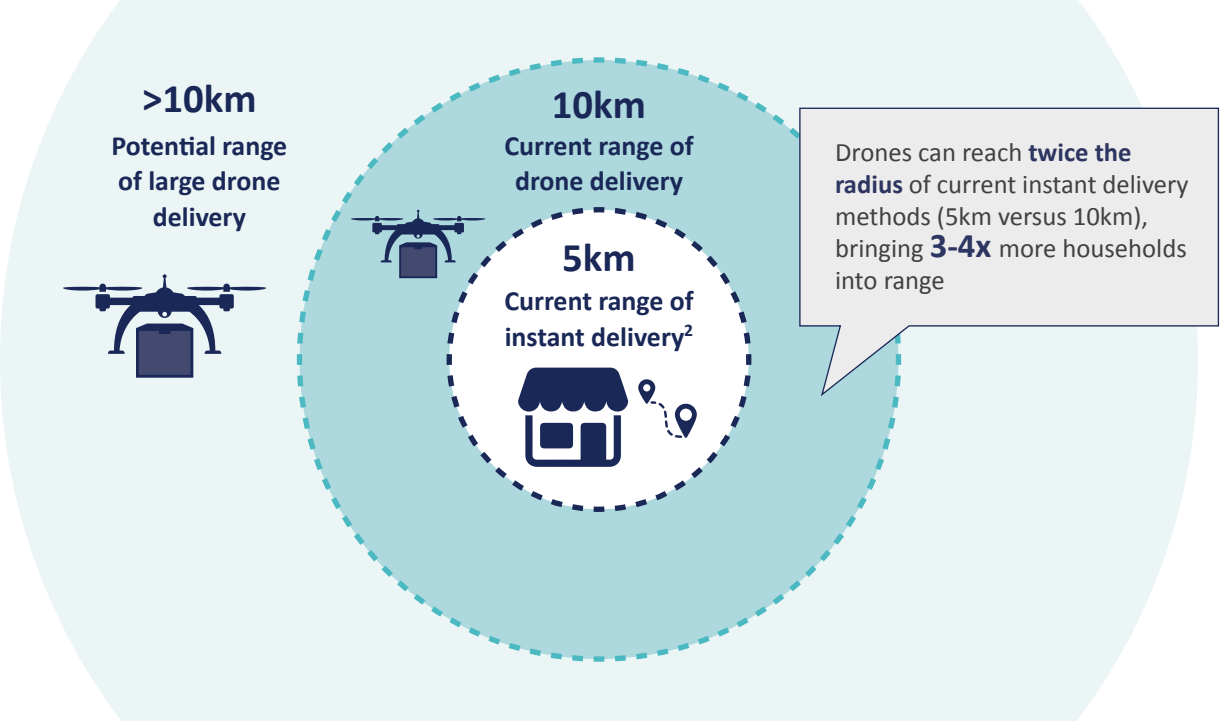
Drones can help ACT businesses reach more customers. The current radius of food delivery in Canberra, for example, is only about 4 or 5 km.[21] Road delivery vehicles are too slow to get food in good condition to customers much further than that, so businesses focus just on nearby customers.

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 triples the number of households within range of a restaurant based in central Canberra, from 25,000 households to 75,000 households.[22]

EXHIBIT 7

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[1]



1 Current range of 4-5 km based on the current UberEATS and Deliveroo delivery radius in the ACT, estimated based on the furthest restaurant displayed on the on 8 October 2018 from Canberra Central
2 Based on Uber Eats and Deliveroo
Source: AlphaBeta analysis

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 minutes to complete a 10km trip. A drone can cover the same distance in less than 6 minutes, or more than 60% faster.[23]

[21] Current range of 4-5 km based on the Uber Eats and Deliveroo delivery radius on the 8th of October (2018) in the ACT, estimated based on the further restaurant delivery destination available from Canberra Central.
[22] Household estimate based on population in relevant SA3 areas.
[23] Average van speed 40 km/h, average drone speed 100 km/h.

Reducing delivery costs

Delivery costs represent a significant expense for ACT businesses, especially in cases where delivery is time-sensitive. Restaurants currently pay around 30% of each order value to online delivery service providers.[24] Further, for other items, same-day parcel delivery alone can cost over $30 (with a share of these costs borne by the retailer in some cases).[25] These costs make it unprofitable for some businesses to offer last-mile delivery at all, despite a growing customer preference for online shopping and delivery.

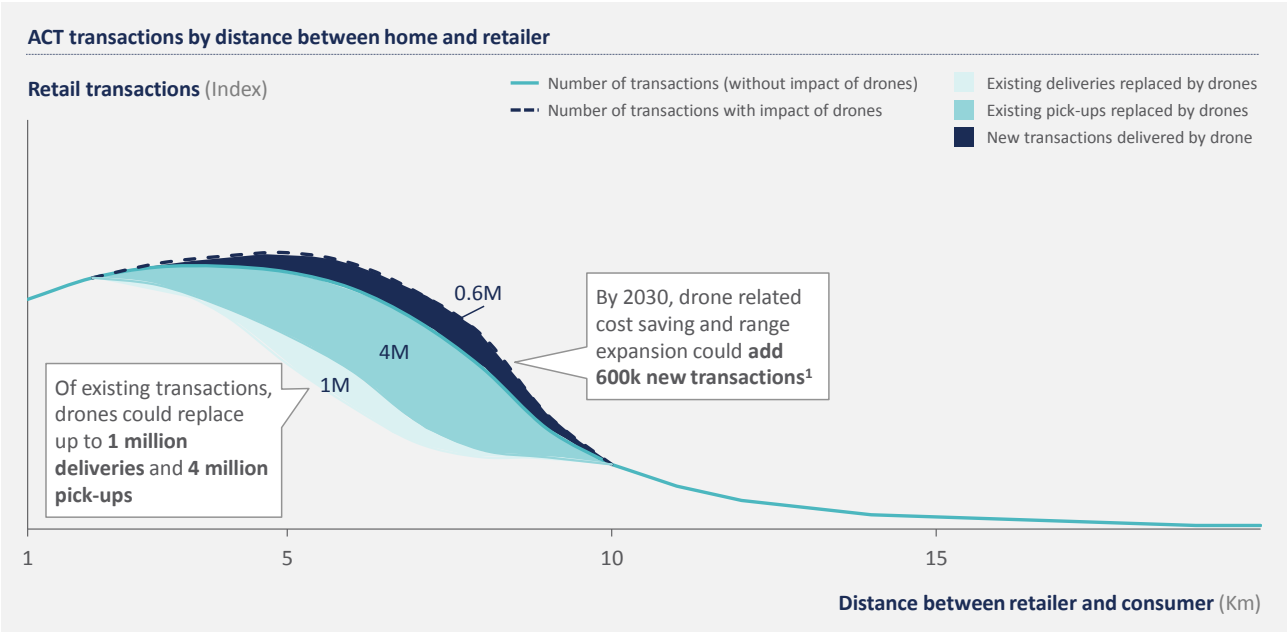
Drone delivery costs are likely to be up to 90% less expensive than existing methods of instant and same-day delivery. Even after factoring in the likely savings for delivery customers in the ACT, businesses there could save more than $12 million in 2030.[26]

Generating increased sales

As explored in Section 4 (Consumer Benefits), drones will save customers time and money. That cuts the effective cost of retail purchases, so consumers will make additional or higher-value purchases. While the value is hard to estimate precisely, drone delivery could generate an additional 600,000 annual retail transactions in the ACT in 2030, worth around $30-40 million in revenue. This benefit could be as high as $12,000-$16,000 per relevant retail business.[27] About $10-15 million, or just over one third of these benefits, is likely to be accrued by small businesses in the ACT.[28]

EXHIBIT 8

Lower cost, greater range, and the increased convenience of drones could grow transactions in the ACT by 600,000



NOTE: Illustrative axis, retail transactions and distance between retailer and consumer are indicative
SOURCE: AlphaBeta analysis

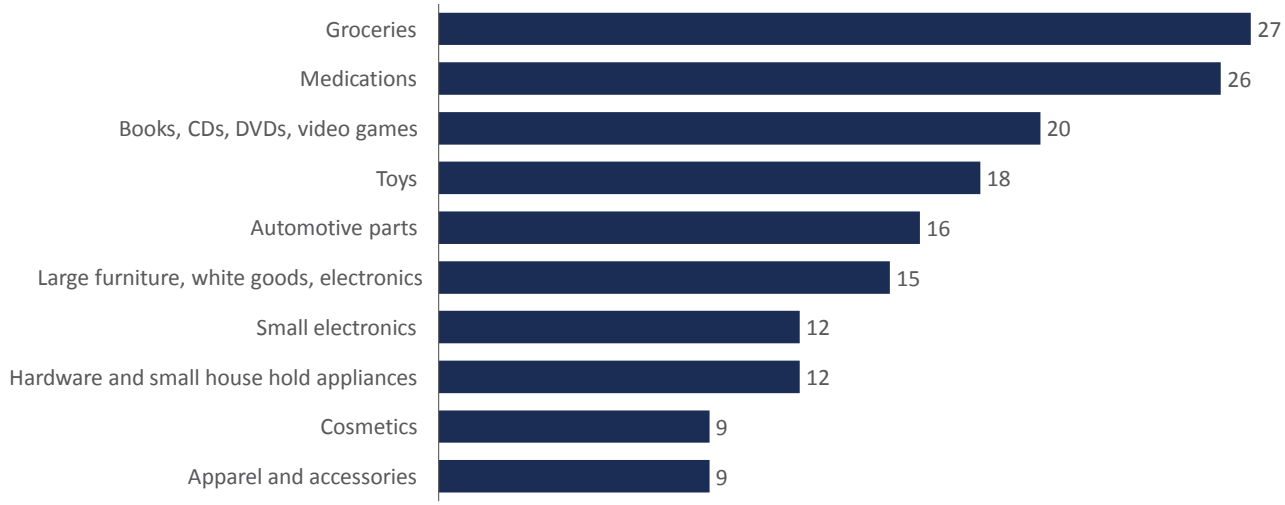
[24] Based on the 2018 pricing model of Uber Eats.
[25] Based on 2018 pricing of Australia Post and Copenhagen Economics (2016), *Principles of e-commerce delivery prices*
[26] Assumes retailers receive a reduction in delivery costs proportional to the reduction in the underlying cost of delivery due to drones.
[27] Relevant businesses defined as food and store-based retailers, based on 2017 business counts from the ABS.
[28] Small businesses are estimated to contribute 34% of value added to the economy. Australian Small Business and Family Enterprise Ombudsman (2016), *Small Business Counts: Small Business in the Australian Economy.*

Many consumers say they do not buy online because delivery takes too long. In a recent survey, more than a quarter of respondents reported not buying groceries and medical items online because of delivery delays.[29] Delays also deter consumers from ordering online for small electronics, cosmetics and other items that could be delivered faster by drone.

EXHIBIT 9

Faster delivery could lead to more purchases, particularly for grocery and medical items

Share of respondents who did not purchase an item online due to long delivery times[1]
Percent of respondents



1 Survey of 4,700 consumers in China, Germany, and the US
Source: McKinsey (2016) Parcel delivery – the future of last mile

[29] McKinsey (2016) Parcel delivery – the future of last mile.Takeaway food did not feature in the report as it was focused on parcel delivery

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 take-away restaurant that specialises in some regional cuisine could thrive when it can access a larger market. While the benefit is difficult to quantify, some ACT businesses will be able to cut costs and increase profits by scaling up to serve such niches.

As discussed earlier in this section, some ACT 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 local businesses to participate in last-mile delivery and engage in e-commerce. This would facilitate a more productive, competitive business environment in the ACT.

CASE STUDY:
Kickstart Expresso

Paul and Liat Davis opened Kickstart Expresso in 2014 with a mission: to serve quality coffee to busy parents like themselves who might otherwise struggle with the logistics of getting young children in and out of the car. The family now runs a cafe in Dickson and a busy drive-through outlet in Fyshwick, offering wholesome, country-style food and premium Toby's Estate coffee.

Drive-through coffee is 95% of Kickstart's Fyshwick business, with the Davis family serving up to 400 drive-through orders each day to a loyal, predominantly local customer base of parents with kids in the car, tradespeople, and workers from local business.

Kickstart plans to open new drive-through outlets in the coming months both in the Canberra region and Sydney's western suburbs and is also looking into a drone delivery service that could deliver coffee directly to its customers, whether they be at home, at work, or outdoors. "It's all about improving the distribution and making it more convenient for people," Paul Davis explains.

In a drone delivery trial with Wing, Kickstart has been delivering a limited menu of coffee and breakfast items to 150 potential customers in the Bonython region. It makes up to 40 deliveries in a three-hour session, averaging 6 to 8 minutes from order to delivery.

According to the Davis family, premium coffee needs to be delivered within a certain timeframe for it to retain optimum quality and taste. Coffee should reach a customer within 10 minutes of them placing an order, and within 4 minutes of it being poured, they say.

Kickstart briefly considered delivering coffee by road through more traditional distribution sources but didn't trust current delivery methods to reliably deliver within its delivery timeframe due to traffic, congestion and a range of other factors.

Drones are faster and more reliable. Travelling above the traffic at speeds of up to 120 km/h, they could deliver hot coffee from a single location to 6,000 households. To put this into perspective, Kickstart currently serves 250 to 400 drive-through customers each day. While not all 6,000 households will purchase Kickstart's coffee, drone delivery has the potential to increase sales by making it more accessible.

3

BENEFITS FOR CONSUMERS

Reaching underserved populations

Delivery drones could have a significant effect on disabled, elderly, or otherwise homebound people in the ACT. 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.

As of 2015, there were more than 13,000 disabled and 6,700 elderly people living in the ACT who needed assistance with mobility, according to statistics from the ABS.[30] 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 a top speed of around 120 km/h based on current small-drone technology. Drones are also not impacted by traffic and can thus deliver products much faster than other ground vehicles. As a result, drones could reduce delivery times for instant deliveries by around 60-70% in 2030.

Further, drone delivery can save people time by replacing 4-5 million customer pick-up journeys. As noted earlier, the last mile accounts for around 25% of the 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 ACT consumers 3 million hours in 2030. This is equivalent to $70 million if valued at today's average earnings.[31] 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 $5 for a food delivery to more than $30 for a courier delivery.[32] In many cases where delivery is not an option, such as a trip to the grocery store to pick up an extra onion, the time cost of picking up an item is also significant. Drones provide an option for consumers who want affordable instant or same-day delivery. Drones can be up to 80-90% less expensive than current methods of instant delivery. Even if only half of those savings are passed onto consumers, drones could save ACT households a total of $5 million in delivery fees in 2030.[33] 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 instant products available to consumers. Consumers in the ACT 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 time is sensitive and current delivery ranges are restricted.

In Canberra, consumers can only order food to be delivered from a maximum of 5 km away.[34] This restricts the options available to them. For example, some consumers can currently only receive food from 30-50 restaurants.[35] Meanwhile, there are over 150 restaurants within a 10 km radius that offer delivery services. Doubling restaurants' delivery range can thus give consumers access to three times the number of restaurants currently available to them.

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.

[30] ABS (2016), *Disability, Ageing and Carers, Australia: Summary of Findings, 2015*
[31] Average earnings per person of $23 per hour based on $34 average earnings for those employed in the ACT, adjusted for employment-to-adult-population ratio of 68%.
[32] Uber Eats, Deliveroo and Australia Post (2018) pricing
[33] Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs
[34] Current range of 4-5 km based on the Uber Eats and Deliveroo delivery radius on the 8th of October (2018) in the ACT, estimated based on the furthest restaurant available to deliver to Yarralumla.
[35] Restaurant count based on the number of restaurants available on Uber Eats and Deliveroo, accessed from Yarralumla on 8 October 2018. Potential increase in restaurants based on the number of restaurants and cafes currently delivering within a 10km radius of Yarralumla.

4

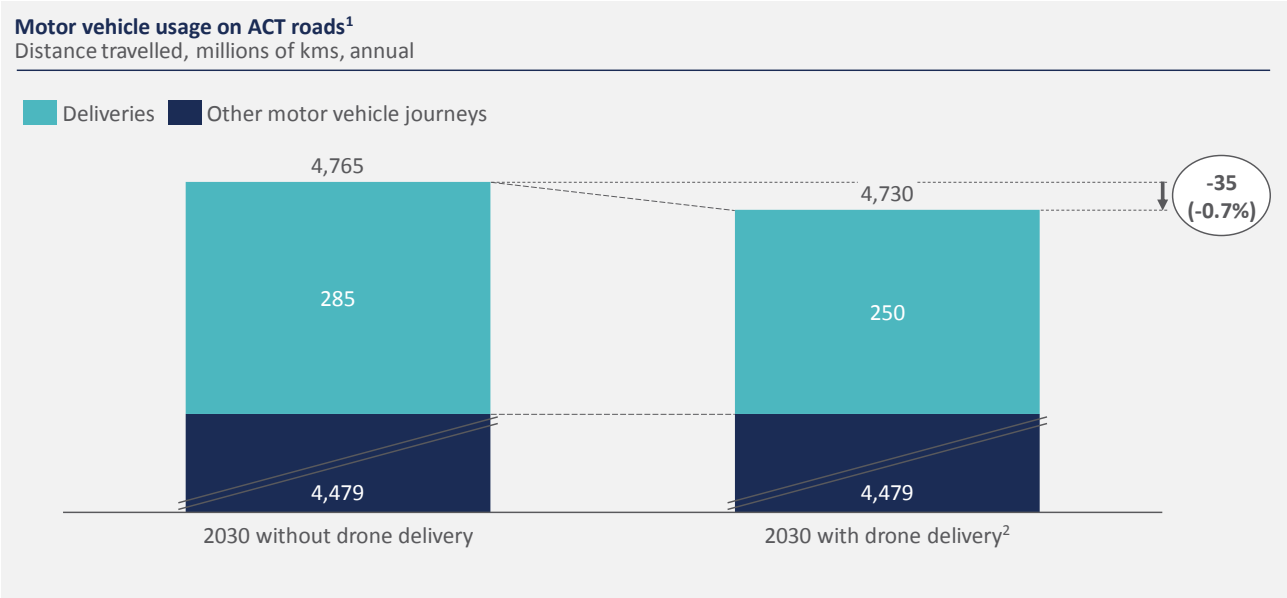
BENEFITS FOR SOCIETY

Reducing congestion

By reducing 35 million kilometres of delivery-related road travel, drones have the potential to reduce ACT road congestion. By 2030, it is estimated that delivery vehicles could be responsible for 6% of the kilometres travelled on ACT roads. Delivery vehicles are large, heavy and 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 ride-sharing and food delivery. By delivering up to 4-6% of transactions, drones could materially reduce the number of unnecessary vehicles on the road, reducing congestion and the associated greenhouse gas emissions.

EXHIBIT 10

Drone delivery could reduce vehicle road travel in the ACT by 35 million kilometers in 2030



1 2030 forecasts project 2017 results at 1.6% CAGR using historical CAGR on distance travelled by motor vehicles from 2010-16
2 Does not include drone deliveries that replace bike deliveries
SOURCE: ABS Survey of Motor Vehicle Use (2016), ABS Retail Trade (2017), ACT Treasury, AlphaBeta analysis

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 2030.[36]

The ACT emits 1.7 million tonnes of greenhouse gas each year, or 4 tonnes per capita.[37] While overall emissions are relatively low relative to Australia as a whole (due to the lack of heavy industry), a high share (69%) of the ACT's emissions are derived from road transportation, versus 16% nationally. In particular, cars account for 44% of the ACT's emissions, versus only 8.3% nationally. This share is second only to Tasmania, and suggests that drones can play a significant role in reducing the ACT's emissions by replacing car journeys.

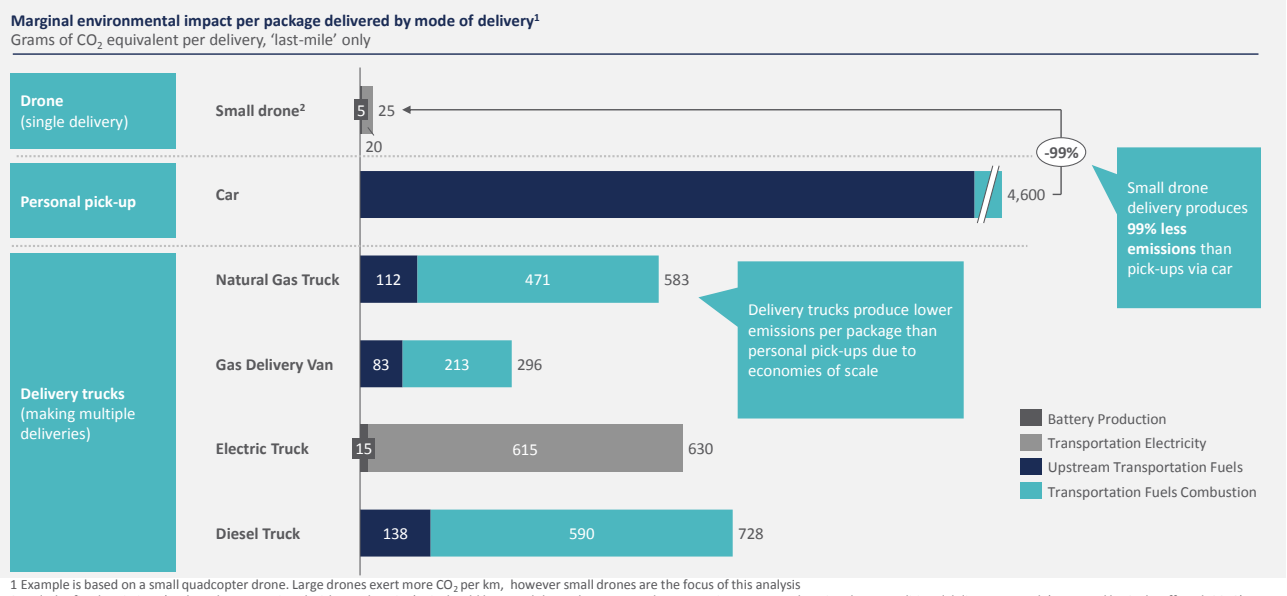
Drones are more environmentally friendly than today's transportation methods – which in the ACT, consist primarily of motor vehicle trips. A 2018 study (results shown in Exhibit 11) found that small drones cause the emission of 25 grams of greenhouse gas per last-mile delivery, versus 296-728 grams for 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 account for about 75% of transactions in the ACT in 2030 – are the worst polluters, emitting an average of 4,600 grams of greenhouse gas per trip.[38]

By using drones to fulfil 4-6% of its deliveries, the ACT could lower its greenhouse gas emissions by about 8,000 tonnes or the equivalent of carbon storage of almost 250,000 trees in 2030.[39]

[36] IPCC (2018), *Global Warming of 1.5°C*
[37] 2016 data, obtained from the Department of the Environment and Energy's National Greenhouse Gas Inventory
[38] 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.
[39] Greenhouse gas to carbon storage using EPA equivalency calculator (2018). Available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator, Assumes 20-30 trees per acre.

EXHIBIT 11

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



1 Example is based on a small quadcopter drone. Large drones exert more CO_2 per km, however small drones are the focus of this analysis
2 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 8,000 motor vehicle accidents a year on ACT roads.[40] Replacing 35 million vehicle-kilometres of road-based deliveries and pick-ups could result in 70 fewer accidents, including a small number that injure or kill native animals. Fortunately, ACT roads are relatively safe and have the nation's lowest road fatality rate.[41] Despite this, the potential injuries, time, inconvenience and economic cost of vehicle accidents is significant and should not be neglected.

[40] ACT Government (2016) ACT Road Crash Report
[41] BITRE (2016), Road Trauma Australia

5

APPENDIX – Detailed methodology

Constructing a scenario for the future role of drone delivery

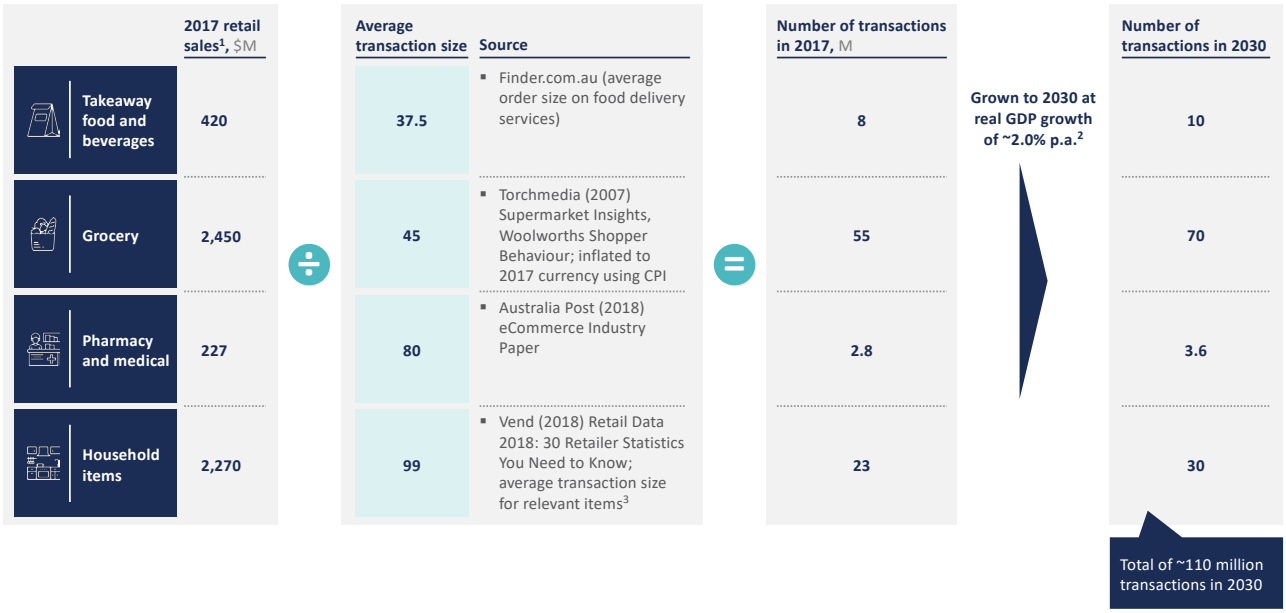
The first step in estimating the benefits of drone delivery is understanding the number and types of deliveries that might be undertaken by drones in 2030. This was done by sizing last-mile delivery in 2017, growing it to 2030, and dividing it up into transactions of different characteristics based on a range of assumptions and data inputs. These transactions were further broken into those which are delivered today (versus picked up by customers), how that might change by 2030. Assumptions were then made about the potential uptake of drones in 2030.

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 2030. For each retail category (see Exhibit 12), we began with total retail sales for the ACT from the Australian Bureau of Statistics. To obtain the number of transactions, the average order value for each retail category was applied. The number of transactions was then grown to 2030 volumes using a real GDP growth rate forecast.

EXHIBIT 12

Estimating the number of transactions in 2030



NOTE: Rows and columns may not sum to totals due to rounding
1 From ABS Retail Trade (2017)
2 Moderated down slightly from the average real GDP growth in the ACT since 2009 of 3.0% p.a. to be conservative and to reflect the rising share of services in Australia's economy. Data from ABS State Accounts (2016-17)

The number of transactions was then divided across three axes:

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

The assumptions and inputs used to disaggregate the transactions are given in Exhibit 13.

EXHIBIT 13

Distance, time sensitivity and size assumptions for transactions

Distance assumptions

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

Required delivery timeframe assumptions (% of households)

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[1]	2%	20%	78%

Size distribution of transactions

			Notes
Takeaway food and beverages	Small (<2.5kg)	85%	▪ 2.5kg payload assumed to capture 80-90% of today's food delivery
	Medium (2.5-6kg)	10%	
	Large (>6kg)	5%	
	Total	**100%**	
Grocery	Small (<2.5kg)	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)	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%**	

1 Shares from McKinsey (2016) Parcel delivery – The future of last mile
SOURCE: ABS Retail Trade (2018), Torchmedia (2007) Supermarket Insights, interviews with 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 transactions that are delivered

	2017		2030	
Takeaway food and beverages	19%	Average Australian online takeaway delivery market shares from finder.com.au and Morgan Stanley, expressed as share of total takeaway sales in Australia	40-50%	Existing growth and market estimates of online takeaway and delivery (Morgan Stanley 2018)
Grocery	3%	Share of transactions that are delivered (from Woolworths 2018 Annual Report)	25-35%	Engagement is industry sector experts. Market estimate and historic growth (Bankwest 2018). Delivery market estimate using predicted growth (Nielson 2018, Woolworths 2018, Livewire 2018)
Pharmacy and medical	2%	Ratio of online to total pharmacy sales in Australia (both obtained from IBIS world)	20-30%	Current market and anticipated growth (ABS 2017, Pharmafile 2016). Estimated delivery and growth (Australia Post 2018)
Household items	8%	E-commerce as a share of total retail in Australia, obtained from Australia Post (2018) E-commerce Industry Paper	25-35%	Current market and historic growth (Australia Post 2018). Current online sales and expected growth (Australia Post 2018, UBS 2018)

The resulting dataset is a rich breakdown of transactions – for both today and 2030 – by weight, distance, time-sensitivity, and current mode (delivery versus pickup). That is, for each cell in the matrix in Exhibit 15, we know the number of transactions that are delivered versus picked up (and an educated guess of what this might be in 2030).

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		
		Instant delivery	Same day	Standard
<2.5kg	<1km			
	1-5km			
	5-10km			
	10km+			
>2.5kg	<1km			
	1-5km			
	5-10km			
	10km+			

For each cell, 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 are estimated both 2017 and for 2030 based on a range of data sources and assumptions

SOURCE: AlphaBeta analysis

Establishing a reasonable scenario for drone uptake

For each cell in Exhibit 15, it was necessary to form a view on the potential uptake of drone delivery by 2030. 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 assumed to be higher for takeaway given it is currently the primary use case for drone delivery in the Wing ACT trials).

The result of these assumptions is provided in Exhibit 16. Note that the assumptions were made at a more detailed level and aggregated to this level for presentation.

EXHIBIT 16

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

Assumed share of transactions delivered by drone in 2030

%

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

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: AlphaBeta analysis

Estimating the change in delivery costs

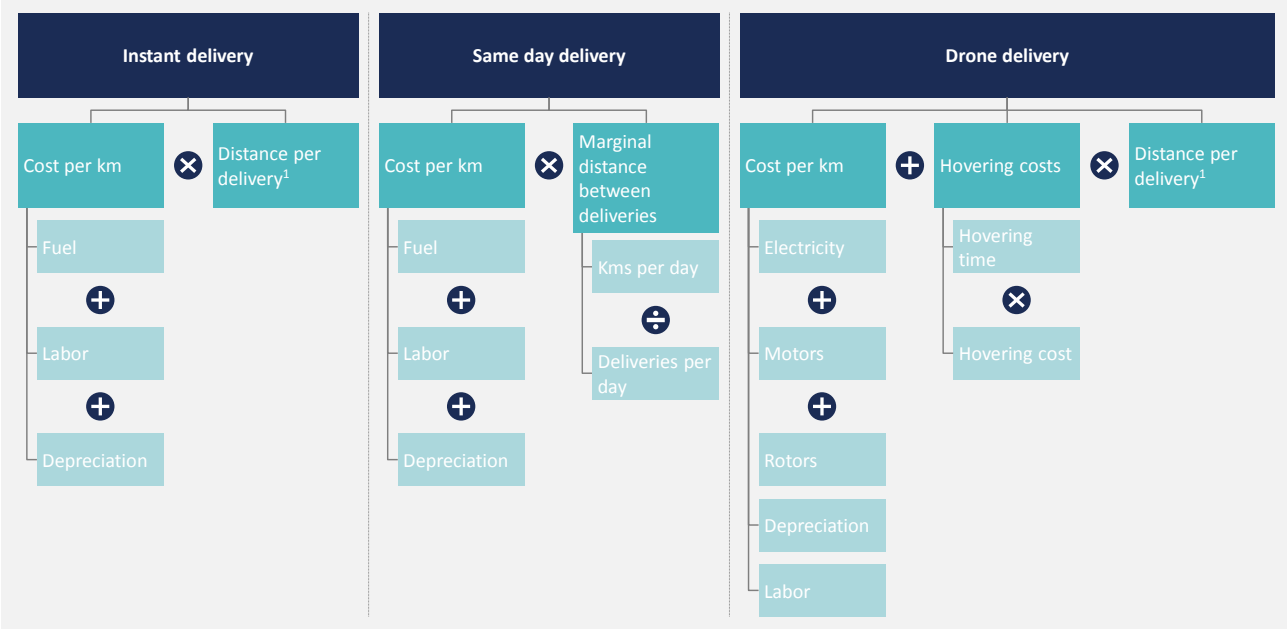
Estimating the cost of current and future delivery modes

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 17). The marginal delivery cost was calculated for all four modes across each distance category and three delivery periods (instant, same day and next day). AlphaBeta's cost saving estimates are consistent with other external views (see Exhibit 18).

EXHIBIT 17

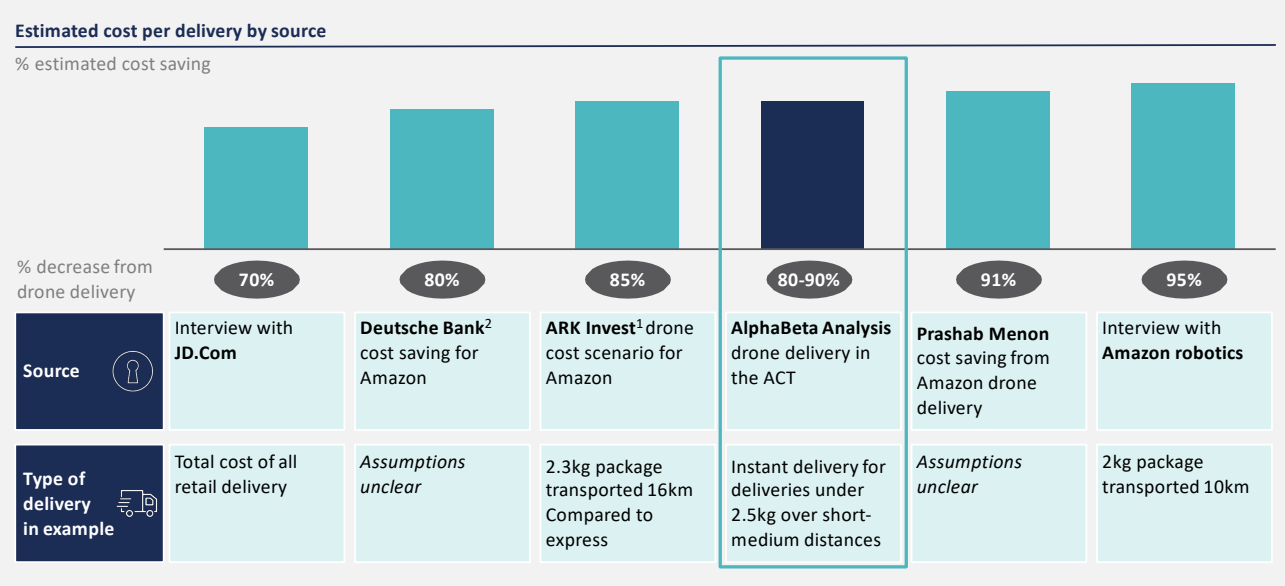
Estimating the cost of instant, same day and drone delivery



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

EXHIBIT 18

The estimated drone cost savings are consistent with external views



NOTE: Cost saving estimates have been collected from desktop research. Assumptions are not always clear and vary by source of analysis. 1 Labour costs are a high share of potential drone delivery costs, 60%
2 Cost saving from a combination of delivery automation, drones and robots
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 Uber Eats, Zoom2u and Australia 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 1: Inputs and sources for calculating current delivery costs

Area	Metric	Source
Marginal cost of delivery	Fuel costs	▪ Australian petrol prices (2018) ▪ Carsales: Mercedes Sprinter and Toyota Corolla (2016)
	Labour costs	▪ Stats Monkey (2014)
	Labour (pick up) costs	▪ ABS (2018) Average hourly national wage
	Depreciation costs	▪ Carsales: Mercedes Sprinter and Toyota Corolla (2016) ▪ ATO (2018) Depreciation of vehicles
	Trip speed	▪ Industry expert interviews
Distance of marginal trip	Distance travelled per trip by vehicle	▪ Roy Morgan (2013) Australian motorists drive an average 15,530km per year ▪ Industry expert interviews
	Parcels delivered per day	▪ AlphaBeta analysis ▪ Industry expert interviews

Estimating the cost of drone delivery

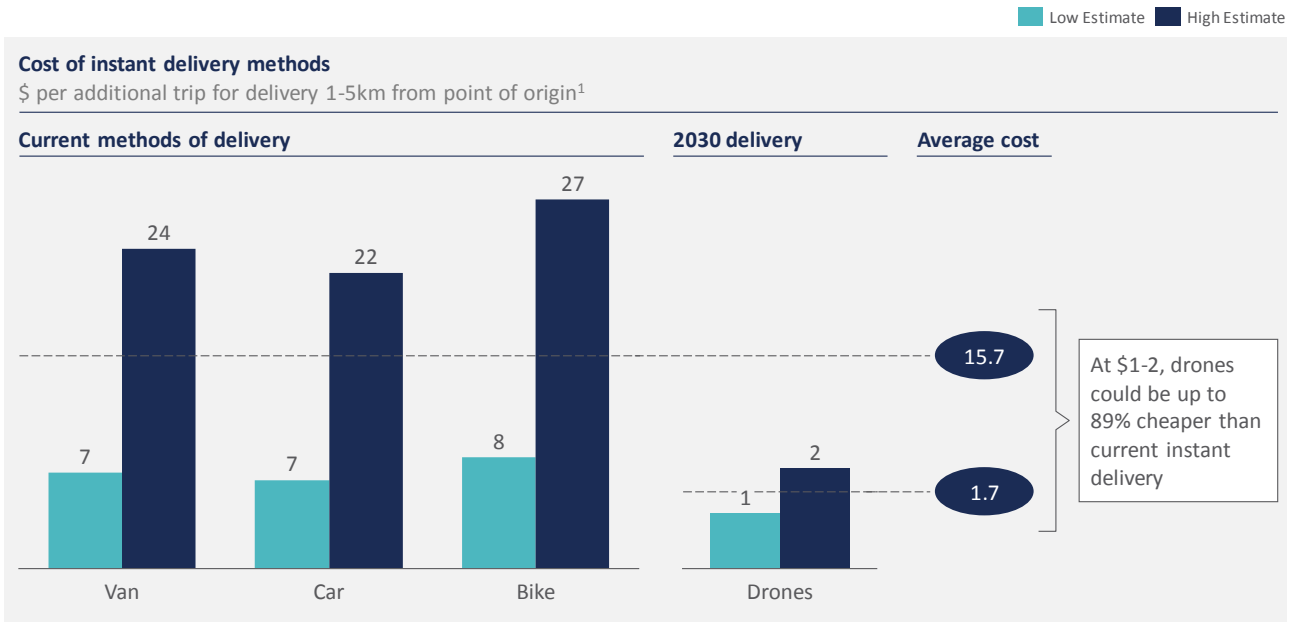
The novel nature of drone delivery has made it relatively difficult to determine potential costs. To solve for the dearth of available information, drone costs referenced in this report represent a bottom up approximation of the individual components of a drone. To ensure the potential of drones is realistic, 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 2: 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	▪ Indeed (2018). Average salary of commercial pilot
Operating trip assumptions	Hovering time	▪ Jenkins et.al (2017) Forecast of commercial UAS package delivery market ▪ Industry expert interviews
	Speed	
	Flight time	
	Trips per day	

EXHIBIT 19

At $1-2 per trip, drones could be 89% cheaper than current instant delivery

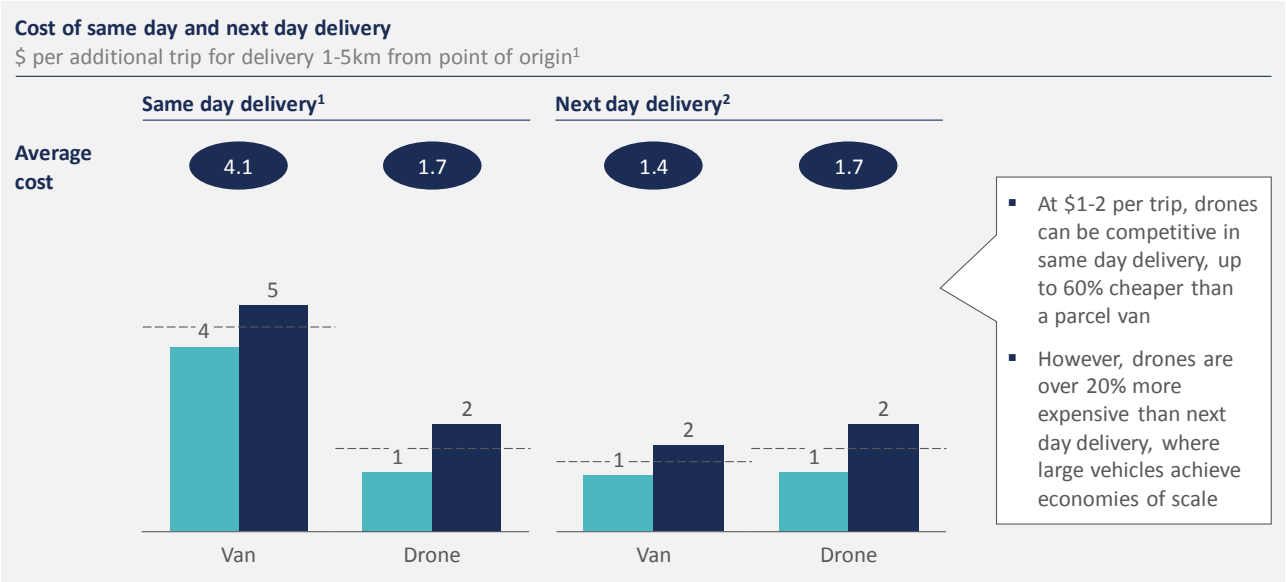


1 Assumes an instant delivery return trip of 3-10 km

SOURCE: AlphaBeta analysis

EXHIBIT 20

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



1 Assumes additional delivery distance on existing route is 0.9-1.1 km per delivery
2 Assumes additional delivery distance on existing route is 0.4-0.6 km per delivery

SOURCE: AlphaBeta analysis

Estimating benefits for local 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 21.

EXHIBIT 21

Calculating the reduction in last-mile delivery costs for ACT businesses

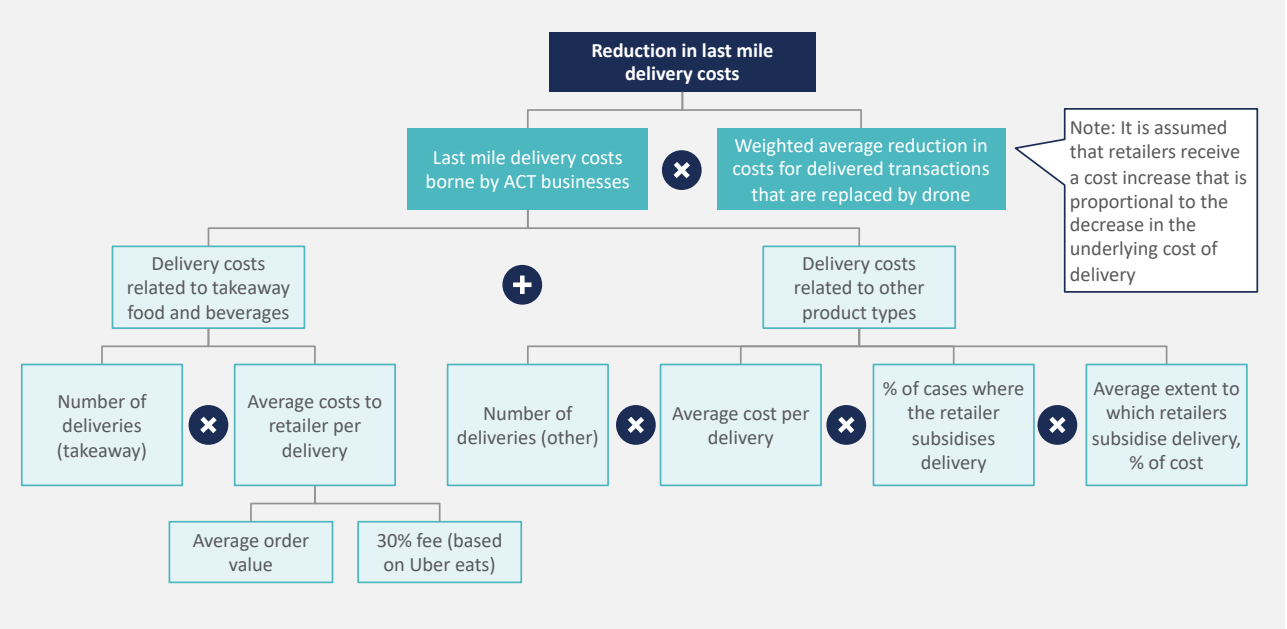


Table 3: Inputs and sources for calculating reduction in delivery costs

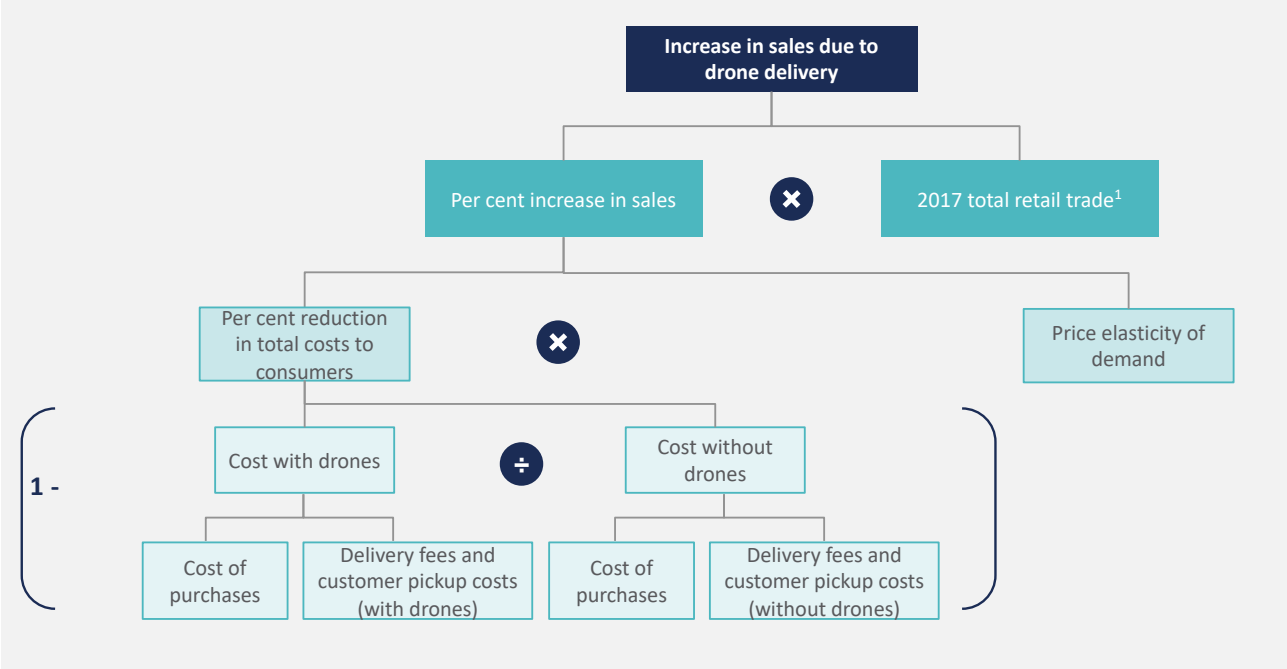
Area	Metric	Source
Weighted average reduction in costs for delivered transactions that are replaced by drone	Weighted average cost reduction (%)	▪ Estimated using the results obtained in earlier sections of this appendix (cost of drones, cost of current methods of delivery and current mix of transaction types
Last mile delivery costs borne by ACT consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last mile sector in 2030)
	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 in the ACT that would otherwise not have occurred. This effect was estimated as in Exhibit 22.

EXHIBIT 22

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



1 Includes takeaway but excludes meals consumed at restaurants

Table 4: Inputs and sources for calculating the increase in sales

Area	Metric	Source
2017 total retail trade	Total retail trade in the ACT in 2017 ($M)	▪ ABS Retail Trade (2018)
Per cent increase in sales	Cost of purchases	▪ ABS Retail Trade (2018)
	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, this report investigated how an increase in delivery range could impact ACT retailers and consumers.

To understand the retailer benefit, one Canberra central restaurant was selected, and its current delivery range was observed using online food delivery websites. This analysis indicated that the average maximum distance of food delivery was approximately 5 km. Using ABS data, it was possible to estimate the number of households within the current delivery radius and the potential increase if the delivery radius was expanded to 10 km.

Table 5: Inputs and sources for calculating expansion of market reach

Area	Metric	Source
Households available in delivery range for a Canberra central restaurant	Current range of restaurant delivery	▪ Delivery radius of Uber Eats and Deliveroo for a specific restaurant (2018)
	Number of current and potential households in range	▪ Census population in relevant SA3 locations, ABS Census (2016)

Estimating benefits for consumers

Reducing delivery fees

The potential reduction in delivery fees to consumers was estimated using the approach shown in Exhibit 23.

EXHIBIT 23

Calculating the reduction in last mile delivery fees for consumers

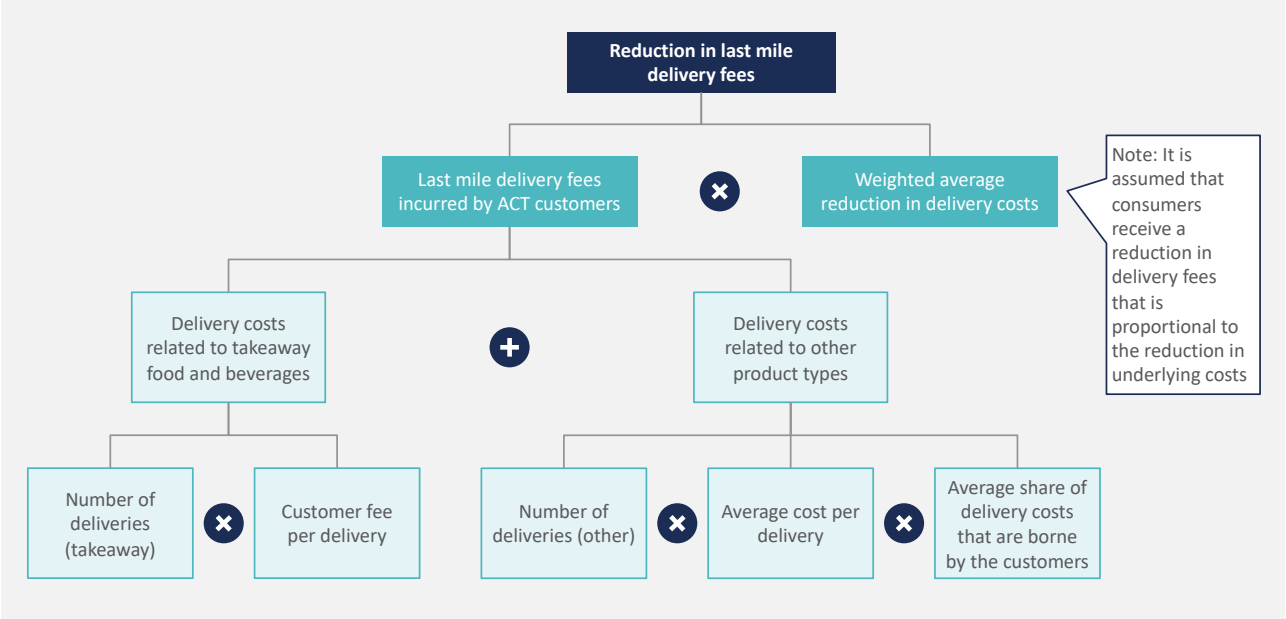


Table 6: Inputs and sources for calculating consumer delivery fee savings

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 ACT consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last mile sector in 2030)
	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 23.

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 7: Inputs and sources for calculating delivery times

Area	Metric	Source
Current vehicle speeds	Average speed of instant delivery	▪ Industry expert interview ▪ AlphaBeta analysis
	Average speed of same day delivery	▪ Australia Post, Zoom2u, Coles, Local flower delivery (2018) ▪ Industry expert interview
Drone delivery speeds	Average speed of trip by deliver distance	▪ Industry expert interview ▪ AlphaBeta analysis

Estimating the reduction in delivery times for consumers

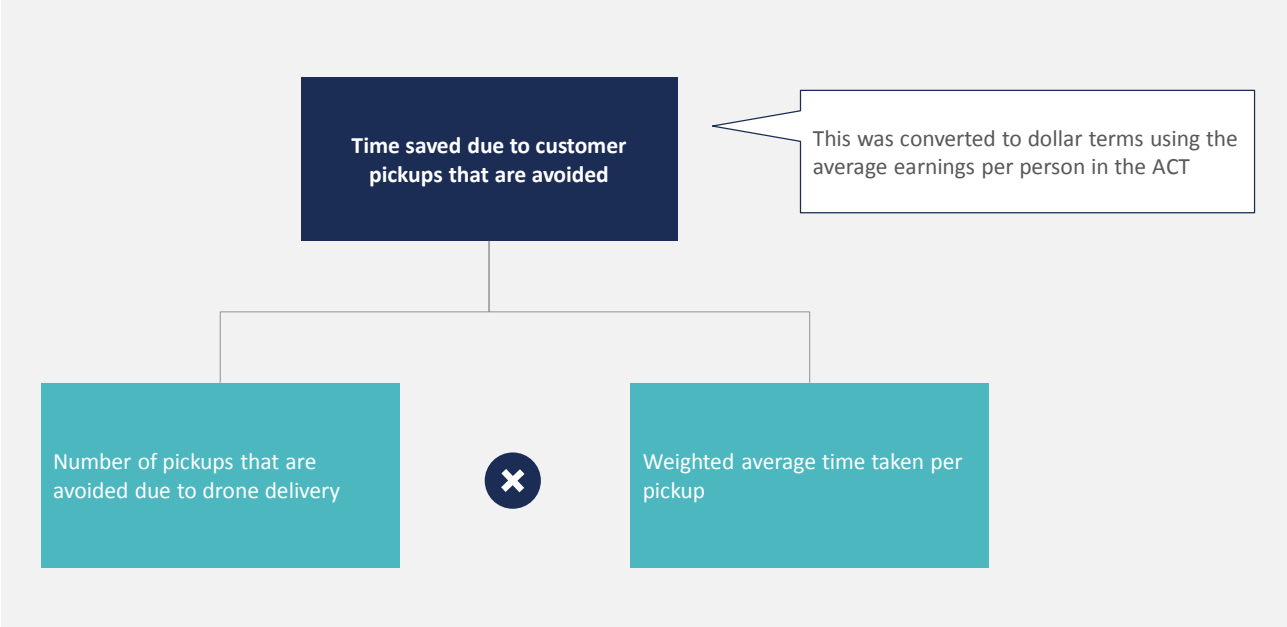
The reduction in delivery times was calculated as the weighted average difference in delivery times between drones and current delivery modes for relevant transaction types (see above for sources). For example, for instant deliveries (which are currently delivered using ground transportation, e.g. by Uber Eats), the weighted average delivery time reduction is 60-70%.

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 24.

EXHIBIT 24

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



Expanding product variety

See earlier section on “Expanding market reach”. A similar method was used to estimate the potential range expansion benefits to consumers. This involved selecting a test delivery destination and observing the furthest restaurants available for delivery. Yarralumla was selected as the test location due to it currently being well serviced by food delivery. The maximum average delivery distance was also 5 km. Using online food delivery websites, it was possible to map restaurants that offer delivery in Canberra and observe the number within 5 km and 10 km of Yarralumula. The difference indicated the potential expansion in food delivery choice available to consumers.

Table 8: Inputs and sources for calculating expansion in product delivery

Area	Metric	Source
Restaurants available for a consumer	Current range of restaurant delivery	▪ Delivery radius of Uber Eats and Deliveroo for a specific address in Yarralumla (2018)
	Number of current and potential restaurants in range	▪ Delivery radius of Uber Eats and Deliveroo from a specific restaurant (2018)

Estimating benefits for society

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 to the ACT that can be observed and described.

Emissions reduction from drone delivery

The potential emissions reduction from drone delivery is the difference between the emissions avoided by reducing the number of motor vehicles on the road and the additional emissions produced by drones. Emissions avoided was estimated by calculating 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. The average emissions per trip for drone delivery versus other methods were modelled by Stolaroff et al. (2018).

Accidents avoided from drone delivery

The potential number of accidents avoided by drone delivery as a result of 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.

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	▪ Department of Environment and Energy
	Total distance travelled by motor vehicles by vehicle type	▪ ABS Survey of Motor Vehicle Use (2016)
	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	▪ ACT Government (2016) Road Crash Report
	Total distance travelled by vehicle type	▪ ABS Survey of Motor Vehicle Use (2016)
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)	▪ AlphaBeta analysis ▪ Industry expert interviews
	Average distance travelled per trip by consumer and vehicle type	▪ AlphaBeta analysis ▪ Google maps (2018) ▪ Refer to cost of delivery analysis in this appendix
	Average number of trips replaced by drone delivery by consumer type	▪ ABS Retail Trade (2017) ▪ ACT Treasury
	Compound annual growth rate of motor vehicle kilometres travelled	▪ ABS Survey of Motor Vehicle Use (2010-2016)

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FASTER, GREENER AND LESS EXPENSIVE

THE POTENTIAL IMPACT OF DELIVERY DRONES IN QUEENSLAND

FEBRUARY 2019

Prepared by AlphaBeta for Wing

αlphaβeta

strategy x economics

Important Notice on Contents – Estimations and Reporting

This report has been prepared by AlphaBeta for Wing. All information in this report is derived or estimated by AlphaBeta analysis using both proprietary and publicly available information. Where information has been obtained from third party sources and proprietary research, this is clearly referenced in the footnotes.

The amounts in this report are estimated and specified in 2017 Australian dollars. Where conversion rates have been used, these are stated in the footnotes.

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Drones will deliver benefits to Queensland businesses, consumers and communities

BENEFITS FOR LOCAL BUSINESSES

Grow retail sales in Queensland by **$400-450 million** of which **$150 million** could accrue to **small businesses** in Queensland in 2030

Reduce delivery costs for businesses by up to **$155 million** per year by 2030.* Delivery costs for some items such as prepared meals could fall in the long term by up to **80-90%**

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

BENEFITS FOR CONSUMERS

Save **35-40 million hours** **for consumers** in 2030 by replacing customer pick-up journeys, as well as **delivery times** that are **60-70% faster** than today's methods

Save consumers **$60-65 million** per year in **reduced delivery costs by 2030**.* Delivery costs for some items such as takeaway food could fall over the long term by up to **80-90%**

Expand choice for consumers by giving them access to up to **4x as many merchants** by bringing more retailers within delivery range of their home or workplace

BENEFITS FOR SOCIETY

Reduce traffic congestion by replacing **470 million vehicle kilometres** each year. This could also avoid up to **1,100 road accidents** each year

Reduce annual **CO_2 emissions** by **100,000 tonnes** due to fewer road vehicle deliveries. This is equivalent to the carbon storage of **3.5 million trees**

* Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs

1

EXECUTIVE SUMMARY

Queensland is at the forefront of global drone technology, with its introduction of an ambitious whole-of-government drone strategy last year.[1] Flying at speeds of up to 120 kilometres per hour 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 the road.

Queensland is among the world's earliest adopters of drone technology. The state was home to the world's first delivery by Wing drone in 2014, and in 2018 issued one of the world's first whole-of-government drone strategies, designed to cement its position as the "drone capital of Australia".[2]

Drones could 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 most costly segments of the supply chain, accounting for 15 to 20% of the total cost of retail transactions in the form of delivery fees or the time spent by consumers picking up their goods. Queensland incurred a total of $13.2 billion of last-mile delivery costs in 2017.

Last-mile delivery is particularly challenging in Australia, where logistics providers face congested city roads at one extreme and sparsely populated countryside at the other. Consumers are doing more of their shopping online, but still face limited delivery options compared with those available overseas, where "same-day" delivery services are more common.[3]

The cost and time taken for items to be delivered in Australia not only limits the range of products available to consumers at home; local 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 urgently. Based on these criteria, drones could deliver up to 4-6% of Queensland's household purchases in 2030, helping to make local businesses more competitive, providing greater choice and convenience for customers, while also reducing the total number of motor vehicle journeys in the region.

Road transportation accounts for 12% of Queensland's greenhouse gas emissions, and replacing some of those journeys with delivery drones could have a significant environmental impact. By using drones to deliver 4-6% of its household purchases, Queensland could reduce its carbon emissions by about 100,000 tonnes – the equivalent effect of 3.5 million trees – as well as reducing the number of accidents on the road.

[1] Queensland Government (2018), Queensland *Drones Strategy*. Available at https://www.premiers.qld.gov.au/publications/categories/plans/assets/qld-drones-strategy-2018.pdf.

[2] ABC (2014), "Google tests prototype drone in Queensland; Warwick farmer has dog food, chocolate delivered". Available at: https://www.abc.net.au/news/2014-08-29/google-project-wing-drone-delivery-test-warwick-queensland/5707034.

[3] SmartCompany (2017), "The last mile: Why Australian shoppers won't see same-day delivery from Amazon for years to come". Available at: https://www.smartcompany.com.au/industries/retail/australian-shoppers-wont-see-amazon-same-day-delivery-for-y-ears/.

EXHIBIT 1

The impact of drone delivery in Queensland was analysed across three areas

The nature and size of each of these types of benefits is explored below.

Benefits for local businesses

Drone delivery could result in several important benefits for Queensland businesses:

- **Expanding market reach.** Drones travel faster than all existing forms of last-mile delivery, reaching a maximum speed of 120 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 2030 drone technology.[4] For a restaurant located in central Brisbane, this could bring an additional 70,000 – 80,000 households into range.[5]
- **Reducing delivery costs.** Queensland businesses, including food outlets, incur costs as part of providing delivery to customers. These costs include fees to delivery service providers (e.g. consumer parcels or food delivery), as well as the cost associated with performing deliveries themselves. These costs make it unprofitable for some 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 $155 million to businesses by 2030.[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 in Queensland. As a result, consumers will be able to purchase more items, or switch to higher-value items. These effects

[4] Current range of 5 km based on the current Uber Eats and Deliveroo delivery radius on 1 November 2018 in Queensland, estimated based on the furthest restaurant delivery destination available from central Brisbane. 10 km range for drones based on conservative estimate of current technology.
[5] Potential increase in households estimated by density of households in Brisbane. ABS Census (2016).
[6] Assumes retailers receive a delivery cost reduction that is proportional to the reduction in underlying costs due to drone delivery.

combined are expected to generate $400-450 million in additional sales for the whole of Queensland in 2030.[7] Of this, $150 million could accrue to small businesses in Queensland.

- **Enabling more businesses to deliver.** Drones could allow more local businesses to offer last-mile delivery, giving them a new way to reach customers. This could allow more specialised businesses to thrive, and encourage and enable new businesses to engage in e-commerce.

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 in Queensland. These include:

- **Improving quality of life for homebound people.** Drones could deliver a wider range of food, medicines and other products to the over 200,000 elderly, people with disability or otherwise homebound Queenslanders for whom visiting shops and restaurants may be difficult or impossible. Drone delivery could also have a role to play after natural disasters, safely resupplying people stranded by fires or flooding.
- **Saving time.** Drones travel faster than all other forms of last-mile delivery and have the potential to shorten delivery times by 60-70%. Further, for suitable transactions (which are described in Exhibit 4), drone delivery reduces the need for consumers to travel to pick up their items. By eliminating an estimated 55 – 60 million 'pick-up' journeys in 2030, drone delivery has the potential to save consumers up to 40 million hours, which is worth about $520 million if valued at today's average earnings.[8] Rapid drone delivery enables consumers to have greater control over their time, knowing for certain that a delivery will arrive within a short time interval.
- **Reducing delivery fees.** In 2017, Queensland consumers incurred an estimated $13.2 billion in last-mile delivery and pickup costs on transactions within Queensland.[9] Because 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. This could save Queensland households a total of up to $65 million in 2030.[10]
- **Expanding product variety.** Because the speed of drones allows retailers to offer instant or same-day delivery to a larger geographical area, customers in Queensland would thus have a wider range of products to choose from. A Queensland suburb that currently receives delivery from 50 restaurants could access over 150 food outlets via drone – a three-fold increase.[11]

Benefits for society

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

- **Reducing 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 Queensland roads. Preliminary estimates suggest that drone delivery could cut the total distance driven by vehicles on local deliveries by over 12 per cent, resulting in 470 million fewer motor vehicle kilometres on Queensland roads in 2030.
- **Reducing greenhouse gas emissions.** Small drones produce fewer emissions per package delivered than today's road vehicle delivery options. Flying a drone emits the equivalent

[7] Relevant businesses defined as food and store-based retailers, based on 2017 business counts from the ABS.
[8] Average earnings per person of $13.85 per hour, based on average earnings for those employed in the Queensland, adjusted for share of population in employment [9] Includes fees for last-mile transport only and does not include transactions sent from outside of Queensland.
[10] Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs.
[11] Restaurant count based on the number of restaurants available on Uber Eats and Deliveroo, accessed from a random sample of Brisbane suburbs on 1 November 2018. Potential increase in restaurants based on the number of restaurants and cafes currently delivering within a 10 km radius of these suburbs.

of about 25 grams of greenhouse gas when delivering a small package, compared with the 296-728g emitted by delivery trucks. Items that are personally picked-up by a purchaser via car emit 4,600 grams of greenhouse gas per package.[12] By replacing these more polluting methods, drone delivery could eliminate about 100,000 tonnes of greenhouse gas emissions by 2030, equivalent to the carbon storage of around 3.5 million trees.

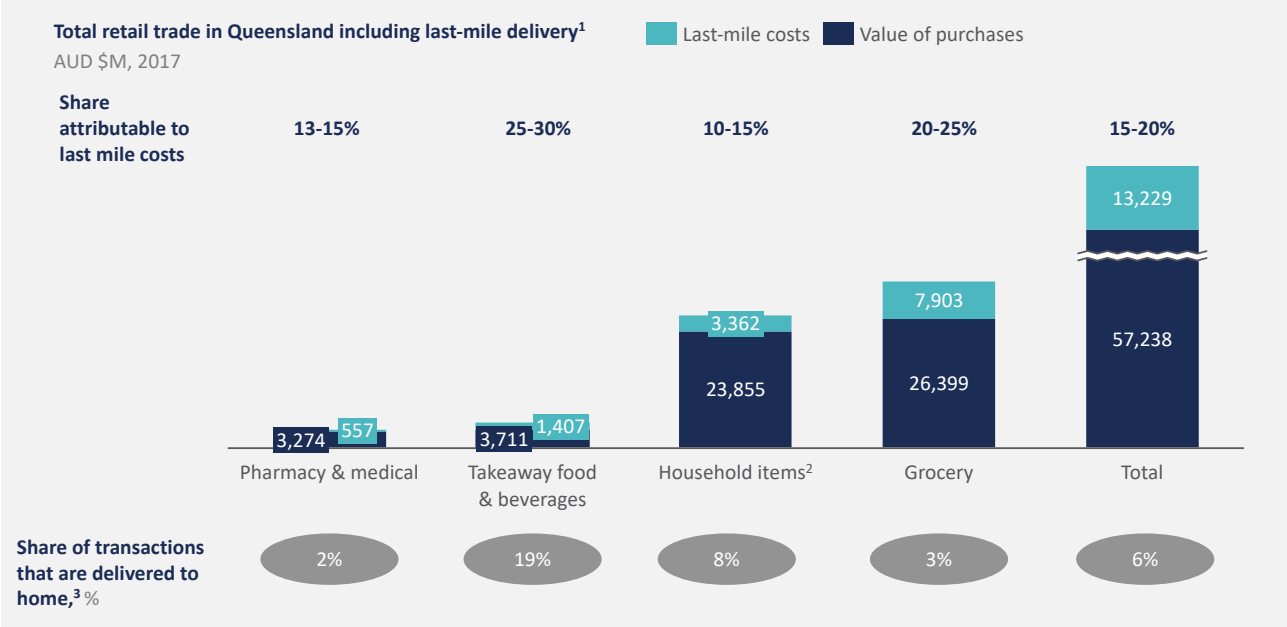
- **Reducing road accidents.** In 2016 there were an estimated 130,000 motor vehicle accidents on Queensland roads.[13] This represents a little over two accidents for every million kilometres travelled by motor vehicles. If drone delivery is able to reduce the number of motor vehicle journeys by 0.7% by replacing road-based deliveries and pick-ups, this could result in 1,100 fewer accidents on Queensland 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 94% of all transactions) or by paid delivery services (around 6% 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). Last-mile delivery can account for 15-20% of the total cost of an item, in the form of either delivery fees or the time of consumers picking up their goods.

EXHIBIT 2

The cost of last-mile delivery (or pick-up) was ~$13.2bn in 2017, which represents 15-20% of the total value of retail trade in Queensland



1 Excludes food consumed on-premise at restaurants/cafes
2 Includes household goods, clothing & footwear, department stores, newspapers/books, other recreational goods and other retailing
3 Other transactions are picked up in store by customers
SOURCE: ABS Retail Trade (2017), AlphaBeta Transport Cost Model

[12] 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).

[13] Estimated based on data from ABS (2016) Road Trauma Statistical Summary. This estimate is higher than official statistics (e.g. *Crash data from Queensland roads*, Queensland Government Data 2016), which presents summaries of crashes that were reported to police.

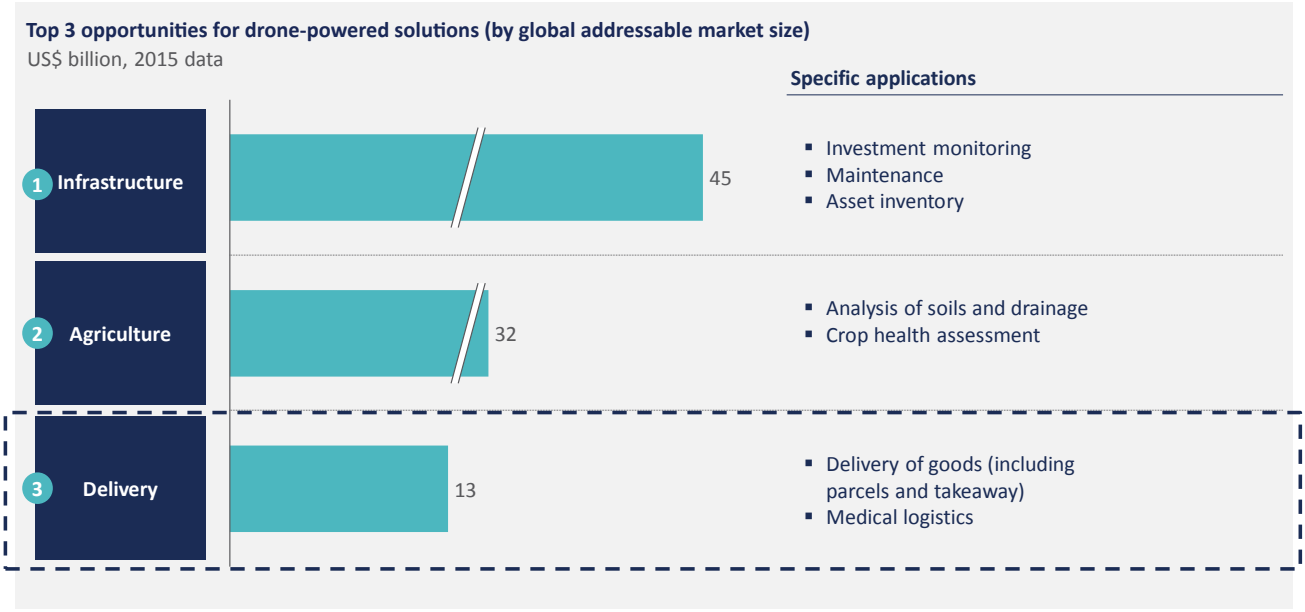
Last-mile delivery cost Queensland more than $13.2 billion last year. By reducing delivery costs, drones have the potential to create massive value for both retailers and consumers.

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. Enterprises globally purchased almost three million drones in 2017, up 39% from 2.15 million in 2016.[14] Further, the global market opportunity for commercial applications of drone technology is estimated at US$127 billion, with drone delivery being the third-largest component (see Exhibit 3).[15]

EXHIBIT 3

Delivery is predicted to be one of the top three commercial applications of drone technology globally



SOURCE: PwC (2016) *Clarity from above*

[14] Gartner (2016), *Forecast: Personal and Commercial Drones, Worldwide, 2016.*
[15] PwC (2016), *Clarity from Above.*

The shift toward drone delivery is already underway. Queensland was home to the world's first delivery by Alphabet's Wing drone in 2014, and is likely to remain at the forefront of drone delivery.

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

Drone technology has the potential to become an important part of Australia's delivery sector, particularly in fulfilling 'last-mile' deliveries.[16] In this report, drones are assumed 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 a maximum speed of 120 km/h for a total round-trip distance of 20 km in 2030;[17]
- **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 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.

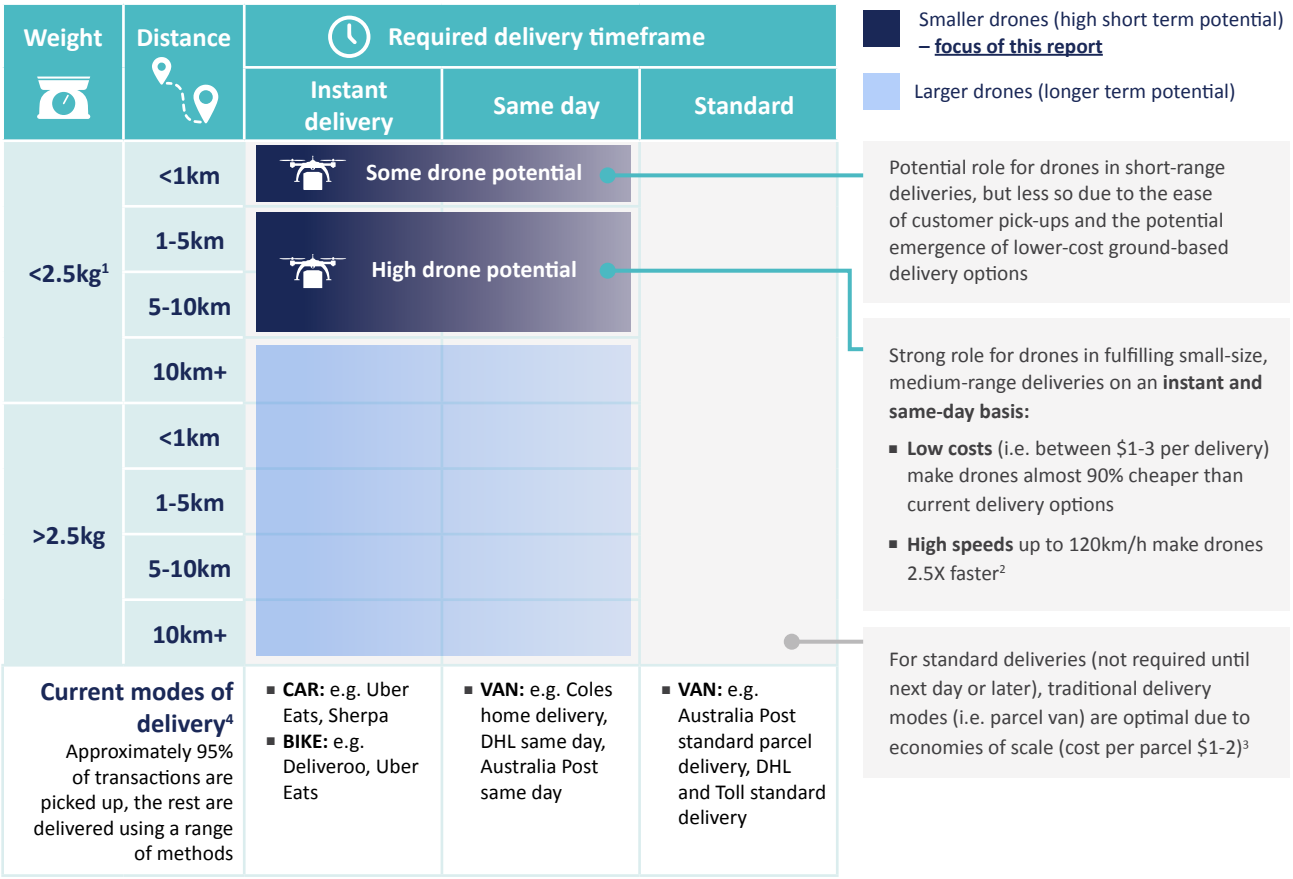
The result of applying these criteria (as shown in Exhibit 4) is that drones are most likely to be used for small item deliveries made on an instant or same-day basis. For these time-sensitive transactions such as food and medicine delivery, drones are significantly less expensive ($1-3 per delivery compared to $14-17)[18] and faster than other methods (more than twice as fast compared with current methods of instant delivery such as Uber Eats). Standard, less urgent deliveries will likely be fulfilled by road vehicles (including autonomous ones) by 2030. 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).[19]

[16] 'Last-mile' deliveries include transporting an item to the customer's location from the retailer (if close) or local distribution centre.
[17] 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).
[18] Cost for 1-5 km instant delivery compared with van, car and bike.
[19] McKinsey (2016), *Parcel delivery – the future of last mile.*

EXHIBIT 4

There is a strong role for drones in fulfilling small deliveries on an instant and same-day basis

Role for drones by transaction type



1 Assumes a maximum payload of 2.5kg and maximum range of 10km (20km round trip) for last-mile drone technology
2 Assumes a 10 km journey where a private car takes 20 minutes and a drone takes 8 minutes
3 Delivery costs refer to transport costs related to labour, fuel and depreciation. See appendix for details and assumptions
4 This list of example delivery modes is non-exhaustive.
Source: AlphaBeta 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 small drones due to greater certainty around the feasibility and economics of small-drone delivery.

Drones could deliver more than one in four take-away food orders, and up to 4-6% of all purchases in Queensland by 2030

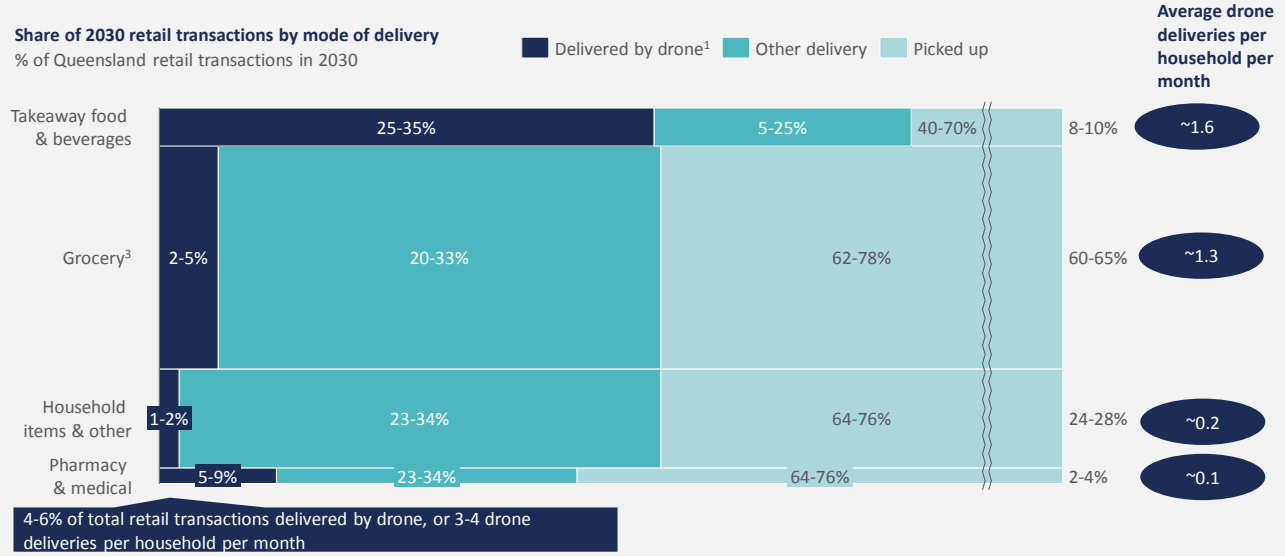
In 2017, Queensland households made an estimated 985 million retail transactions, including groceries, pharmacy goods, takeaway food and other household items. Around 6% of those purchases were delivered to customers, while the remainder were picked up by customers travelling to the retailer's outlet.

The delivery landscape in 2030 will be different. Queensland households will make an estimated 1.3 billion transactions, and a greater share of these will be delivered.[20] Up to 40-50% of takeaway food orders, and 20-35% of transactions in other product categories, are forecast to be delivered by 2030.[21]

Drones will play an important role in this shift toward online delivery. It is estimated that drones could deliver up to 4-6% of household purchases in 2030 (Exhibit 5). 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 Queensland households).

EXHIBIT 5

In 2030, drones could deliver up to 4-6% of retail transactions, and up to 25-35% in some categories (e.g. takeaway)



1 In most categories, drones are assumed 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 assumed 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 assumed 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 assumed to replace ~20-30% of pickups that meet size, distance and time-sensitivity criteria. These are assumptions only and the above represents an example scenario rather than a prediction of future uptake
2 A higher share of deliveries in pharmacy & medical serviced by drone because the transactions are more likely to satisfy drone weight restrictions than grocery or household items
3 Includes convenience stores, which have a smaller average purchase weight than supermarkets
SOURCE: ABS Retail Trade, AlphaBeta analysis

[20] Based on a conservative forecast GSP growth rate for Queensland of 2.5% p.a. from 2017-30 (based on growth rate of relevant retail sales categories, ABS 5220.0) [21] Based on various sources including Morgan Stanley, Bankwest, Australia Post. See Appendix for details.

2

BENEFITS FOR LOCAL BUSINESSES

Expanding market reach

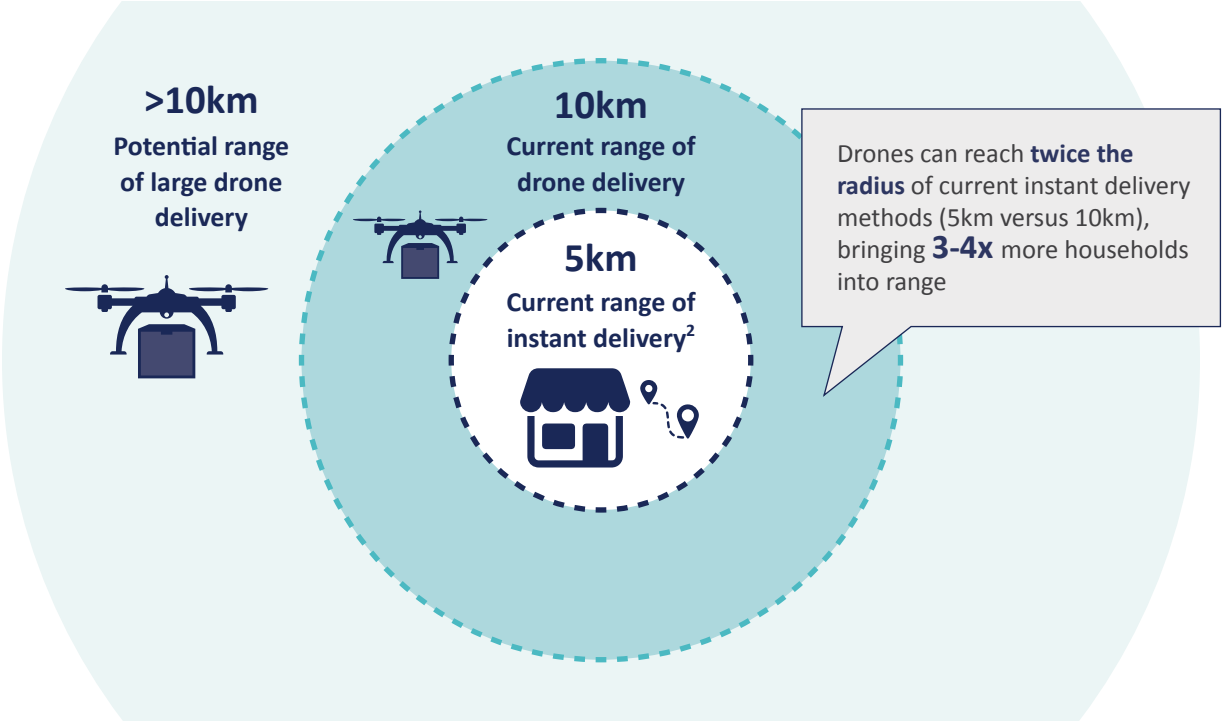
Drones can help Queensland businesses reach more customers by expanding their delivery range. The current radius of food delivery in Brisbane, for example, is only about 5 km.[22] Road delivery vehicles are too slow to get food in good condition to customers much further than that, so most food delivery businesses focus on a small local customer base.

But drones can deliver a package 10 km in less time than it takes a car to drive 5 km, thereby doubling the effective delivery range. Doubling the range can more than double the market each business can reach. For example, doubling the range to 10 km quadruples the number of households within range of a restaurant based in central Brisbane, from 25,000 households to 100,000 households.[23]

EXHIBIT 6

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[1]



1 Current range of 5 km based on the current Uber Eats and Deliveroo delivery radius on 1 November 2018 in Queensland, estimated based on the furthest restaurant delivery destination available from central Brisbane.
2 Based on Uber Eats and Deliveroo
Source: AlphaBeta analysis

Even within today's delivery range, drones can help businesses better serve their customers where speed matters, for example, with food and pharmaceuticals. Today an 'instant' delivery van takes about 15 minutes to complete a 10 km trip. A drone can cover the same distance in less than 6 minutes, or more than 60% faster.[24]

[22] Based on the current Uber Eats and Deliveroo delivery radius on 1 November 2018 in Queensland, estimated based on the furthest restaurant delivery destination available from central Brisbane.
[23] Household estimate based on population in relevant SA3 areas.
[24] Average van speed 40 km/h, average drone speed 100 km/h.

Reducing delivery costs

Delivery costs represent a significant expense for Queensland businesses, especially in cases where delivery is time-sensitive. Restaurants currently pay around 30% of each order value to online delivery service providers.[25] Further, for other items, same-day parcel delivery alone can cost over $30 (with a share of these costs borne by the retailer in some cases).[26] These costs make it unprofitable for some businesses to offer last-mile delivery, despite a growing customer preference for online shopping and delivery.

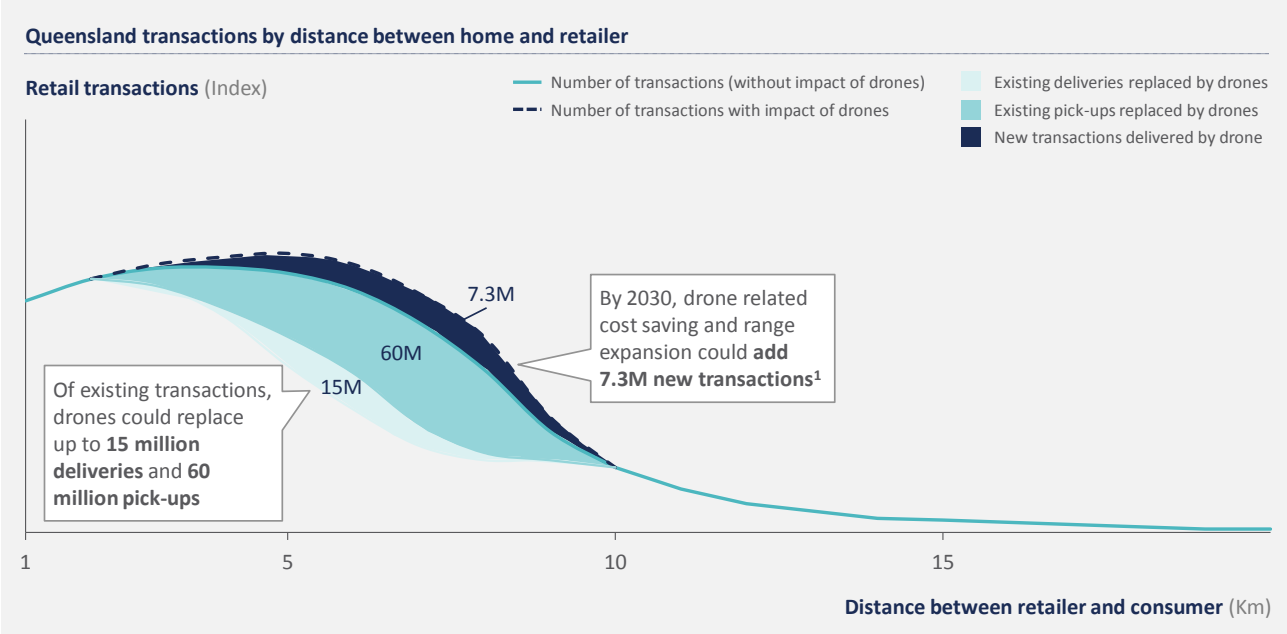
Drone delivery costs are likely to be up to 90% less expensive than existing methods of instant and same-day delivery. Even after factoring in the likely savings for delivery customers in Queensland, businesses there could save more than $155 million in 2030.[27]

Generating increased sales

As explored in Section 3 (Consumer Benefits), drones will save customers time and money. That cuts the effective cost of retail purchases, so consumers will make additional or higher-value purchases. While the value is hard to estimate precisely, drone delivery could generate an additional 7 million annual retail transactions in Queensland in 2030, worth $400-$450 million in revenue. About $150 million, or just over one third of these benefits, is likely to be accrued by small businesses in Queensland.[28]

EXHIBIT 7

Lower cost, greater range, and the increased convenience of drones could grow transactions in Queensland by 7.3 million



NOTE: Illustrative axis, retail transactions and distance between retailer and consumer are indicative
SOURCE: AlphaBeta analysis

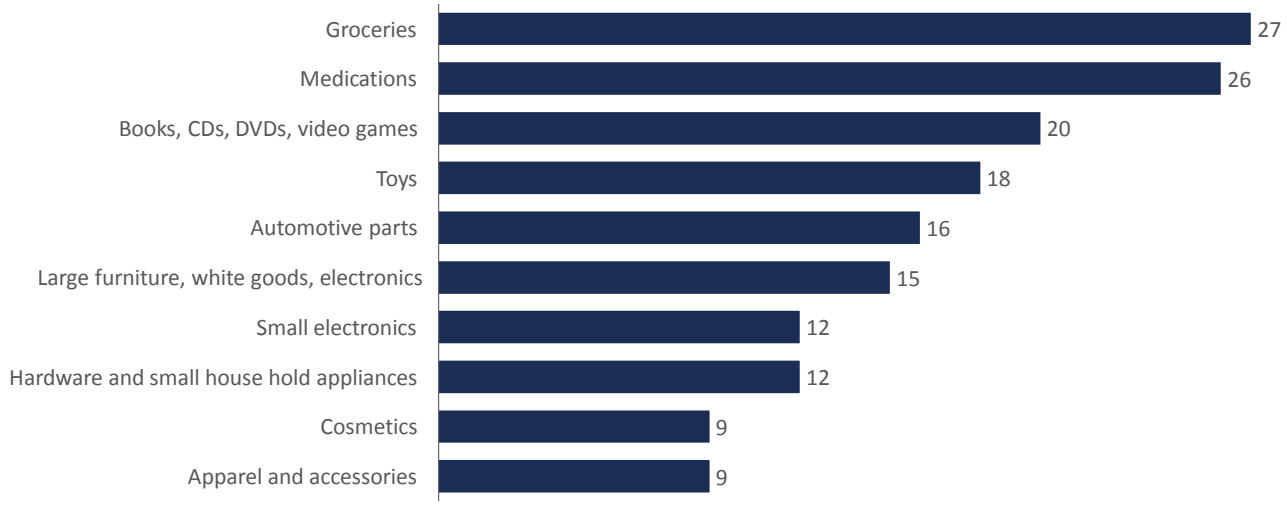
[25] Based on the 2018 pricing model of Uber Eats.
[26] Based on 2018 pricing of Australia Post and Copenhagen Economics (2016), *Principles of e-commerce delivery prices*
[27] Assumes retailers receive a reduction in delivery costs proportional to the reduction in the underlying cost of delivery due to drones.
[28] Small businesses are estimated to contribute 34% of value added to the economy. Australian Small Business and Family Enterprise Ombudsman (2016), *Small Business Counts: Small Business in the Australian Economy.*

Many consumers say they do not buy online because delivery takes too long. In a recent survey, more than a quarter of respondents reported not buying groceries and medical items online because of delivery delays.[29] Delays also deter consumers from ordering online for small electronics, cosmetics and other items that could be delivered faster by drone.

EXHIBIT 8

Faster delivery could lead to more purchases, particularly for grocery and medical items

Share of respondents who did not purchase an item online due to long delivery times[1]
Percent of respondents



1 Survey of 4,700 consumers in China, Germany, and the US
Source: McKinsey (2016) Parcel delivery – the future of last mile

[29] McKinsey (2016) Parcel delivery – the future of last mile.Takeaway food did not feature in the report as it was focused on parcel delivery

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 take-away restaurant that specialises in some regional cuisine could thrive when it can access a larger market. While the benefit is difficult to quantify, some Queensland businesses will be able to cut costs and increase profits by scaling up to serve such niches.

As discussed earlier in this section, some Queensland 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 local businesses to participate in last-mile delivery and engage in e-commerce. This would facilitate a more productive, competitive business environment in Queensland.

BOX 1:

Queensland's strategy for being the "drone capital of Australia"

Queensland is among the world's earliest adopters of drone technology, with an ambitious plan to become the "drone capital of Australia".

In 2014, farmer Neil Parfitt became one of the first people in the world to receive a package by drone when he took delivery of a small box of Cherry Ripe chocolate bars on his property in Darling Downs in Queensland's south-east. He later placed orders for dog food and cow vaccines to be delivered by the same method.*

The Queensland government has since released a five-point strategy aimed at cementing the state's world-leading position. The 2018 Queensland Drone Strategy is the first of its kind in Australia and among the first whole-of-government drone strategies worldwide. It aims to support research and development, establish suitable regulations, improve industry and workforce capability, improve government service delivery, and attract investment to the state.

The strategy concerns not only delivery drones but also unmanned autonomous vehicles used in a broad range of situations from filming to surveying to recreational fishing.

"The strategy's vision is for Queensland to be a world leader in drone technology and application," the strategy document states. "Our drone industry has strong investment and jobs growth, supported by our world-leading research and development capability and a highly skilled workforce. Queensland is a place where drones complement and enhance peoples' lives and support our communities."

Queensland's strategy was informed by a one-year industry consultation that highlighted opportunities in supporting emergency services, exporting new technology and skills to Asia's high-growth markets, and attracting tourism to the state.

*Sydney Morning Herald (2014), 'Google drones tested in Queensland'.
Available at: https://www.smh.com.au/technology/google-drones-tested-in-queensland-20140828-109jvb.html

3

BENEFITS FOR CONSUMERS

Reaching underserved populations

Delivery drones could have a significant effect on people with disability, elderly, or otherwise homebound people in Queensland. 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.

As of 2015, there were more than 200,000 people with disability and elderly people living in Queensland who needed assistance with mobility, according to statistics from the ABS.[30] Drone delivery could play a role in serving these populations and improving their quality of life.

Drone delivery could also have a role to play after natural disasters, safely bringing supplies to people stranded by fires or flooding. Queensland is the most disaster-prone state in Australia and many communities run the risk of being temporarily isolated during these incidents.[31]

Saving time

Drones travel faster than all other forms of last-mile delivery, at a top speed of around 120 km/h based on current small-drone technology. Drones are also not impacted by traffic and can thus deliver products much faster than other ground vehicles. As a result, drones could reduce delivery times for instant deliveries by around 60-70% in 2030.

Further, drone delivery can save people time by replacing 50-60 million customer pick-up journeys. As noted earlier, the last mile accounts for around 25% of the 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 Queensland consumers 35-40 million hours in 2030. This is equivalent to about $520 million if valued at today's average earnings.[32]

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 $5 for a food delivery to more than $30 for a courier delivery.[33] In many cases where delivery is not an option, such as a trip to the grocery store to pick up an extra onion, the time cost of picking up an item is also significant. Drones provide an option for consumers who want affordable instant or same-day delivery. Drones can be up to 80-90% less expensive than current methods of instant delivery. Even if only half of those savings are passed onto consumers, drones could save Queensland households a total of $60-65 million in delivery fees in 2030.[34] 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 instant products available to consumers. Consumers in Queensland 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 time is sensitive and current delivery ranges are restricted.

In Brisbane, consumers can only order food to be delivered from a maximum of 5 km away. This restricts the options available to them. For example, some Brisbane consumers can currently only order deliveries from 30-50 restaurants, although there are over 150 restaurants within a 10 km radius that offer delivery services.[35] Doubling restaurants' delivery range can thus give consumers access to three to four times the number of restaurants currently available to them.

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.

[30] ABS (2016), *Disability, Ageing and Carers, Australia: Summary of Findings, 2015.*
[31] Queensland Government (2018), 'Disaster Management Guideline'. Available at: https://www.disaster.qld.gov.au/dmg/Pages/DM-Guideline.aspx.
[32] Average earnings per person of $13.85 per hour, based on average earnings for those employed in the Queensland, adjusted for share of population in employment. [33] Uber Eats, Deliveroo and Australia Post (2018) pricing.
[34] Assumes consumers receive a fee decrease that is proportional to the reduction in underlying costs.
[35] Based on the current Uber Eats and Deliveroo delivery radius on 1 November 2018 in Queensland, estimated based on the furthest restaurant delivery destination available from central Brisbane.

4

BENEFITS FOR SOCIETY

Reducing congestion

Today, 'last-mile' delivery vehicles in Queensland travel about 2.8 billion kilometres every year. Delivery vehicles are large, heavy and can disproportionately disrupt other road users. Parking and access to loading areas can delay and inconvenience other commuters and pedestrians.

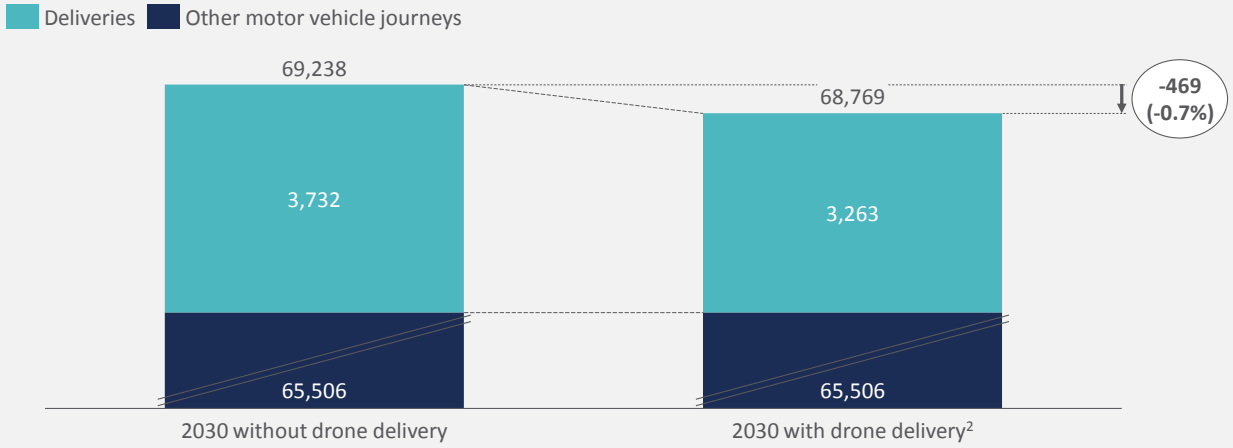
By 2030, delivery transport-kilometres could increase by almost a third, to about 3.7 billion kilometres a year, as e-commerce and food deliveries are expected to grow. By then, it is estimated that delivery vehicles could be responsible for 6% of the kilometres travelled on Queensland roads.

By serving 4-6% of last-mile transactions, and reducing delivery vehicle-kms by about 12 per cent, drones can eliminate 470 million delivery-related vehicle-kms, materially reducing the number of unnecessary vehicles on the road, reducing congestion and its associated greenhouse gas emissions.

EXHIBIT 9

As flying drones replace delivery vehicles, Queensland road traffic could fall 470 km (0.7%) by 2030

Motor vehicle usage on Queensland roads[1]
Distance travelled, millions of kms, annual



1 2030 forecasts project 2017 results at 1.6% CAGR using historical CAGR on distance travelled by motor vehicles from 2010-16
2 Does not include drone deliveries that replace bike deliveries
SOURCE: ABS Survey of Motor Vehicle Use (2016), ABS Retail Trade (2017), ACT Treasury, AlphaBeta analysis

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 2030.[36]

Queensland emits two tonnes of greenhouse gas per capita from cars each year, 13% more than the national average.[37] Cars account for 12% of Queensland's emissions. Drones can play a significant role in reducing Queensland's emissions by replacing car journeys.

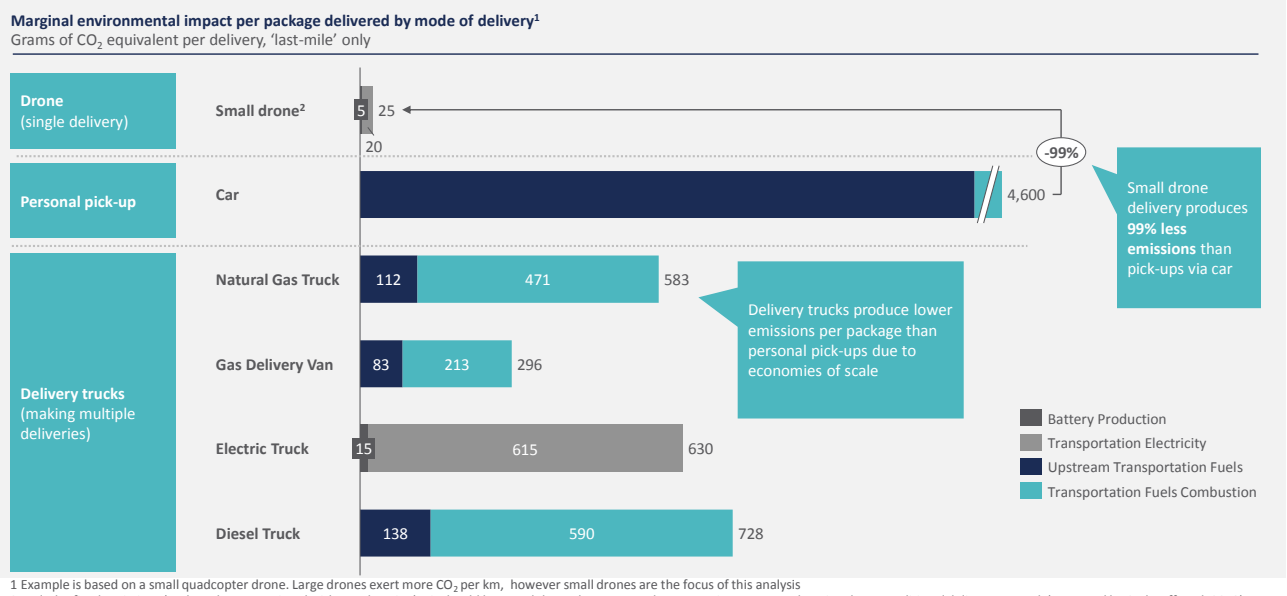
Drones are more environmentally friendly than today's transportation methods – which in Queensland, consist primarily of motor vehicle trips. A 2018 study (results shown in Exhibit 10) found that small drones cause the emission of 25 grams of greenhouse gas per last-mile delivery, versus 296-728 grams 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 are the worst polluters, emitting an average of 4,600 grams of greenhouse gas per trip.[38]

By using drones to fulfil 4-6% of its deliveries, Queensland could lower its greenhouse gas emissions by about 100,000 tonnes or the equivalent of carbon storage of almost 3.5 million trees in 2030.[39]

[36] IPCC (2018), *Global Warming of 1.5°C.*
[37] 2016 data, obtained from the Department of the Environment and Energy's National Greenhouse Gas Inventory.
[38] 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.
[39] Greenhouse gas to carbon storage using EPA equivalency calculator (2018). Available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator, Assumes 20-30 trees per acre.

EXHIBIT 10

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



1 Example is based on a small quadcopter drone. Large drones exert more CO_2 per km, however small drones are the focus of this analysis
2 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 130,000 motor vehicle accidents a year on Queensland roads.[40] Replacing 470 million vehicle-kilometres of road-based deliveries and pick-ups could result in 1,100 fewer accidents. The potential injuries, time, inconvenience and economic cost of vehicle accidents is significant and should not be neglected.

[40] Estimated based on data from ABS (2016) *Road Trauma Statistical Summary*. This estimate is higher than official statistics (e.g. Crash data from Queensland roads, Queensland Government Data 2016), which presents summaries of crashes that were reported to police.

5

APPENDIX – Detailed methodology

Constructing a scenario for the future role of drone delivery

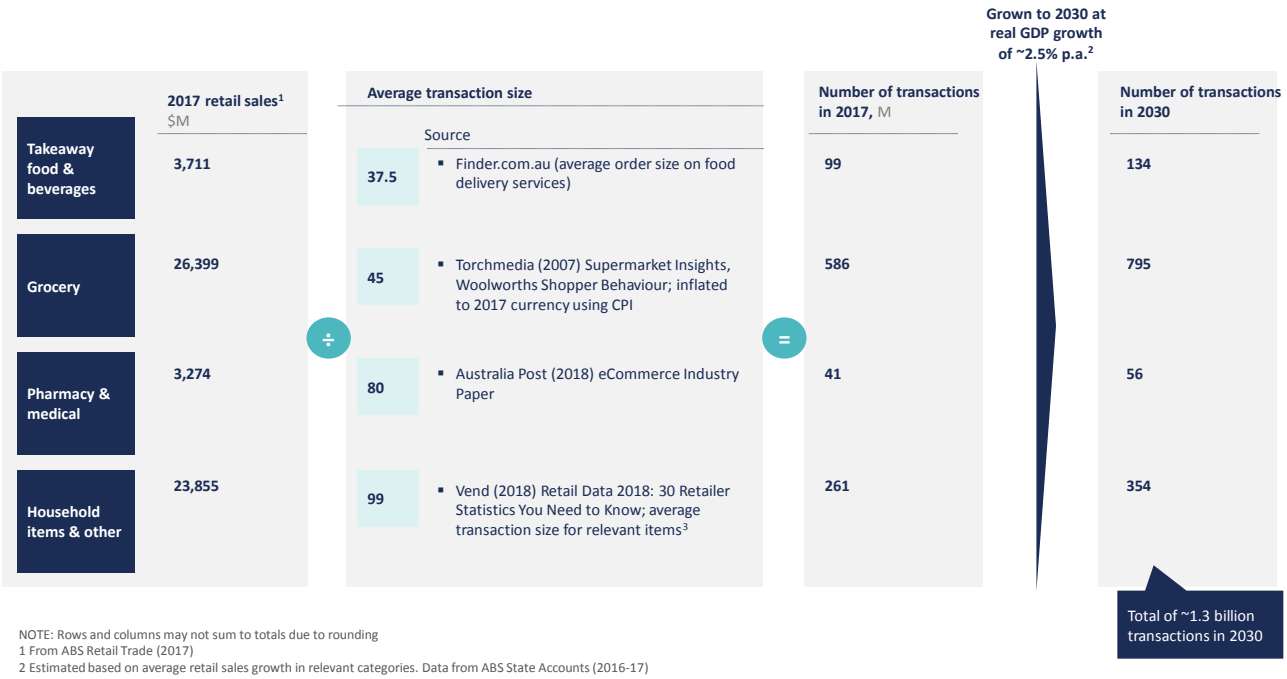
The first step in estimating the benefits of drone delivery is understanding the number and types of deliveries that might be undertaken by drones in 2030. This was done by sizing last-mile delivery in 2017, growing it to 2030, and dividing it up into transactions of different characteristics based on a range of assumptions and data inputs. These transactions were further broken into those which are delivered today (versus picked up by customers), how that might change by 2030. Assumptions were then made about the potential uptake of drones in 2030.

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 2030. For each retail category (see Exhibit 11), we began with total retail sales for Queensland from the Australian Bureau of Statistics. To obtain the number of transactions, the average order value for each retail category was applied. The number of transactions was then grown to 2030 volumes using a real GDP growth rate forecast.

EXHIBIT 11

Estimating the number of transactions in 2030



NOTE: Rows and columns may not sum to totals due to rounding
1 From ABS Retail Trade (2017)
2 Estimated based on average retail sales growth in relevant categories. Data from ABS State Accounts (2016-17)

The number of transactions was then divided across three axes:

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

The assumptions and inputs used to disaggregate the transactions are given in Exhibit 12.

EXHIBIT 12

Distance, time sensitivity and size assumptions for transactions

Distance assumptions

Distance from outlet, %	% of households
<1KM	9%
1-5KM	52%
5-10KM	31%
10+KM	7%

Time sensitivity assumptions

Time sensitivity by 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[1]	2%	20%	78%

Size distribution of transactions

			Notes
Takeaway food and beverages	Small (<2.5kg)	85%	▪ 2.5kg payload assumed to capture 80-90% 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)
	Medium (2.5-6kg) *(Top-up)*	30%	▪ Convenience stores included in this category, and have smaller purchase sizes, so share of small transactions increased slightly to 40%
	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)	44%	▪ 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)	43%	
	Large (>6kg)	13%	
	Total	**100%**	

1 Shares from McKinsey (2016) Parcel delivery – The future of last mile
SOURCE: ABS Retail Trade (2018), Torchmedia (2007) Supermarket Insights, interviews with 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 13.

EXHIBIT 13

Estimating the share of transactions that are delivered

	2017		2030	
Takeaway food and beverages	19%	Average Australian online takeaway delivery market shares from finder.com.au and Morgan Stanley, expressed as share of total takeaway sales in Australia	40-50%	Existing growth and market estimates of online takeaway and delivery (Morgan Stanley 2018)
Grocery	3%	Share of transactions that are delivered (from Woolworths 2018 Annual Report)	25-35%	Engagement is industry sector experts. Market estimate and historic growth (Bankwest 2018). Delivery market estimate using predicted growth (Nielson 2018, Woolworths 2018, Livewire 2018)
Pharmacy and medical	2%	Ratio of online to total pharmacy sales in Australia (both obtained from IBIS world)	20-30%	Current market and anticipated growth (ABS 2017, Pharmafile 2016). Estimated delivery and growth (Australia Post 2018)
Household items	8%	E-commerce as a share of total retail in Australia, obtained from Australia Post (2018) E-commerce Industry Paper	25-35%	Current market and historic growth (Australia Post 2018). Current online sales and expected growth (Australia Post 2018, UBS 2018)

The resulting dataset is a rich breakdown of transactions – for both today and 2030 – by weight, distance, time-sensitivity, and current mode (delivery versus pickup). That is, for each cell in the matrix in Exhibit 14, we know the number of transactions that are delivered versus picked up (and an educated guess of what this might be in 2030).

EXHIBIT 14

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		
		Instant delivery	Same day	Standard
<2.5kg	<1km			
	1-5km			
	5-10km			
	10km+			
>2.5kg	<1km			
	1-5km			
	5-10km			
	10km+			

For each cell, 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 are estimated both 2017 and for 2030 based on a range of data sources and assumptions

SOURCE: AlphaBeta analysis

Establishing a reasonable scenario for drone uptake

For each cell in Exhibit 14 it was necessary to form a view on the potential uptake of drone delivery by 2030. 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 assumed to be higher for takeaway given it was the primary use case for drone delivery trials held in the ACT in 2017-2018).

The result of these assumptions is provided in Exhibit 15. Note that the assumptions were made at a more detailed level and aggregated to this level for presentation.

EXHIBIT 15

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

Assumed share of transactions delivered by drone in 2030

%

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

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: AlphaBeta analysis

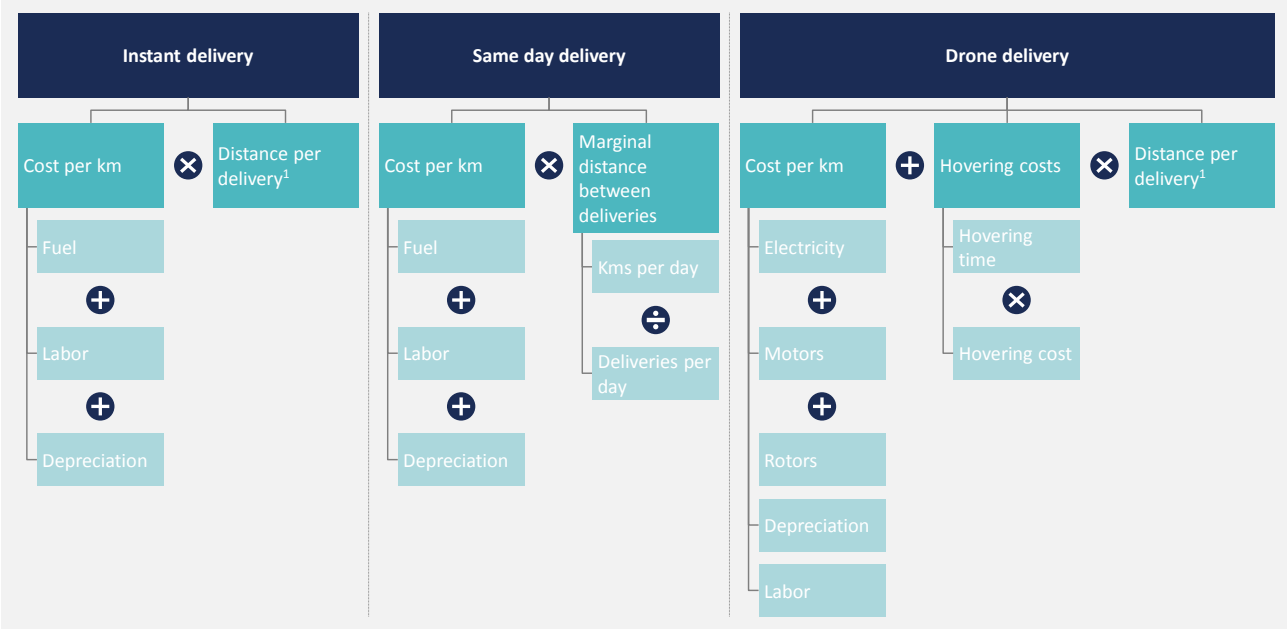
Estimating the change in delivery costs

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). AlphaBeta's cost saving estimates are consistent with other external views (see Exhibit 17).

EXHIBIT 16

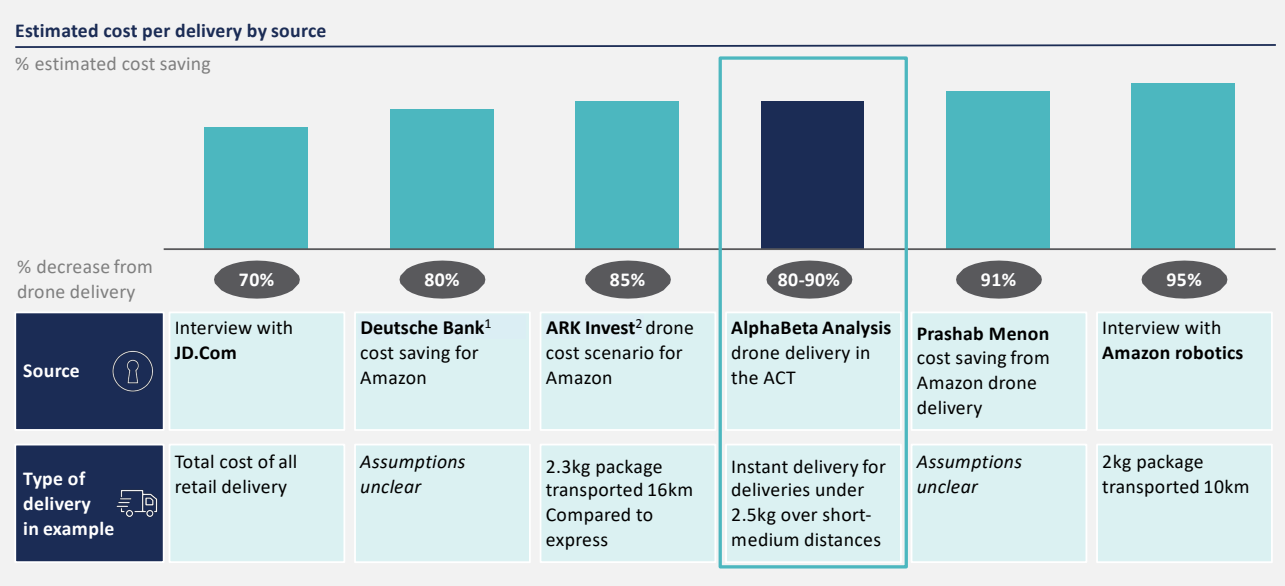
Estimating the cost of instant, same day and drone delivery



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

EXHIBIT 17

80-90% drone cost savings are consistent with existing views



NOTE: Cost saving estimates have been collected from desktop research. Assumptions are not always clear and vary by source of analysis.
1 Cost saving from a combination of delivery automation, drones and robots
2 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 Uber Eats, Zoom2u and Australia 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 1: Inputs and sources for calculating current delivery costs

Area	Metric	Source
Marginal cost of delivery	Fuel costs	▪ Australian petrol prices (2018) ▪ Carsales: Mercedes Sprinter and Toyota Corolla (2016)
	Labour costs	▪ Stats Monkey (2014)
	Labour (pick up) costs	▪ ABS (2018) Average hourly national wage
	Depreciation costs	▪ Carsales: Mercedes Sprinter and Toyota Corolla (2016) ▪ ATO (2018) Depreciation of vehicles
	Trip speed	▪ Industry expert interviews
Distance of marginal trip	Distance travelled per trip by vehicle	▪ Roy Morgan (2013) Australian motorists drive an average 15,530km per year ▪ Industry expert interviews
	Parcels delivered per day	▪ AlphaBeta analysis ▪ Industry expert interviews

Estimating the cost of drone delivery

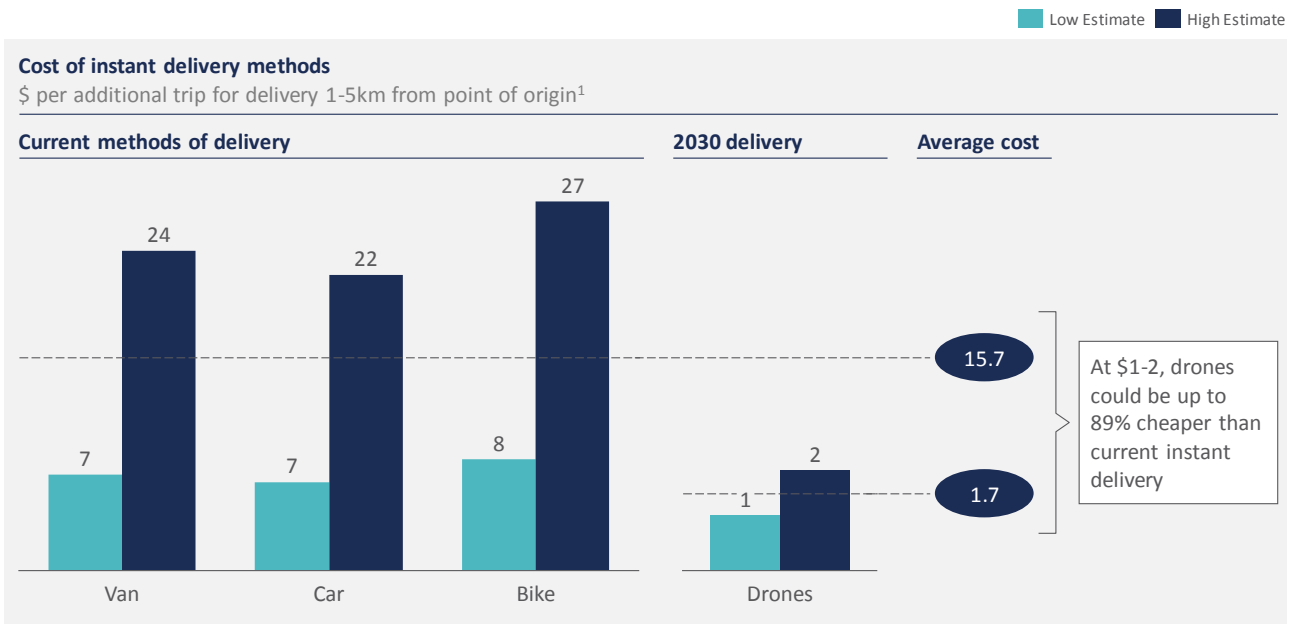
The novel nature of drone delivery has made it relatively difficult to determine potential costs. To solve for the dearth of available information, drone costs referenced in this report represent a bottom up approximation of the individual components of a drone. To ensure the potential of drones is realistic, 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 2: 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	▪ Indeed (2018). Average salary of commercial pilot
Operating trip assumptions	Hovering time	▪ Jenkins et.al (2017) Forecast of commercial UAS package delivery market ▪ Industry expert interviews
	Speed	
	Flight time	
	Trips per day	

EXHIBIT 18

At $1-2 per trip, drones could be 89% cheaper than current instant delivery

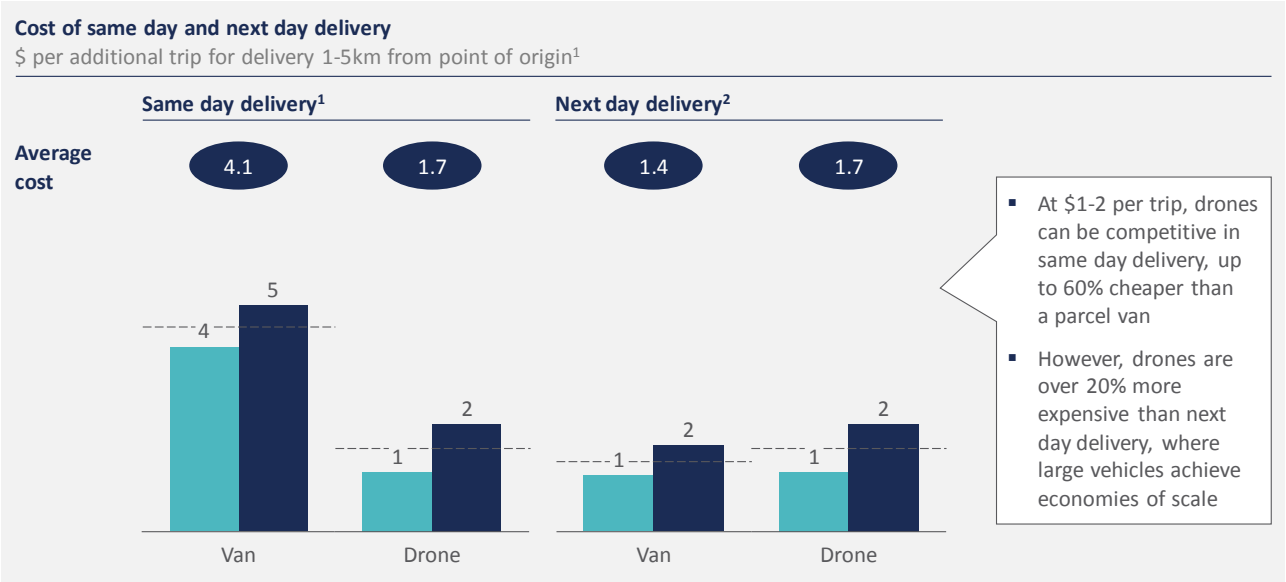


1 Assumes an instant delivery return trip of 3-10 km

SOURCE: AlphaBeta analysis

EXHIBIT 19

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



1 Assumes additional delivery distance on existing route is 0.9-1.1 km per delivery
2 Assumes additional delivery distance on existing route is 0.4-0.6 km per delivery

SOURCE: AlphaBeta analysis

Estimating benefits for local 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 20.

EXHIBIT 20

Calculating the reduction in last-mile delivery costs for Queensland businesses

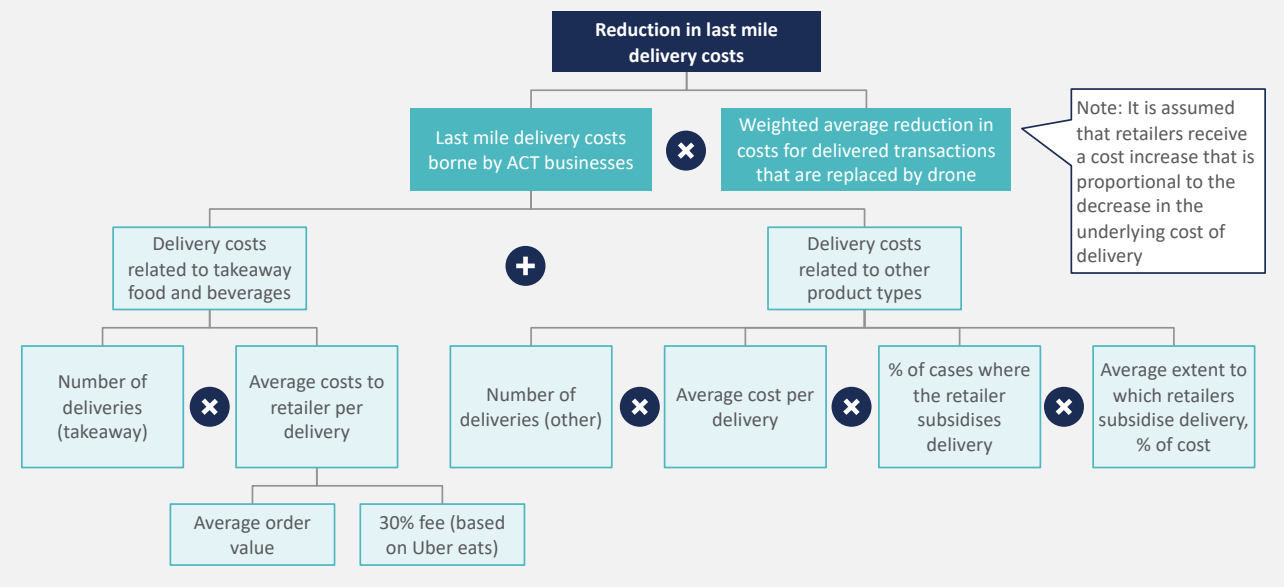


Table 3: Inputs and sources for calculating reduction in delivery costs

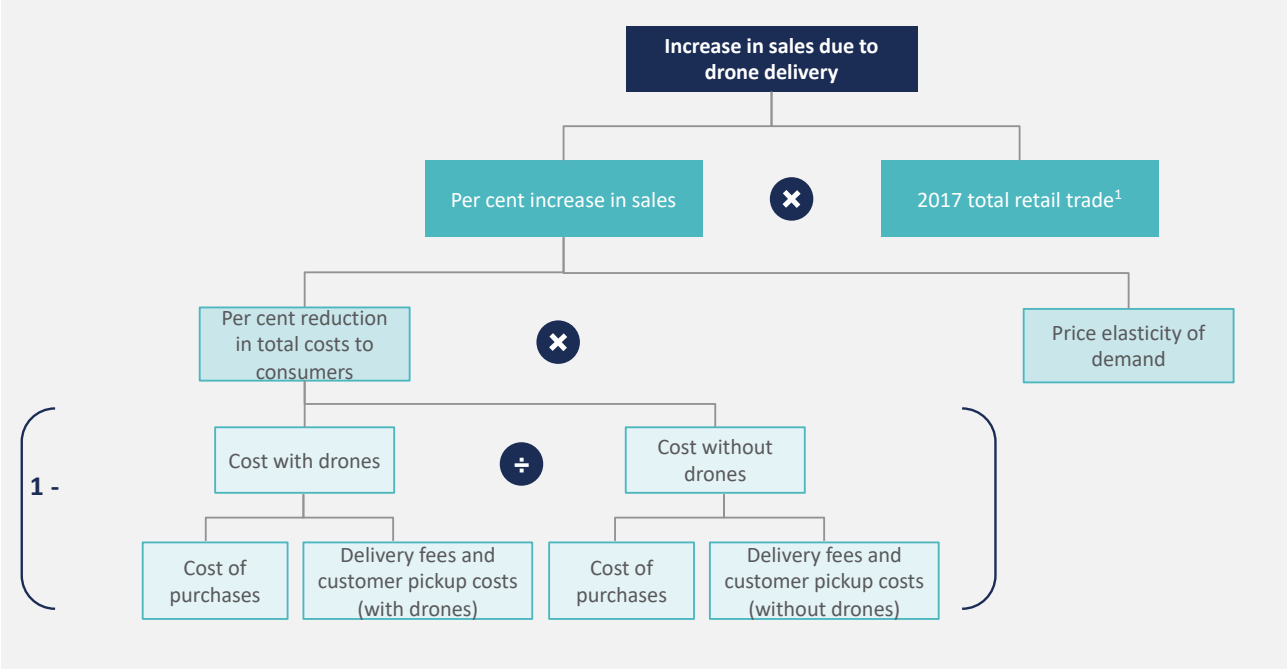
Area	Metric	Source
Weighted average reduction in costs for delivered transactions that are replaced by drone	Weighted average cost reduction (%)	▪ Estimated using the results obtained in earlier sections of this appendix (cost of drones, cost of current methods of delivery and current mix of transaction types
Last mile delivery costs borne by Queensland consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last mile sector in 2030)
	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 in Queensland that would otherwise not have occurred. This effect was estimated as in Exhibit 21.

EXHIBIT 21

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



1 Includes takeaway but excludes meals consumed at restaurants

Table 4: Inputs and sources for calculating the increase in sales

Area	Metric	Source
2017 total retail trade	Total retail trade in Queensland in 2017 ($M)	▪ ABS Retail Trade (2018)
Per cent increase in sales	Cost of purchases	▪ ABS Retail Trade (2018)
	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, this report investigated how an increase in delivery range could impact Queensland retailers and consumers.

To understand the retailer benefit, a sample of central restaurants in Brisbane were selected, and its current delivery range was observed using online food delivery websites. This analysis indicated that the average maximum distance of food delivery was approximately 5 km. Using ABS data, it was possible to estimate the number of households within the current delivery radius and the potential increase if the delivery radius was expanded to 10 km.

Table 5: Inputs and sources for calculating expansion of market reach

Area	Metric	Source
Households available in delivery range for central restaurant	Current range of restaurant delivery	▪ Delivery radius of Uber Eats and Deliveroo for a specific restaurant (2018)
	Number of current and potential households in range	▪ Census population in relevant SA3 locations, ABS Census (2016)

Estimating benefits for consumers

Reducing delivery fees

The potential reduction in delivery fees to consumers was estimated using the approach shown in Exhibit 22.

EXHIBIT 22

Calculating the reduction in last mile delivery fees for consumers

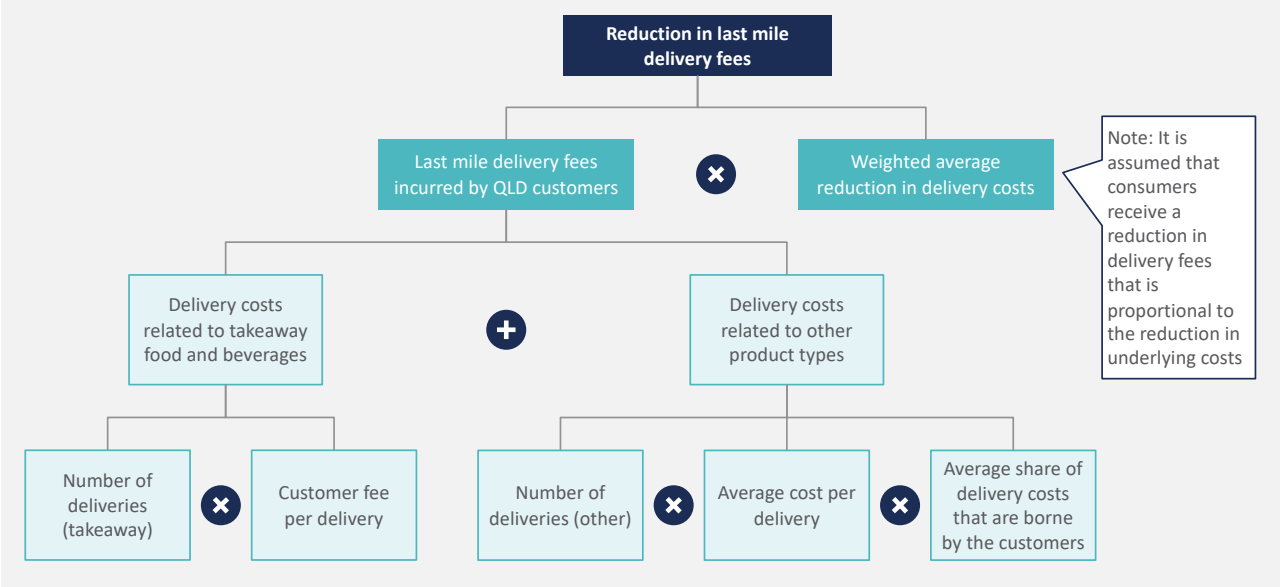


Table 6: Inputs and sources for calculating consumer delivery fee savings

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 Queensland consumers	Number of deliveries (takeaway)	▪ Obtained from earlier analysis (sizing the last mile sector in 2030)
	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

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 7: Inputs and sources for calculating delivery times

Area	Metric	Source
Current vehicle speeds	Average speed of instant delivery	▪ Industry expert interview ▪ AlphaBeta analysis
	Average speed of same day delivery	▪ Australia Post, Zoom2u, Coles, Local flower delivery (2018) ▪ Industry expert interview
Drone delivery speeds	Average speed of trip by delivery distance	▪ Industry expert interview ▪ AlphaBeta analysis

Estimating the reduction in delivery times for consumers

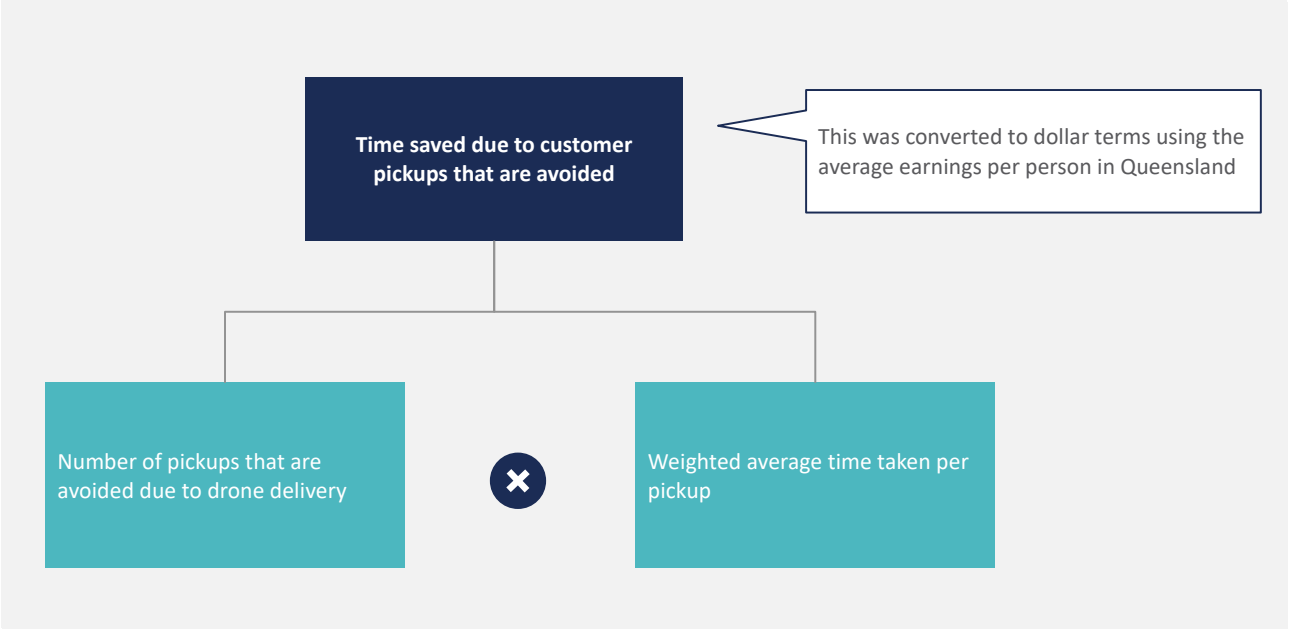
The reduction in delivery times was calculated as the weighted average difference in delivery times between drones and current delivery modes for relevant transaction types (see above for sources). For example, for instant deliveries (which are currently delivered using ground transportation, e.g. by Uber Eats), the weighted average delivery time reduction is 60-70%.

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 23.

EXHIBIT 23

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



Expanding product variety

See earlier section on “Expanding market reach”. A similar method was used to estimate the potential range expansion benefits to consumers. This involved selecting a test delivery destination and observing the furthest restaurants available for delivery. Brisbane was selected as the test location due to it currently being well serviced by food delivery. The maximum average delivery distance was also 5 km. Using online food delivery websites, it was possible to map restaurants that offer delivery in Brisbane and observe the number within 5 km and 10 km of a sample of addresses. The difference indicated the potential expansion in food delivery choice available to consumers.

Table 8: Inputs and sources for calculating expansion in product delivery

Area	Metric	Source
Restaurants available for a consumer	Current range of restaurant delivery	▪ Delivery radius of Uber Eats and Deliveroo for a sample of specific addresses in Brisbane (2018)
	Number of current and potential restaurants in range	▪ Delivery radius of Uber Eats and Deliveroo from a sample of randomly chosen specific restaurants (2018)

Estimating benefits for society

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 to Queensland that can be observed and described.

Emissions reduction from drone delivery

The potential emissions reduction from drone delivery is the difference between the emissions avoided by reducing the number of motor vehicles on the road and the additional emissions produced by drones. Emissions avoided was estimated by calculating 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. The average emissions per trip for drone delivery versus other methods were modelled by Stolaroff et al. (2018).

Accidents avoided from drone delivery

The potential number of accidents avoided by drone delivery as a result of 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.

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	▪ Department of Environment and Energy
	Total distance travelled by motor vehicles by vehicle type	▪ ABS Survey of Motor Vehicle Use (2016)
	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	▪ Estimated based on national road crash data
	Total distance travelled by vehicle type	▪ ABS Survey of Motor Vehicle Use (2016)
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)	▪ AlphaBeta analysis ▪ Industry expert interviews
	Average distance travelled per trip by consumer and vehicle type	▪ AlphaBeta analysis ▪ Google maps (2018) ▪ Refer to cost of delivery analysis in this appendix
	Average number of trips replaced by drone delivery by consumer type	▪ ABS Retail Trade (2017)
	Compound annual growth rate of motor vehicle kilometres travelled	▪ ABS Survey of Motor Vehicle Use (2010-2016)

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