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Bridging the final metres: public feedback on a last mile driverless delivery service

A GATEway CAV trial

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1 Executive summary

Introduction

CargoPod, a driverless urban delivery vehicle, was created by the GATEway (Greenwich Automated Transport Environment) project to provide the UK's first demonstration of a driverless last mile delivery service in an urban area. GATEway is an £8m research project, led by TRL and jointly funded by government and industry, to understand and overcome the technical, legal and societal challenges of implementing automated vehicles in an urban environment. Consumers, businesses and local communities can expect driverless urban delivery services to:

- Deliver more goods over longer hours each day with reduced costs as part of more efficient logistics models
- Improve local communities by using vehicles that are smaller, safer, less polluting and less congesting

CargoPod was designed specifically to provide a driverless grocery delivery trial in conjunction with Ocado, a British online grocery retailer. A trial delivery route was established in the Royal Borough of Greenwich, London in an area with a high concentration of residential properties. CargoPod was provided with an autonomous control system that enabled it to operate without human intervention along the route.

Approach

A sample of 108 local residents signed up to receive a driverless grocery delivery over the two-week trial period. The process of booking a delivery closely resembled the process followed by Ocado customers for the standard service. When a participant was due to receive a delivery, they received text notification that CargoPod had arrived and were then encouraged to leave their home and interact with CargoPod at the kerbside to provide the most realistic experience of a driverless delivery service. This included opening CargoPod, retrieving their goods and carrying them back home: in essence, bridging the final few metres of the delivery process. After receiving their delivery, participants were invited to complete an online questionnaire about their experience.

Findings

Overall, participants responded positively to the driverless delivery experience. Satisfaction ratings with each aspect of the driverless delivery process exceeded 80%. This suggests that the public may be receptive to bridging those final metres between the kerbside and their door. This initial willingness to accept driverless deliveries – and the role that the recipient has to play in enabling the service – might have been motivated by some of the expected consumer and community benefits. For example, the majority of participants agreed that driverless deliveries offered a secure service that could make it easier to arrange deliveries over a broader range of times and days. At the same time, participants agreed that the

vehicles and technology used offered the potential to reduce noise and air pollution locally, as well as generally being more efficient than human-driven delivery services. Such benefits were also expected to be cost-neutral to the consumer – or even offered for a slight discount over a standard delivery charge.

Based on their experience of CargoPod, 77% of participants wanted between half and all of their future home deliveries to be sent by driverless vehicles. This was probably because 96% of the sample reported that their overall experience of using CargoPod was positive and 89% would be likely to use driverless delivery services in the future. This consumer enthusiasm for driverless delivery services could further support the business case for the future implementation of autonomous vehicle technology in the logistics industry.

2 Introduction

Connected and autonomous vehicles (CAV) have the potential to revolutionise transportation, especially in urban areas. One particular application for driverless systems is the transportation of goods. To prove and explore the concept, the GATEway project has developed CargoPod, a driverless urban delivery vehicle, to provide the UK's first demonstration of a driverless last mile delivery service in an urban area.

2.1 Anticipated benefits of last mile driverless deliveries

Using CAV to provide urban delivery services is expected to provide several benefits for consumers, businesses and local communities. Specifically:

- Improvements in air quality and reductions in noise by using low carbon delivery vehicles (most CAV systems are based on quiet, electric-drive, zero emission platforms)
- Reductions in urban congestion (driverless delivery platforms have the potential to be smaller and more space efficient than the types of vehicles commonly used to deliver goods at present, and also capable of operating in a more efficient traffic network)
- Improved options for home and business delivery services (driverless vehicles have potential to operate over a longer period without the constraints of a human operator and can also adopt unique delivery models, such as providing local temporary 'locker' style collection points)
- Driverless delivery systems are anticipated to be safer and potentially offer quicker deliveries over a wider range of times than human driven vehicles when supported by appropriate connected infrastructure

Given these expected benefits, logistics companies and local authorities are both keen to deploy CAV systems to provide urban delivery services. Driverless deliveries are also expected to gain traction in the market sooner than driverless passenger services because they are affected by fewer of the risks and issues associated with the carriage of passengers. However, public perception of driverless delivery services is largely untested. Moreover, most recipients expect deliveries to make it directly to their doors; driverless deliveries will initially fail to do this and are likely to require the customer to bridge the final metres between the kerbside and the property. The purpose of the GATEway driverless delivery trial was therefore to explore public perception and experience of driverless deliveries to inform future deployments of such services.

2.2 About CargoPod

The GATEway consortium commissioned Oxbotica to create a bespoke driverless delivery vehicle for this trial. Based on an existing Garia Utility City¹ vehicle, Oxbotica converted the full electric drive-by-wire drivetrain to interface with its autonomous control system (ACS), Selenium.

To create a viable use case for the vehicle, the GATEway team partnered with Ocado, an online grocer in the UK. Together with Ocado, a design for the load bay of the vehicle was created so that it could house multiple grocery delivery totes behind eight individually numbered cargo doors (Figure 1).



Figure 1. CargoPod with numbered cargo doors

Each Ocado tote can hold up to four shopping bags, providing a total CargoPod capacity of 32 bags – enough for more than a dozen small shops or around half a dozen larger shops.

¹ <http://www.gariautility.com/models/utility-city/>

2.2.1 *The autonomous control system (ACS)*

Oxbotica equipped CargoPod with Selenium, an autonomous control system (ACS). Selenium uses a combination of LIDAR and camera units to provide driverless vehicle control. Oxbotica integrated Selenium with the CargoPod base vehicle platform so that the ACS could command the electric drive-by-wire drivetrain directly. Conventional vehicle controls (steering wheel, brake and accelerator) were retained to ensure that a safety driver could take control of CargoPod in any hazardous situations that were not within the capabilities of Selenium. The safety driver was an important hazard mitigation in the deployment of CargoPod in a public environment. Any input from the safety driver via the steering wheel, brake or accelerator immediately revoked control from the ACS and handed it to the safety driver. The safety driver was seated behind the controls during all operation and had good visibility around the vehicle, as required by the safety case that was developed by TRL for the trial.

2.3 **About the use case**

Ocado is a British online supermarket. It has no customer-facing stores; all purchases are made online and then delivered direct from its warehouses to customers by van. Ocado is proud of its customer service record and its delivery agents are the primary human interface between the retailer and its customers. As part of its ongoing innovation programme, Ocado is exploring driverless technology as a means of expanding its capability. Ocado was therefore delighted to partner with the GATEway project to deliver the CargoPod service as a proof of concept for last mile urban grocery deliveries.

2.4 **About GATEway**

GATEway (Greenwich Automated Transport Environment) is an £8m research project, led by TRL and jointly funded by government and industry, to understand and overcome the technical, legal and societal challenges of implementing automated vehicles in an urban environment.

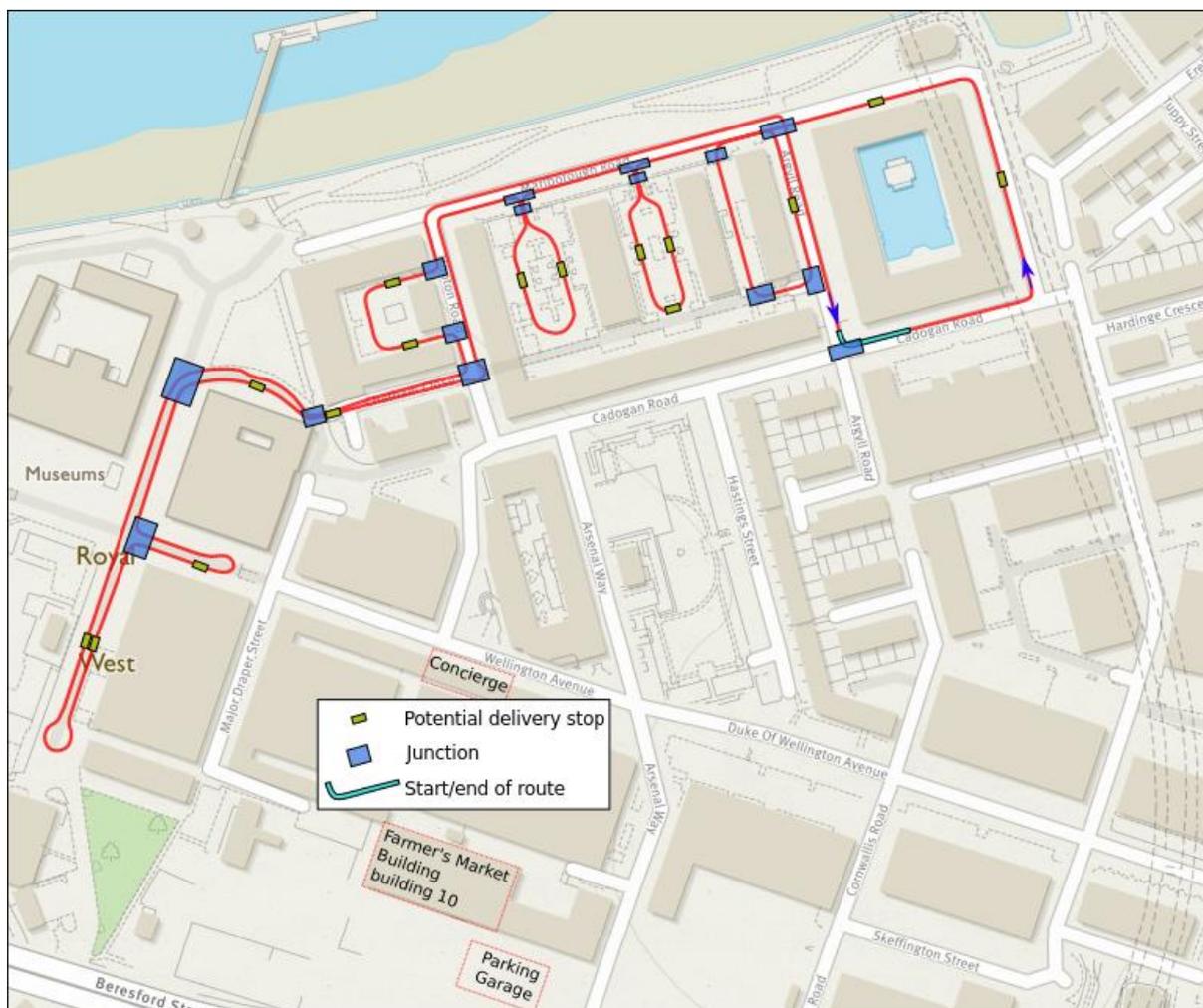
Taking place in the Smart Mobility Living Lab: London, within the Royal Borough of Greenwich, the project tests different use cases for automated vehicles, including driverless pods for first and last mile public transport and automated last mile urban deliveries.

Results will help both industry and policymakers understand the implications of driverless vehicles and deliver a safe and validated test environment in the UK, driving job creation and investment in a rapidly emerging technology area.

3 Approach

3.1 Driverless delivery route

The CargoPod trial was located at the Royal Arsenal Riverside, a Berkeley Homes development within the Royal Borough of Greenwich². A delivery route (Figure 2) was agreed with Berkeley Homes that ensured CargoPod could access a high proportion of houses and apartments within the residential complex. The route was circular and comprised both pedestrianised sections and private roads (gated and accessed by light residential traffic primarily). Berkeley Homes provided open access to CargoPod to the apartment complex car parks and courtyards so that delivery stops could be programmed as close as possible to building entrances to minimise walking distance for customers. Fifteen potential delivery stops were created (i.e. CargoPod could be programmed to stop if there was a demand for a delivery at that location, otherwise the stop would be bypassed).



² <https://www.berkeleygroup.co.uk/new-homes/london/woolwich/royal-arsenal-riverside>

Figure 2. CargoPod delivery route at the Royal Arsenal Riverside

CargoPod was loaded for each series of deliveries at a makeshift ‘depot’ created at an on-site warehouse located at the Farmer’s Market (Figure 2). Ocado sent a larger conventional delivery van to this location to serve as a refrigerated storage unit for groceries prior to local delivery to customers. This process mimicked a typical ‘hub and spoke’ delivery network where longer distances outside urban areas might be covered by conventional vehicles and then more efficient, zero emission electric (and in this trial, driverless) vehicles cover the last mile of the delivery process.

CargoPod was then manually driven to the start of the route before being run autonomously along the delivery route. CargoPod would be pre-loaded with the scheduled delivery stops and would only stop at those locations where a delivery had to be made. On completion of the route, it was driven manually back to the temporary depot for reloading (it was also stored and charged at that location for the duration of the trial).

CargoPod was programmed to complete its entire delivery route without human intervention as far as was reasonably practicable. A human safety driver was always seated behind the wheel to take control if required, with the Ocado customer services agent in the passenger seat. The safety driver would only take control if the ACS did not respond appropriately to any developing hazards along the route. CargoPod was even programmed to manage the 15 junctions along the route without intervention. At these points, the vehicle would pause momentarily to enable the sensors to make a lateral check for traffic in both directions; if the exit was clear, CargoPod would ‘creep’ out of the junction.

All trials were conducted at 5mph which was the site speed limit.

3.2 Driverless delivery process

The driverless delivery process was automated as far as possible and enabled participants to have direct interaction with CargoPod. Participants selected their preferred grocery delivery online (choosing from three delivery bundles offered for the trial). Each day, the CargoPod delivery schedule would receive an upload from the Ocado booking platform to provide the delivery orders and locations. This would be used to create a delivery booking sheet for the Ocado customer service agent who travelled with CargoPod.

The delivery process had the following steps:

1. Upon leaving the local delivery depot, the Ocado agent would typically text the customers that were scheduled to receive a delivery on the next run to provide them with an estimated time for the delivery and the proposed CargoPod location.
2. CargoPod would drive to the scheduled delivery location and wait for the customer to leave their home and come to find the vehicle.
3. On arrival at the vehicle, the Ocado agent would introduce themselves and CargoPod and provide verbal instructions on how to retrieve the delivery.
4. Participating customers would then be invited to open the illuminated CargoPod locker that contained their delivery by pressing a button on the side of CargoPod.

5. The locker would open and the customer would withdraw the tote from CargoPod to access their grocery delivery.
6. After removing their delivery, the customer would be asked to place the tote back into the CargoPod locker and close the locker door.
7. The customer was reminded by the Ocado agent to complete the delivery survey, the details of which were included in the grocery bag.
8. The customer would carry the delivery back to their home.

If customers had difficulties with any of the steps in the process, the Ocado agent was on hand to provide support.

3.3 Participants

3.3.1 Recruitment

The trial was advertised to all residents in the Royal Arsenal Riverside³ who were eligible to take part (i.e. lived in buildings that were along the delivery route). Participants self-selected by responding online in response to direct advertising of the trial (leaflets were distributed to all residences that qualified for the trial because of their proximity to the route and the selected delivery locations).

3.3.2 Sample

Of the 108 driverless deliveries to customers during the demonstration, 43 recipients⁴ completed the online questionnaire to provide feedback on their experience (22 males, 20 females, 1 declined to state gender). Participants had a mean age of 36 years (range 22-58 years; n=41). The sample comprised of 84% white, 7% Asian/Asian British, 5% mixed or multiple ethnic groups and 2% black/black British (n=42), which closely matches the ethnic diversity reported in the UK 2011 Census (87%, 7%, 2% and 3%, respectively).

The sample was highly educated: 79% of respondents (n=42) were educated to degree-level or higher, which compares to 27% of the population in England according to the UK census (2011). All (n=42) were employed. The sample was also comparatively wealthy, with 95% (n=40) declaring a household income over £35,000, which is equivalent to the median household income for the UK (£35,204; ONS, 2017). Three disabilities were reported by three different participants (sight loss, mobility impairment and a learning disability).

In summary, the sample was broadly representative of the population in terms of age and ethnicity but was otherwise relatively young, well-educated and wealthy.

³ The Royal Arsenal Riverside is a residential development within the Royal Borough of Greenwich. It was selected for this trial as it has a high concentration of residents in a compact area with access to a combination of private roads and pedestrianised areas that presented the perfect trial route environment for CargoPod.

⁴ Some participants did not respond to all the questions; where sample sizes are lower than 43, this is stated

3.4 Questionnaires

Participants who received a driverless grocery delivery were encouraged to complete an online questionnaire to provide us with feedback on their experiences. The questionnaire invited recipients to rate their satisfaction with the CargoPod delivery experience, explored their opinions on the expected benefits and challenges of driverless deliveries in urban areas and collected key demographic data. The survey could be completed in less than 10 minutes and most answers were on a five or seven point scale of agreement or satisfaction.

4 Findings

Recipients were invited to rate their satisfaction with the different stages of the driverless delivery process (Figure 3). This typically began with a text message notification from the Ocado customer services agent to notify the recipient that the delivery was imminent. Almost all recipients (93%) were satisfied with this element. The next step in the process was for the customer to leave their house or apartment and try to find CargoPod at the nearest agreed delivery points. Again, most recipients (82%) were satisfied that the delivery vehicle was easy to find. Upon locating the vehicle, trial customers were encouraged to interact directly with the vehicle to get the most representative ‘driverless’ experience. The customer services agent was on hand to assist if required (Figure 4). Overall, customers were satisfied by their direct interaction with CargoPod, with high satisfaction ratings for opening CargoPod’s load bay (85%), retrieving their goods (87%) and closing CargoPod afterwards (84%).

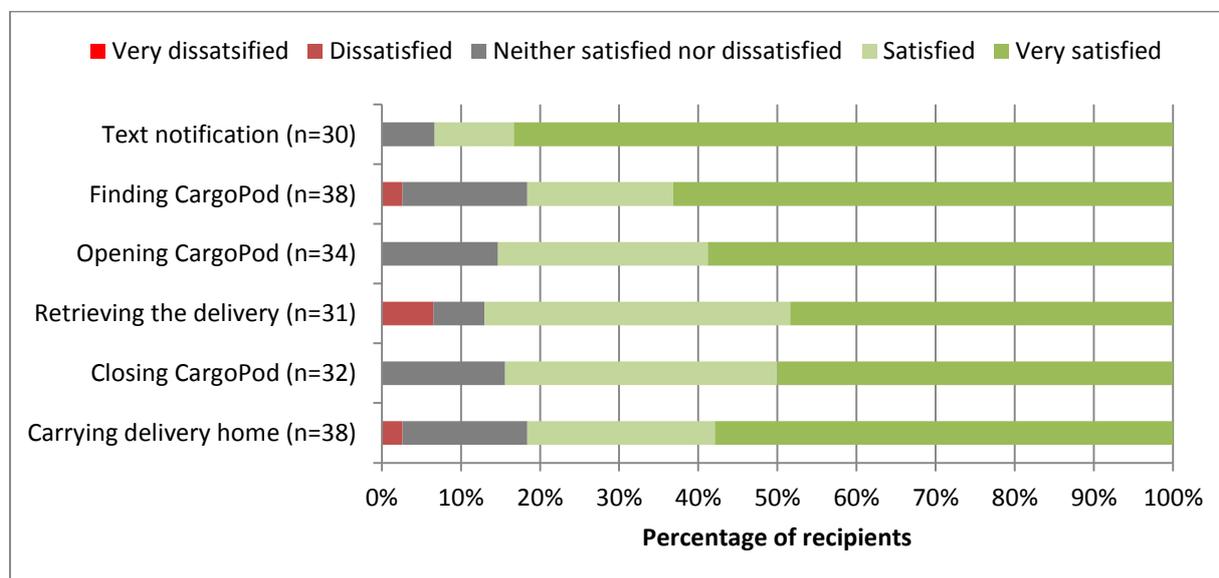


Figure 3. Satisfaction with the CargoPod delivery process⁵

⁵ Not all participants answered all questions about the process, hence the different sample sizes. It is not known why answers were not provided for all questions but it may be because the agent assisted with some aspects of the delivery process.



Figure 4. Retrieving the delivery from CargoPod

The final step – and perhaps the greatest potential barrier to driverless delivery services – was for the customer to carry the delivery back home (Figure 5). However, 82% of recipients were satisfied with bridging those final metres between the kerbside and their home.



Figure 5. Carrying the delivery home

As a consumer proposition, driverless delivery services would ideally provide additional benefits when compared with regularly delivery services. Figure 6 shows that recipients certainly tended to agree that driverless services would enable deliveries over a broader range of times and days (86% thought so) and would make arranging a home delivery easier (according to 70%). The majority (88%) were satisfied that driverless delivery services would be secure. About two-thirds expected that a driverless delivery service would be more practical and cheaper than a conventional delivery service. However, most recipients were still to be convinced that driverless deliveries would be faster. It was also clear to recipients that driverless delivery services would not suit people with disabilities, with 58% disagreeing that a similar delivery service to the CargoPod demonstration would be accessible.

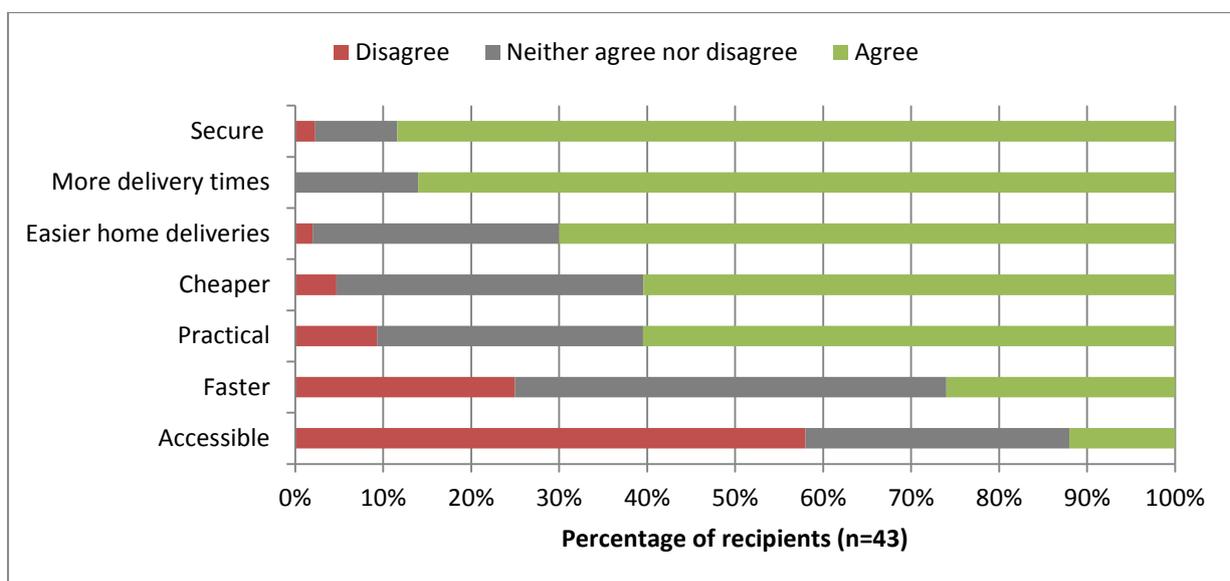


Figure 6. Level of agreement about expected service benefits

The popularity and acceptance of driverless delivery vehicles will partly depend on convincing the public that they can provide community-wide benefits when compared with conventional delivery services (Figure 7). Using the CargoPod delivery experience as an example, more than three-quarters of recipients (77%) were already in agreement that driverless delivery services will contribute to reductions in noise and air pollution locally, as well as generally being more efficient (72%). Perhaps more development is required to demonstrate that driverless vehicles could reduce congestion in urban areas (less than half of recipients (48%) agreed this was a potential benefit) and the majority (51%) were undecided as to whether such vehicles will be a safer option.

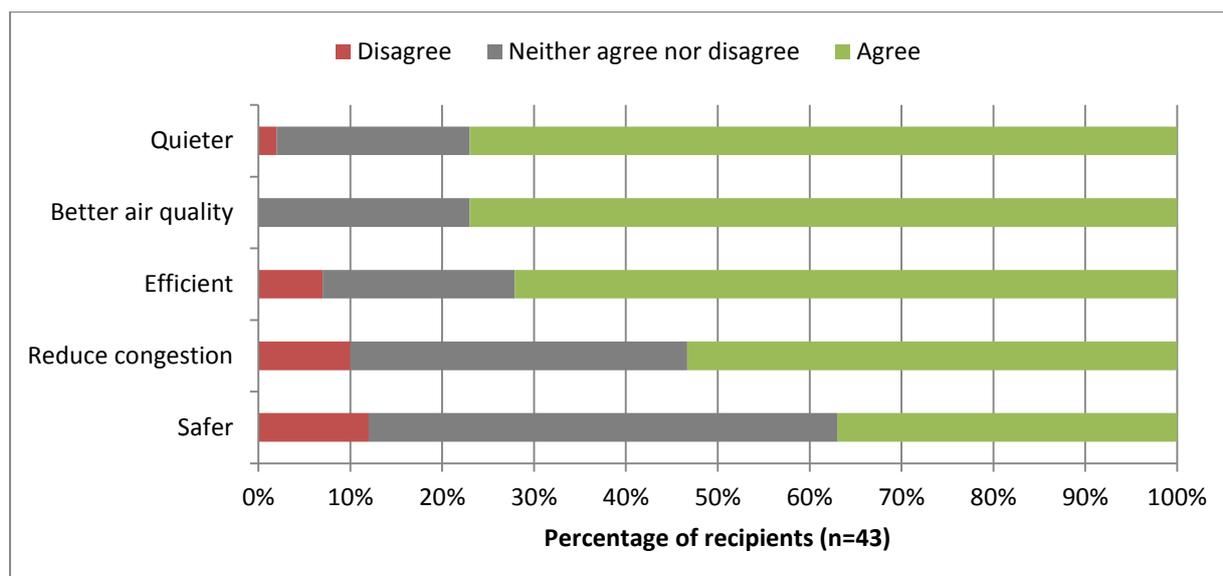


Figure 7. Level of agreement about expected community benefits

To support the business case for driverless delivery services, recipients were asked to state how much more or less they would expect to pay for a driverless grocery delivery (like the one they experienced during the trial) when compared with a standard grocery delivery service with a human driver (Figure 8). They were asked to specify the premium for two different driverless delivery options:

- 1) without a customer services agent
- 2) with a customer services agent.

Without a customer services agent, most recipients (81%) would not pay a premium: 35% would expect it to be cost-neutral and 46% would expect a discount of up to £3 on their grocery order. With a customer services agent (which was the type of service demonstrated with CargoPod), the majority (56%) would expect a driverless delivery service to cost the same as a regular delivery. About a third (36%) would pay £1-£3 more for a driverless delivery with an agent (with £2 being the most common premium offered). Few (7%) would expect a discount with this option.

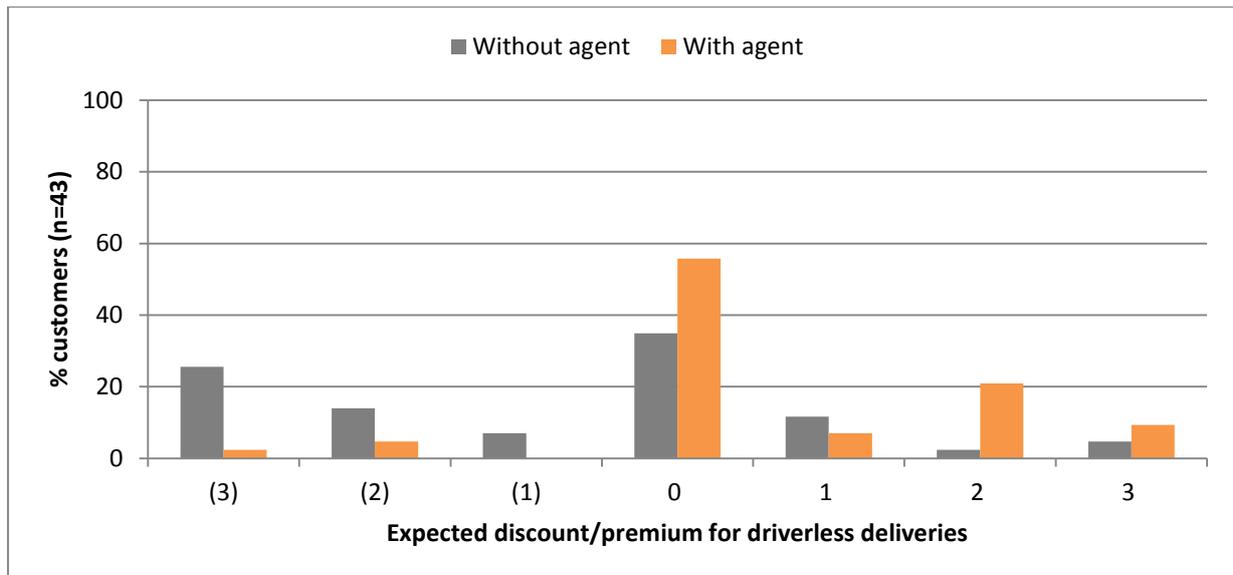


Figure 8. Expected discount/premium for a driverless grocery delivery when compared with a standard human driven service

Based on their experience of receiving a driverless grocery delivery from CargoPod, recipients were asked to consider what proportion of all future home deliveries they would prefer to be delivered by a driverless vehicle (Figure 9). Overall, 77% of participants wanted between half and all of their future home deliveries to be sent by driverless vehicles. This was probably because 96% of the sample reported that their overall experience of using CargoPod was positive and 89% would be likely to use driverless delivery services in the future.

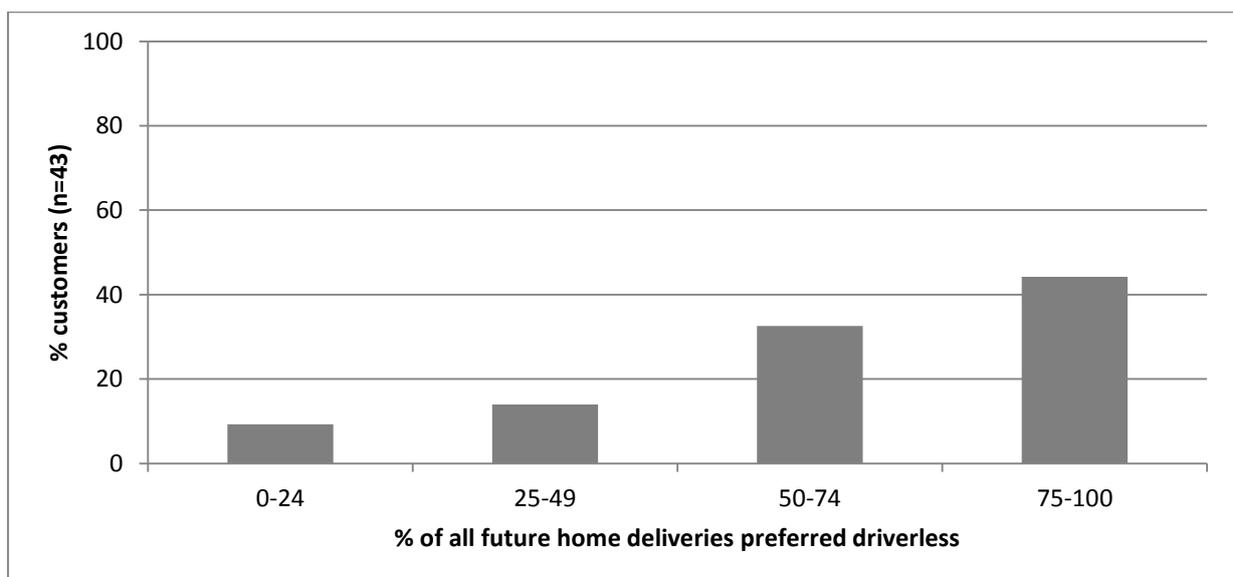


Figure 9. Percentage of all future home deliveries that customers would like to be delivered by driverless vehicles

5 Discussion

CargoPod provided a sample of the public with a unique opportunity to trial last mile driverless delivery. For trial participants, it was a familiar product (groceries) and a familiar retailer (Ocado) with the only change being the mode of delivery (driverless). For the first time in the UK, it was therefore possible to explore how real consumers respond to the variations in service that are associated with using a driverless delivery vehicle rather than a regular human-driven delivery vehicle.

Overall, participants responded positively to the driverless delivery experience. Some of the key differences attributed to a driverless delivery service included being notified that the vehicle had arrived, finding where the vehicle was located and then walking to the vehicle, collecting the delivery and returning home. Satisfaction ratings were high across all aspects, with more than 80% of all participants being satisfied with these differences. This suggests that the public may be receptive to bridging those final metres between the kerbside and their door to enable driverless home deliveries to become an acceptable – and possibly cheaper – consumer offering in the near future.

The sample of consumers in this trial were also keen to realise the anticipated benefits of driverless delivery services, such as more delivery slots and longer operating hours for – potentially – a lower delivery fee. Whilst driverless delivery services might not suit every type of consumer (for example, people with disabilities might find the service less accessible), they may offer greater consumer choice for those who are willing to accept the compromises.

Part of the attraction of driverless deliveries are the potential community benefits from using low or zero emissions vehicles that are smaller and have less impact on urban environments. Participants were generally in agreement that driverless delivery vehicles would improve communities by reducing congestion and noise and air pollution. These potential benefits can be used to promote the acceptance of driverless delivery services, especially if autonomous control systems can demonstrate that they are safer than human driven vehicles.

For retailers and logistics companies, driverless delivery services could present new commercial opportunities; in this trial, Ocado was exploring how autonomous technology could enable express deliveries of smaller grocery loads over longer operating periods. As an online retailer, Ocado relies on its customer service agents to provide a personalised service as the primary point of human interaction with customers. Ocado saw that driverless technology could enable its delivery agents to do more activities whilst on the move, such as calling customers in advance of arrival and, when at a delivery location, allow agents to focus on taking goods from the vehicle to the customer(s) without necessarily needing to move and park multiple times in a single area. Of course, in other delivery scenarios, driverless systems could save on labour costs and limitations associated with human driven delivery vehicles. It is likely that customers will expect a modest saving if accepting a driverless delivery – or the other associated community and service benefits would need to be realised to support uptake.

6 Conclusions

Driverless delivery vehicles have the potential to offer a clean, efficient and low-impact platform for transporting goods in urban areas for the last few miles. This CargoPod trial has now provided new evidence to suggest that consumers are also willing to bridge the final few metres by interacting with a driverless delivery vehicle at the kerbside and carrying their delivered goods home. This demonstration of driverless delivery technology and consumer appetite for driverless delivery services collectively shows that there is commercial opportunity for such operations in the near future. This is expected to bring safety and environmental benefits to urban communities as driverless delivery vehicles like CargoPod can be introduced to cover the urban segments in a hub and spoke delivery model.

Bridging the final metres: public feedback on a last mile driverless delivery service



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