Impact of Autonomous Vehicles for Freight in Urban Areas

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1. Executive Summary

Cross River Partnership (CRP) commissioned TRL to undertake a study to analyse the impact that autonomous vehicles (AVs) for deliveries and servicing will have on wider transport and public space in central London. The study was requested by the Central London Sub-Regional Transport Partnership (CLSRTP), a collective of transport specialists from eight central London boroughs convened by CRP on behalf of Transport for London (TfL). This report outlines the physical, technical and governance based interventions central London boroughs should consider in the lead up to AV freight. AV freight vehicles have the capacity to perform all driving functions without the need for human supervision. The primary benefits of deploying AVs for deliveries and servicing are identified as increased efficiency of logistics operations, reduced road congestion, reduced emissions and improved road safety. Barriers are identified as the lack of existing policy, the cost of investing in the technology and contested space in central London.

2. Methodology

The aim of this project is to uncover the current and potential barriers and enablers for AV freight. This was achieved through desk-based investigation in to relevant literature and information on current AV trials. The literature review is supported by 28 in depth stakeholder interviews with academics, fleet managers, vehicle manufacturers, local authorities, government officials, business improvement district figures and insurers. These groups were identified as suitable as they are at the forefront of AV freight development and can offer the greatest insight in to current market forces.

Interviews took a structured form and varied between stakeholder types to ensure relevant topics were covered based on each group's expertise. Structured interviews enable accurate comparison between different interviewees' responses. The uniformity of questions in a structured interview minimises the possibility of multiple interpretations of questions by interviewees and improves the quality of the data. Interviews were conducted over telephone in all cases, as this is the most time efficient means of conducting the research. All interviews were recorded and transcribed.

Analysis of data was undertaken by means of thematic analysis. The dominant codes identified at this stage were aligned with themes from the literature review and further sub themes became apparent with closer analysis. Codes were weighted by frequency and divided between stakeholder groups. Reoccurring codes were highlighted as the prominent enablers and barriers to AV implementation.

3. Background of Autonomous Vehicles in an Urban Context

3.1. Technology

Ahead of the deployment of fully autonomous vehicles, we will see vehicles with varying degrees of autonomous functionality operating on public roads. The levels of automation can be split in to five categories, as displayed in Table 1.

Table 1: Categorisation of the five levels of automation (SAE, 2017)

	1 Assisted driving	2 Partial automation	3 Conditional automation	4 High automation	5 Full automation
Driver role	Longitudinal and lateral control	Constantly monitoring the driving environment. Ready to take back control at any time.	Ready to take over in case of a request to intervene.	Not required in some driving environments or modes (e.g. specific routes, low speed driving).	Not required
System capabilities	Individual automated systems can sometimes be employed; for example steering and acceleration/ deceleration.	One or more driver assistance systems can work at the same time.	All aspects of driving task in certain environments (motorways). The system recognises if human intervention is needed and alerts the driver in good time.	All aspects of driving task (in some driving modes), even if the driver is not able to resume the control when required.	All driving tasks, under all environment al conditions.
Timeline for adoption	Now	2015-2019	2018-2022	2020 onwards	~2030

Fully Autonomous Vehicles (AVs) are those with the capacity to perform all driving functions on any road, in any environmental conditions, without the need for human supervision. The timescale for deployment of such vehicles is ambiguous and depends upon a number of factors: the speed of technological advancements; the readiness of the infrastructure, and the development of the legislative framework. Ahead of the deployment of fully autonomous vehicles, we will see vehicles with varying degrees of autonomous functionality operating on public roads as well as increased use of automation in warehouses.

There are two different types of vehicles currently considered and tested for use on urban delivery cycles:

3.1.1. Van-like vehicles

In 2017, Ocado online supermarket ran the first UK trial of an automated delivery vehicle, the CargoPod, developed by Oxbotica, as part of the TRL led GATEway project. The CargoPod is capable of carrying up to 128kg of groceries in secure crates and has the capacity to drive at 25mph on public roads, though was limited to 5mph during the trials. In practice, it is intended that the vehicles will be unmanned and recipients will unload their own deliveries when notified that the vehicle has arrived at their location. The vehicle can access areas that larger vans are not able to, but are limited to smaller delivery loads. (Ocado Technology, 2017). Assisted trials were performed in the Royal Borough of Greenwich to assess human reactions to the presence of an automated vehicle. Responses from the public exposed to the trials have been positive (Guardian, 2017).

3.1.2. Ground Drones

Ground drones use pedestrian and cycle space and are suitable for small deliveries in quiet environments. Their applications within freight range from the delivery of goods from a shop or restaurant within an urban area, to last mile deliveries where a fleet of ground drones are loaded on a van from a large distribution centre, which then drives to a central delivery area and releases the ground drones for dispatch (Starship Technologies, 2018). Starship Technologies developed a semi-autonomous delivery robot as a solution to last-mile deliveries. This robot operates on pavements and is capable of carrying goods up to 10kg. Navigation is controlled by GPS, computer vision and the use of ultrasonic sensors to detect obstacles. Although capable of speeds of 10mph, a 4mph speed limit is currently applied so that it can function alongside cyclists and pedestrians with limited risk.

3.2. Benefits for businesses

AVs offer the potential to optimise delivery services by finding the quickest route in real time, adapting their speed to the surrounding environment in order to travel at the highest safe velocity, and driving for long periods without rest. They thereby increase efficiency and ease congestion in built up areas, enabling new operational models as well as reducing the risk of collision (SMMT, 2016). Operators can also make cost savings through the repurposing or elimination of the driver from the delivery task. This could provide cost savings as high as 40% per kilometre (DHL, 2014). The absence of a human occupant could reduce crashworthiness requirements for unmanned delivery vehicles and therefore allow lighter, more fuel (or electrically) efficient vehicles with consequent advantages for vehicle and operational costs.

3.3. Benefits for consumers

The rising popularity of online consumerism has driven the freight market to become unsustainable. Consumers have shown willingness to pay additional tariffs for the convenience of same day delivery (McKinsey & Company, 2016), which is leading to an increasing number of vans with less than-full loads on the roads performing dedicated trips for a single customer. The introduction of autonomous vehicles, in particular ground drones, could help ease unsustainable impacts of congestion and fuel inefficiency associated with responsive deliveries.

3.4. Impact on infrastructure

AVs may require the implementation of new urban infrastructure and designated space for the movement of vehicles. Infrastructure to enable communications is already in place, as existing 4G networks (and, in time, 5G networks) can be utilised.

Additional infrastructure to allow vehicle-to-vehicle and vehicle-to-infrastructure communications may be required in the future, though the necessity for this has not yet been proven.

In some cases pedestrian, cycling, and road spaces will need to be upgraded and expanded to accommodate the AV freight traffic. Conversely, it has been argued that AV freight will facilitate the more efficient use of existing land space such as parking areas and garage spaces that will gradually become redundant as private car ownership decreases, thereby mitigating the negative impacts of additional users within pedestrian, cycling, and road spaces (WSP Parsons Brinckerhoff & Farrels, 2016). Parking space alongside roads may be transformed in to extended space for other road users. There will likely be a transitional period during which increased demand on current infrastructures leads to congested pedestrian, cycling, and road networks. London Boroughs should take authority to control the number of AVs that organisations can deploy at one time during the transitional period.

4. Stakeholder Engagement

4.1. Technological Review

4.1.1. Application of AV Freight

Fleet managers suggested that AV freight’s most useful urban application is as a last mile delivery solution. The popularity of e-commerce has elevated the demand on last mile deliveries, and AV technology is recognised by the automotive industry as a solution to the current inefficiency of conventional vehicles performing many urban deliveries at short notice, for reasons outlined above. A suggested use case is for AVs to travel between urban consolidation centres and residential areas to perform deliveries.

4.1.2. Benefits

Increased fuel, time and space efficiency are at the core of what makes AV technology beneficial in comparison to its conventional predecessor according to logistics operators.

Electric pods could contribute to improved air quality in urban areas.

Quieter vehicles mean that it will be possible for night-time deliveries in urban areas where night-time deliveries from conventional vehicles are impracticable. Operating vehicles that do not have the same rest requirements as human delivery personnel means that the vehicle can operate for longer periods of time.

Space efficiency is particularly apparent when operating pavement-mounted delivery pods. Taking vehicles off the road eases congestion which is a major issue in built up urban areas; however, this does impact on pavement capacity which is also in competition and could inhibit the possibility of achieving goals set out in the Healthy Streets Agenda.

4.1.3. Concerns

An issue for urban freight is the high incidence of conflicts with vulnerable road users, often caused by human error which accounts for 90% of road accidents (Pinsent Masons, 2016). AVs are equipped with sensors designed to avoid collisions. By removing the possibility for human error, numbers of road collisions will drop and overall road safety will improve. However, the current capabilities of these systems are limited since they lack the ability to predict the movements of others and do not have the capacity to assess the course of actions that result from braking suddenly. For instance, whilst the capacity to stop instantly if a human were to step in front of the vehicle is clearly advantageous, the act of braking suddenly to avoid a harmless object, such as an empty box, could have knock on implications that cause danger to other road users. This is of particular concern in the transition period where roads are shared between automated and conventional vehicles. To mitigate the risks of an unpredictable environment, it is sensible to enforce a low speed limit on AVs until technology or infrastructure improves.

Logistics is an industry that typically operates with small profit margins and the capacity to explore the use of AV is limited; it is a risky investment in an industry that is traditionally risk averse. To overcome this, government sponsored trials of the technology are necessary to demonstrate the safety features and assure investors of the readiness of the technology.

4.1.4. Opportunities

Opportunities for uptake of automated technology can be tailored to the specific needs of businesses. OEMs suggested that the move to autonomy presents a business opportunity for the development of a package or solution to a particular customer. OEMs can add value to the proposition by tailoring the technology or offering different levels of autonomy for different prices to enhance existing technology. This requires harmonised development of the technology. OEMs would need to collaborate to develop a standardised platform to ensure that there are not numerous methods of reaching the same end solution. It was suggested that this standardisation should be a top-down government led strategy.

Engagement from London Boroughs and TfL in demonstration projects, such as Smart Mobility Living Lab (London) will develop evidence which will support adoption in real use cases, demonstrating and quantifying the benefits of AV technology.

4.2. Physical Review

4.2.1. Benefits and concerns

Delivery robots are intended to operate on pavements, sharing space with pedestrians. A beneficial aspect of this is that freight transferred on pavements reduces the amount of freight transferred on the road, thus easing road congestion. Local Authority stakeholders expressed concerns that some of London's old roads are already narrow, with no space available for widening walkways. The way that humans will interact with pods is not yet known; it has been suggested that pavement mounted pods may incur a safety concern as humans tend to be less mindful when walking on pavements in comparison with roads. However, it is likely that as pods become more commonplace, the public will become more mindful.

Concern was also expressed for the impact on pavement space on the public's capacity to walk and cycle. London's Healthy Streets Agenda promotes active travel; by adding congestion to pavements this agenda could be threatened if people feel discouraged to walk or cycle due to contested space. Conversely, it was expressed that AVs would actually act as an enabler for active travel. By reducing road congestion, more road space is available for cyclists who may feel safer cycling alongside sensor-equipped AVs in comparison with human-driven freight.

In London, there is public debate on how implementing new cycle lanes has worsened congestion by slowing traffic in busy areas, which has the knock on effect of worsening air quality in the city. Though this notion was contested by cycle campaigners (Independent, 2017), a similar debate may ensue if space is allocated to slow-moving delivery vehicles which may impede other forms of travel. This issue is particularly relevant during the transition period in which there will be peak contest for space, but is likely to ease as more freight moves from conventional vehicles to AVs.

4.2.2. Infrastructure considerations

New infrastructure, such as road signs and charging points, is required to accommodate AV freight. This may be extended to include infrastructure to enable an AV connectivity network if this is deemed necessary. Local authority stakeholders expressed concern that the addition of new infrastructure will add clutter to already crowded streets. However, as AVs do not have the same requirements for on-street parking as conventional vehicles, there is also a possibility that existing space could be made available and could be utilised for dedicated AV lanes or for supporting infrastructure.

It is envisioned that AVs will have the capacity to identify an appropriate location to perform automated drop-offs, such as a roadside container, reducing the current space issue caused by freight vehicles parking on-street in cities which causes localised congestion and hazardous road conditions for vulnerable road users. Former freight loading bays could be repurposed to expand on valuable road space, in turn easing congestion and increasing pedestrian capacity. Moreover, with less time spent parked, AVs will be capable of more deliveries in a shorter period of time, making them more cost effective for businesses. Vehicles will be kept and charged at locations outside of the city where space is less contested.

The Mayor's Transport Strategy gives consideration to the next generation of road user charging systems, aiming to support efficient transport movements. To discourage unnecessary journeys by freight, the Mayor proposes for London boroughs to introduce road pricing and encourage the retiming of deliveries to off-peak hours; AV freight could aid efficient and off-peak journeys and allow operators to avoid road user charging.

The uptake of AVs for public use will also have an impact on the overall amount of space dedicated to parking in central London. Should AVs become a realistic, convenient and cost effective means of transport for the public, private car ownership is likely to decrease, freeing space on roads and in parking bays for AVs to function without contest.

4.3. Governance Review

The lack of existing governance relating to the general concept of AVs is a barrier which may slow development and uptake of all types of AV technology.

OEMs expressed that it is essential that legislation supports the move to automation if uptake is to be successful. Legislation which drives customer demand would be advantageous in terms of managing investment risk for technology developers. Certifying that customers will uptake the technology ensures AV freight vehicles are a less risky commercial proposition and affords OEMs the opportunity to invest more certainly in developing and producing vehicles. A suggestion of how to drive uptake would be for the government to take control and enforce managed zones stipulating the use of AV for urban freight deliveries. Otherwise, incentivising the uptake of AVs in the same way that taxi drivers have been encouraged to uptake electric vehicles would have a positive impact on the growth of AV applications. In April 2017, the government announced plans to offer grants of up to £7500 to taxi drivers purchasing electric vehicles (LEVC, 2017). Similarly, the funding of government research initiatives into AV technologies akin to the funding initiatives for Low Emissions Freight and Logistics Trial and Low Emissions Bus Scheme may help to provide much needed independent real-world demonstrations of the technology to encourage operators and the industry to consider AV solutions, and drive development.

4.3.1. Concerns

Concerns were also expressed during stakeholder interviews that the complexity of suitable policy and regulation covering all aspects of AVs may slow the uptake, and even once suitable policy has been developed, agenda does not always translate quickly in to physical change. Developing a realistic regulatory framework for AVs for public and private use has been identified as the biggest barrier to deployment by those working in the public sector. The framework must be flexible and adaptable so as not to slow implementation. The scope of the regulatory framework must be broad enough to determine where and how AVs can operate, taking in to consideration the constraints applied to AV users and other road users and whether these constraints are acceptable to all parties.

4.3.2. Developing Policy

The power to shape policy is held by central government. However, local authorities are most aware of the particularities that could prevent a successful deployment of AVs in their local authority area. It is sensible to include council representation in the decision making process when developing legislation. With discussions already taking place at a national level, the needs of specific areas could be overlooked. AVs are considered in the upcoming national transport strategy which will be completed before the technology has been fully developed or widely adopted. It is too early to discern the complexities of issues that may become apparent once the technology is adopted. However, local authority stakeholders suggest that the most sensible approach may be to identify the key principles of how government and local authorities envision early stage AVs function, and for the technology to be developed in accordance with these principles, rather than writing policy in retrospect of the technology emerging.

To ensure a satisfactory framework is developed, analysis of the benefits and drawbacks of automation for all groups must be undertaken and referenced to ensure that the benefits of implementing the technology will outweigh the challenges. The idea of local governance of AVs is rejected as this could lead to a fragmented approach across the UK and even within London.

4.4. Market Review

4.4.1. Benefits

Consideration by logistics operators is currently high level due to the early stage of the technology. The primary business case for adopting this technology was the potential cost saving of having a driverless fleet. This cost saving not only comes from the lack of requirement for a driver, but from improved efficiency across operations.

Accessibility to areas such as campuses, pedestrianised areas or cycle lanes, where conventional vehicles do not have access is improved. This is dependent upon legislation outlining where AVs will be allowed to operate, but could have implications for ease, speed and facilitation of delivery. This legislation could specify pedestrian and cyclist protection measures.

AV freight can operate for longer periods of time without the requirement for rest periods. Later deliveries will improve operational efficiency; if deliveries can be unloaded to a secure site without human intervention, deliveries can occur through the night without causing noise disruption in residential areas. This has the added benefit of easing road congestion during daytime and in turn improving safety for vulnerable road users.

Another driving factor for the uptake of AV freight vehicles by logistics operators was the positive association of being at the forefront of new technology and the benefits this would have for brand image. However, this was outweighed by the risk of brand image being damaged if the technology were not to be successful and the loss of money that would be incurred with an unsuccessful investment. Technology would need to be proven before smaller companies invested money.

4.4.2. Concerns

The impact of AVs on the job market is a contentious issue. Whilst cost savings can be achieved in the case that businesses will no longer need to pay an individual to drive, it is apparent that an employee may still need to be present to hand over goods, certainly in the short term. The presence of this employee would negate the benefit of driver related cost savings; whilst the wages for a non-driver would be reduced in comparison, other costs such as pensions and payroll would still apply, and the bottom line cost saving would be marginal.

The UK is facing a driver shortage. This driver shortage is expected to worsen following Brexit when the pool of potential employees shrinks. Automation may be seen as a way to remedy this. Logistics operators assert that job loss may not be significant, but instead we are likely to see a shift in the types of job available. Whilst individuals are deskilled in terms of professional driving, there may be opportunities to upskill in other areas which could allow a better service, such as better customer service, visibility of freight or security of the load.

The development of AVs is set to create 320,000 jobs (SMMT, 2016). Many of these jobs are likely to be technical and require highly skilled expertise, and thus cannot be seen as a direct solution to driver job loss. Whilst unemployment may be offset, a social cost may emerge if job quality and job satisfaction decrease as drivers are expected to move in to low-skill positions, such as delivery attendants, and do not feel that they are being well utilised.

5. State of Play

The state of play with AV freight is a feeling of uncertainty across all stakeholders. We are in the early stages of a technology that will have impact across society, not limited to those working in the logistics industry. The introduction of this technology may result in a restructure of deliveries and servicing and the wider impacts of this can only be speculated at this stage. It is possible, nevertheless, to envision how the deployment of AV freight could impact London.

Demand for space in Central London is increasing and may be exacerbated by the introduction of AV freight, at least during the transition phase. Future transport strategies should clearly outline priorities in areas of shared space. In the introduction phase of AV freight, an attendant should be present to ensure AV freight vehicles are fully adapted to London's complex driving conditions.

Journey times in Central London are longer per distance in comparison with other UK cities (Financial Times, 2016). Congestion has worsened in the past five years despite a significant drop in private car use, attributed to the rise of Uber and Amazon deliveries. Logistics operators will benefit from being able to access more customers over a shorter period if AVs can ease congestion issues.

In 2014-2017, HGVs were responsible for 70% of cyclist deaths in London. The introduction of AV freight could reduce the risk posed by HGVs.

Plans to pedestrianise Oxford Street will affect freight movements. AV freight vehicles which operate in pedestrianised zones could present a solution to the restrictions of access to Oxford Street by allowing the safe, quiet and efficient delivery of goods to businesses.

The introduction of the Ultra-Low Emission Zone in April 2019 will be a big step toward reducing emissions, and this can be further improved by the reduction of conventional freight vehicles on the road if they are to be replaced by electric AVs.

6. Recommendations and Interventions

If managed effectively, the implementation of autonomous freight vehicles in Central London for deliveries and servicing could have a multitude of positive impacts over a long period; businesses could run more efficiently with lower driver related costs and extended delivery hours; congestion could be reduced with fewer freight vehicles using the road; emissions could be lowered by the adoption of more fuel-efficient vehicles; reduced business costs could be passed on to customers who will pay less for deliveries; road safety could see a huge improvement; and the UK could be the market leader in the deployment of this emerging technology.

For this to be successful, it is integral that the following provisions are considered:

6.1. Government investment is required in the development and testing of new technologies, specifically freight and logistics.

Investment must be made in AV freight and logistics. This can be driven by government funding through current mechanisms and resources such as Innovate UK and the local

London Boroughs where appropriate. Investment should be used to develop new test beds and exploit existing test beds in partnership with freight and logistics operators.

Robust technology is fundamental to the successful uptake of AVs. Manufacturers are working alongside research institutes to develop effective technology using public funding from Innovate UK. An example of this is the Smart Mobility Living Lab: London, where over £100 million has been invested in AV projects. This presents a commercial opportunity for OEMs when scaled up and tailored to specific business needs.

Existing freight and logistics service operators will have the opportunity to drive efficiency, improved services and new service models, whilst retail businesses which rely on successful completion with the end consumer will have new, cost effective services to satisfy rising customer demand.

It is suggested that investment in developing and testing AV technology continues, but with increased focus on freight and logistics test beds.

6.2. TfL funding needs to support logistics operators with the uptake of AV freight

Customer demand for AV technology would spur existing OEMs to invest money into research and development, and could see new OEM entrants in the market. Logistics operators have shown willingness to trial new technologies as they emerge. This willingness seems likely to extend to trialling AVs, though as an industry logistics operators are typically risk averse and would require an incentive beyond investigating new opportunities.

Government funding to support logistics operators would increase the number prepared to take up the technology. At a London-centric level, this funding should come from Transport for London. Outside of London, other existing test beds can be exploited; one example is Coventry's City Lab. OEMs must lobby central government for funding in AV testing, but it is essential that technology providers, insurers and central government collaborate to establish a strategy for testing the technology and driving uptake.

6.3. AV freight trials must focus on determining what infrastructure is necessary ahead of deployment

Road signage and markings are crucial to allow AVs to function and must be up to standard ahead of testing or deployment of AV freight. Beyond this, it is not yet clear what further infrastructure is required for safe deployment. This area requires further investigation. Communications infrastructure may be necessary to enhance safety. Trials should aim to understand what additional infrastructure would improve the performance of the technology. Real-world projects are necessary before the full functionality of AV freight is uncovered.

Localised trials in different settings will help identify what further infrastructure is needed for wider deployment.

6.4. Public perceptions of AV freight should be influenced by positive media coverage.

Positive publicity in the media highlighting the benefits of AVs would be beneficial in managing public perceptions. Whilst the benefit of AVs for private use may be more pertinent with the public, demonstrating how AV freight may also improve their daily lives will allow insight in to an industry that the public do not necessarily feel closely invested in.

Inherently there is public suspicion over automation, but this could be managed by engaging with the public and directly addressing fears or uncertainties. Public workshops, forums and experiences interacting with AVs would provide opportunities for this engagement to take place. Examples of this are TRL's GATEway programme at the Smart Mobility Living Lab and Coventry's City Lab which can be used to facilitate such forums. Publicity around trials is integral to conveying a positive image.

Local authorities should identify which services would be suitable for replacement by AV freight and collaborate with OEMs to develop an autonomous solution.

There should be a media push to engage the public with developing AV freight technologies and address any concerns in a public sphere.

6.5. Policy and regulation must be in place before AV technology is deployed.

Perhaps the most important intervention in the lead up to AV freight is the need for the government to outline policy and regulation. Development of technologies is happening at pace and it is inevitable that policy and regulation will lag the technology. However, early demonstration and on-road activity can develop evidence to inform the next stage of policy, regulation and approvals regimes. Further discussions relating to policy development should be inclusive of stakeholders including local authorities, technology developers, vehicle manufacturers, service operators, customers, and should be informed by evidence.

There is a sense of apprehension among manufacturers developing technology before they are aware of any political constraints that may affect its functionality. This has not necessary slowed development; many UK OEMs are investing and developing AV technology, though a sense of uncertainty exists and stakeholders expressed concern that uptake by the automotive industry must be driven to an extent by policy and regulation. Conversely, policymakers cannot make decisions before they know the full extent of the technology. To ensure that this situation does not result in a standstill which delays deployment, policymakers should take the lead in outlining the key principles that AVs can help to achieve. Technology should be developed in accordance with these principles, rather than the other way around. Changes in regulation are required before commercial systems can go in to operation. In the meantime, vehicle trials should be continued to increase understanding of the extent of the technology and to ensure the technology is ready to be deployed once regulation is in place.

Once AV policy is in place, technology developers will be able to move capabilities forward at a faster pace.

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