D3.9 GATEway Trial 3: One decade toward a driverless world

Exploring the role Connected Autonomous Vehicles could play in the logistics industry

March **2018**

This report is a deliverable for the GATEway project consortium based on the findings of the trial 3 research study. It was written and designed by DG Cities and reviewed by the project lead TRL and all of the interviewees who participated in the research.

Title Selection: 'One Decade towards a driverless world' was chosen as a title because both the market review and the interviews stated that Connected Autonomous Vehicles will come in logistics in one decade.

DG Cities Ltd is the commercial arm of Digital Greenwich, the Royal Borough of Greenwich's in-house smart city team**.** As a team, DG Cities Ltd offers a broad mix of skills in smart city strategies, urban innovation, economics & business development, sustainability, the modern built environment and technology management. Our focus areas are in the disciplines which support smart city innovation, including: the economics of the digital economy**;** smart mobility and autonomous transport**;** sustainable spatial development and integrated planning**;** citizen facing services and government as a platform**;** urban energy systems**;** multi-city collaboration and procurement.

GATEway is an £8 million project funded by Innovate UK and industry and led by TRL. Based in the Royal Borough of Greenwich in London, it comprises of a team of leading companies and academic institutions. It is a technology-agnostic programme of automated vehicle research and test criteria development that enables industry, government and society to gain critical knowledge, safely accelerate innovation and deliver smart city integration.

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1. Executive Summary

Market Review

Industrial bodies have set up a framework which defines the different levels of automation in vehicles, ranging from 0 where a "human driver monitors driving environment" to 5 where "automated driving systems monitors driving environment".

The level 5 technologies have many potential benefits: safety, transportation savings, efficiency gains, accessibility improvements, increase in distance travelled, spatial gains, traffic efficiency, environmental value and noise reduction. However, the technology also currently faces significant barriers: regulatory framework, infrastructure, disruption, ethics, public acceptance, technical expertise, social division, cyber threats and public financing.

The market currently offers 4 logistics models that could utilise level 5 technologies: Warehousing Operations, Outdoor Logistics Operations, Long Haul Transportation Operations and Last Mile Delivery Operations.

Level 5 technology can be applied in a variety of scenarios ranging from airports to agriculture; level 5 technology has received media attention because of trials by multinational corporations such as Amazon and Tesla, but also because of the implications that it could have on the economy and the environment.

Methodology

Research around Connected Autonomous Vehicles within the logistics industry is at an early stage and the societal impact is not well understood yet. Our methodology is divided into two work streams: Interviewing and Modelling.

Interviews were conducted between November 2017 and January 2018 in London. We interviewed a variety of companies that operate and deliver in Greenwich.

In order to select the specific businesses and candidates four criteria were established: Logistics Operation, Diversity, Interviewees Expertise and Geographical Location. Each interview was structured, but open to communication, and covered 6 themes: Context, Background, General Perception, Business Interest, Public and Urban Change. For data collection purpose, the interviews were recorded while conducted by one person asking the interview questions and one person taking notes.

Findings

The data collected pointed that the key benefits observed for autonomous by businesses were safety compared to traditional cars, economic savings on reducing the labour cost of driving vehicles and time efficiency gains in the logistics industry.

On the other hand, technology readiness and regulatory, insurance and liability framework were the highlighted obstacles discouraging investments and interest from the private sector. Every company showed a notable excitement around the driverless cars topic and expressed their willingness to piloting more trials and research projects. However, technology and regulatory constrains discourage logistic companies to adopt autonomous vehicles at the present. Public governments are expected to be the first mover for their developments.

In logistics operations, the last mile delivery presented less of a business case for the interviewees as due to its challenging deployment in a free urban environment. Long haul freights have been reiterated as offering the best scenario for applying autonomous technologies. The majority confirmed that autonomous logistics vehicles will land on roads in one decade from now.

Recommendations

Retraining Scheme: countering the disruptive impact of driverless cars

Education: expanding awareness and appetitive and ease public acceptances

Knowledge Sharing: overcoming the technical challenges of autonomous vehicles

Urban Design: understanding the impact through further research

Traffic laws: understanding the impact through further research

Funding: offering incentives opportunities

Regulatory Regime: creating a new regulatory regime

Electric vehicles policies: changing behaviour

Logistics Models: focusing on simple models

Interest Groups: gathering key players

2. Introduction

The GATEway (Greenwich Automated Transport Environment) project is an £8m research project funded by Innovate UK and industry to understand and overcome the technical, legal and societal challenges of implementing automated vehicles in an urban environment. DG Cities role as part of the GATEway consortium has been to facilitate trial implementation, conduct research and organise the final dissemination event. There are three trials within the overall GATEway project:

Trial 1 - Autonomous Shuttle Pods Trial
Trial 2 - Autonomous Valet Parking Trial
Trial 3 - Autonomous Cargo Pod Trial

This report focuses on the industry and policy implications of Trial 3 - Logistics.

The third trial within GATEway investigated customer perceptions and the industry viability of last mile delivery of goods to people using autonomous delivery vehicles.

Ocado and Oxbotica, in collaboration with the wider GATEway consortium, created a cargo pod delivering groceries to residents within Woolwich Arsenal. Residents could 'order' one of three complementary pre-defined packages from Ocado. Residents were notified by text message when the automated delivery vehicle arrived so they could collect their order.

As part of the trial, residents were invited to fill in a survey about their delivery experience and perception of the CargoPod. Based on the insights of the TRL report “77% of participants wanted between half and all of their future home deliveries to be sent by driverless vehicles. 96% of the sample reported that their overall experience of using Cargo Pod 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” (TRL, 2017).

DG Cities have carried out complimentary work, interviewing a cross-section of businesses and industrial bodies to gauge their awareness, appetite and potential future plans around application of Connected Autonomous Vehicles in logistics.

Modelling work has also been carried out to help assess and inform the viability and benefits of deploying eCAV fleets for last-mile deliveries. The purpose of this work is to design logistics scenarios in Greenwich to see the benefit of using an CAV fleet over a traditional fleet. The outputs of this modelling exercise will be published in a separate report. The results of the work will inform both industry and policy makers as to the potential opportunities and barriers to the adoption of Connected Autonomous delivery and logistics vehicles.

This report details the methodology, the findings and the potential implications and future extensions of this research study and sets out recommendations for both public bodies and industry operators within a realistic market context and timeframe for CAV adoption.

3. Stakeholders

1. UK Government

Government entities such as the Department for Transport and Centre of Connected and Autonomous Vehicles and Innovate UK wishing to understand the readiness and potential of this technology to improve national policies

2. Regional and local authorities

Authorities such as the Royal Borough of Greenwich or City Hall so that transport CAV logistics can be taken into account of before the technology becomes widespread

3. Industrial Bodies

Industry Associations, such as the Freight Transport Association, interested in the implications and best practices around autonomous vehicles and their potential impact on the industry as a whole

4. Logistics Companies

Logistics businesses wishing to understand the potential impact of CAV on their operations and the potential of CAVs in terms of cost savings, efficiencies, safety, environmental benefits if adopted in their fleets.

5. Vehicle Manufactures

Vehicle manufacturers interested in understanding the business appetite of both public and private bodies for deploying CAVs within their logistics operations

6. International Audience

International governments and authorities wishing to realise potential opportunities and benefits that could be delivered by CAVs within logistics.

4. Market review

4.1 Overview of Autonomous Vehicles

The Society of Automotive Engineers and the German Federal Highway Research Institute have set out a framework, which has now been widely adopted, that defines 5 levels of vehicle automation (SAE, 2014; BASt, 2012).

Figure 1 (below) shows the 5 progressive levels of automation. At the level 0, the vehicle does not have any automated systems and its entirely monitored and controlled by the human driver.

Level 1 includes limited driver assistance aids. These systems are the most common today and are built into new cars, with functionality such as parking assistance.

Level 2 introduces partial automation such as automation driving systems (ADS) or adaptive cruise control which support some basic elements of the driving task.

Levels 3 and 4 introduce further automation systems which reduce the need for human intervention, however the attention of the driver is still required and the driver must be ready to intervene at any moment.

Level 5 is where full automation is in place, allowing the driver to focus their attention elsewhere and removes the need for driver intervention.

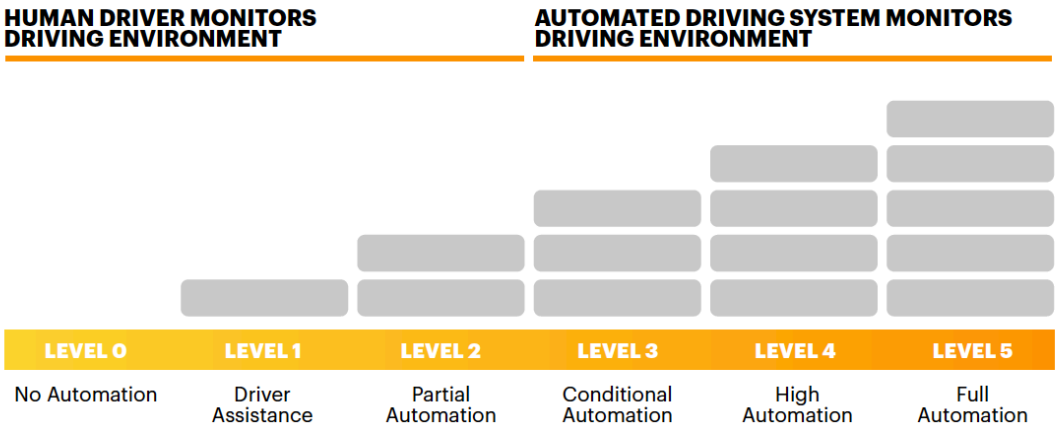


Figure 1: Level of Automation of Autonomous Vehicles (Accenture, 2017).

Autonomous vehicles work by using a range of sensors to monitor the surrounding urban environment. These include: radar, LiDAR, lasers, GPS and HD video. The information gathered by these sensors is then analysed by an intelligent driving system which then makes driving decisions in real-time (EPoSS, 2015).

4.2 Benefits

- **Safety**: CAVs could operate more effectively than humans and reducing the risk of collisions (Neuweiler & Riedel, 2017; Roland Berger, 2016; Bagloee, Tavana, Asadi & Oliver, 2016; Roland Berger, 2015; DHL, 2014; McKinsey Global Institute, 2013; Polis Network, 2018).

- **Cost Savings**: reduction in logistics costs due driven by labour and fuel savings (Roland Berger, 2016; Roland Berger, 2015; Hars, 2015; Viereckl, Ahlemann, Koster & Jursch, 2015).

- **Efficiency gains**: Optimised delivery times and routes through use of real-time data (Mckinsey, 2016).

- **Accessibility Improvements**: improving accessibility in areas with limited transport access and improving accessibility for people suffering from reduced mobility (Polis Network, 2018).

- **Distance Travelled**: increasing the distance travelled in one journey due to working time directive restrictions not applying to CAVs (Polis Network, 2018).

- **Spatial Gains**: creating more available space through improved efficiency in terms of parking and road space use (Polis Network, 2018).

- **Traffic Efficiency**: reduced vehicle ownership and the more efficient use of vehicles could reduce congestion (Roland Berger, 2016; Bagloee, Tavana, Asadi & Oliver, 2016; Viereckl, Ahlemann, Koster & Jursch, 2015, Polis Network, 2018).

- **Environmental Value**: decreasing carbon dioxide direct emissions and improving air quality (Bagloee, Tavana, Asadi & Oliver, T., 2016; DHL, 2014).

- **Noise Reduction**: reduction of noise due an electric engine system (Polis Network, 2018).

4.3 Barriers

- **Regulatory and Liability:** absence of legal framework to enable fully autonomous vehicles roads (McKinsey & Company, 2016a; Roland Berger, 2016; Bagloee, Tavana, Asadi & Oliver, 2016; International Transport Forum, 2015; Roland Berger, 2015; Viereckl, Ahlemann, Koster & Jursch, 2015; McKinsey Global Institute, 2013; Habibovic, Englund & Wedlin, 2014; Polis Network, 2018; Smith, 2012, 2013).

- **Infrastructure:** challenges of changing the urban environment and infrastructure to accommodate autonomous technology (Roland Berger, 2016; Polis Network, 2018).

- **Ethics:** the moral and legal issues surrounding computers rather than humans making driving decisions McKinsey&Company, 2016a; Roland Berger, 2016; International Transport Forum, 2015; Habibovic, Englund & Wedlin, 2014; Goodall, 2014; Van Meldert & De Boeck, 2015).

- **Public Acceptance:** how the public is going to react and accept such technology (McKinsey & Company, 2016a).

- **Technology Readiness:** lack of technical knowledge and technology readiness to make fully efficient and responsive automated cars McKinsey&Company, 2016a; Roland Berger, 2016; Bagloee, Tavana, Asadi & Oliver, 2016; Roland Berger, 2015; DHL, 2014; McKinsey Global Institute, 2013).

- **Human Factor:** the potential negative impact of removing the human from customer experience of deliveries (Van Meldert & De Boeck, 2015).

- **Disruption:** the risk to drivers jobs through increased automation (Polis Network, 2018).

- **Social Inclusion:** autonomous vehicles are likely to be expensive at first and could driver further private car ownership (Polis Network, 2018).

- **Cyber Threat:** connected technologies pose a substantial risk in terms of cyber security (McKinsey&Company, 2016a; Viereckl, Ahlemann, Koster & Jursch, 2015; McKinsey Global Institute, 2013).

4.3 Logistics Models

- **Warehousing Operations:** where vehicles move goods around the site, unload and load packages and assist with the picking process (DHL, 2014).

- **Outdoor Logistics Operations**: these applications are usually more challenging than in a private and closed environment. Public roads and free urban environments can cause unpredictable driving circumstances (DHL, 2014).

- **Long Haul Transportation Operations**: long distance freight transportation with large heavy vehicles such as assisted highway trucking (DHL, 2014).

- **Last Mile Delivery Operations**: the final mile is the least predictable stage of the entire logistics journey. Vehicles deal with dynamic and vibrant congested urban environments full of trucks, cars, cyclists and pedestrians. On the other hand, the urban setting offers many advantages for autonomous vehicles such as low speed limits and their implementation could result in substantial benefits. Within this domain, a number of uses are identified such as parcel station loading, autonomous shared cars, self-driving parcels, self-driving repositories and finally support vehicles for letter and parcel deliveries (DHL, 2014).

4.4 Technology Applications

- **The Mole underground** freight pipeline is an innovative driverless concept transporting high volume of goods into capsules.
- **Nuro** is a silicon valley start-up focussed on developing a driverless delivery vehicle
- **Dispatch** is a platform for local deliveries, operating with an autonomous fleet on pavements and pedestrian areas.
- **The Ultra Pod** developed by Ultra Global PRT in 2011 operates in Heathrow Airport and transports up to 6 passengers to different terminals. The same pod design has been used in GATEway Trial 1.
- **LUTZ** pathfinder pod is public transport driverless technology developed by UK RDM Group for a research project in 2015.
- **Self-driving tractors** via satellite navigation and radio communications are being used within the agriculture industry
- **The Waymo bubble car** is the Google self-driving project to improve urban mobility.
- **The Mars Rover Curiosity** is an automated vehicle developed by NASA.
- **The HomeRun** is an autonomous vacuum cleaner developed by Philips.

4.5 Media Coverage

- **Amazon**: In 2017, Amazon set up a team dedicated to research the potential use for autonomous vehicles in logistics to transform its entire logistics operation to fully autonomous, including warehouse operations through to last mile delivery.

- **Toyota & Uber & Pizza Hut** havesigned a partnership mobility alliance, to develop fully driverless cars for delivery of packages, pizzas and passengers to desired destinations (Bloomberg, 2018).

- **Ford**: has announced $ 1 Billion investment in AI for the deployment of autonomous vehicles (Silicon UK, 2017).

- **Tesla** have announced for that in 2019 Tesla will start producing trucks equipped with autonomous features such as automatic lane keeping, autonomous emergency braking and forward collision warning (Strategic Risk Europe, 2017).

- **TRL** are conducting trials around the potential of platooning driverless HGVs for the logistics industry (Strategic Risk Europe, 2017).

5. Methodology

5.1 Research questions

Autonomous driving has the potential to transform how we live and how people and goods are transported. This report explores CAV opportunities within the context of logistics. This report aims to establish why, what and how connected autonomous vehicles will impact people, businesses and cities through their adoption in the logistics industry. This research aims to respond to 4 key questions:

- What urban logistics solutions could be provided by automated vehicles?
- What benefits for the city could be generated by automated delivery vehicles?
- What are the main barriers to the deployment of automated vehicles in logistics?
- How will infrastructure, policy, planning and design have to adapt or change to cater for automated delivery vehicles in the future and capture the full opportunities that the technology provides?

The scope of the research outlines the potential economic, social and environmental wellbeing benefits, opportunities and risks to cities, as a result of autonomous vehicle adoption within the logistics industry. This report will propose additional solution that could provide benefits to cities, local residents and businesses, and finally make recommendations in order to realise the opportunities of autonomous vehicle technologies in the logistics industry. The Study is divided into two work streams: an interview study and a modelling exercise. This report will be focused on the interview study.

5.2 Interview Method

SCOPE

The interview method involved questioning logistics and service delivery businesses. The purpose of these interviews was to gather qualitative information from the private sector to better understand:

- Their understanding of autonomous vehicle technologies;
- Their views on the use of autonomous vehicle technologies in logistics and service delivery;
- The direction or approach they are considering in terms of future business models;
- What their drivers are for considering or not considering autonomous vehicle technology in logistics and service delivery;
- The benefits and risks to businesses of implementing autonomous vehicle technologies in logistics and service delivery;
- How they might change their business to realise the opportunities of the technology;
- What future business needs they might have as a result of implementing such technologies;
- Which stages of the logistics chain they see autonomous vehicles applicable to;
- What future role they think public bodies should play to deploy the technology, and:
- How they believe the urban environment might change with the introduction of driverless vehicles;

SAMPLING REQUIREMENTS

Four criteria were established in selecting businesses and candidates for this study:

- **Logistics Operations:** Candidates must have logistics operations within their business to ensure a base level of knowledge of the industry, it's workings and challenges

- **Diversity:** A range of businesses were included to give as rounded a view as possible from different sectors

- **Expertise:** Candidates were required to have significant experience in the field of logistics or service delivery

- **Location:** UK companies were targeted, especially those with an interest in and around the Royal Borough of Greenwich

Participants were contacted via email and sent a presentation of the GATEway research project, a description of Trial 3 and the Ocado video of the Trial 3 Cargo pod.

PARTICIPANTS

- **IKEA - IAIN FOSS**
  Business Developer
  Iain has more than 10 years of experience in supply chain with IKEA, currently managing the contracts of all ESPs (spell out in full) who provide a direct service to the customer and is also looking at new projects opportunities.

- **SAINSBURY - GARY KING**
  Operations Support Manager
  Gary has more than 15 years of experience in fleet management, he previously managed Tesco's commercial fleet and is now currently responsible for Sainsbury's fleet operations.

- **JOHN LEWIS PARTENERSHIP - JUSTIN LANEY**
  General Fleet Manager
  Justin has more than 25 years of experience in logistics, he previously managed the international fleet of UPS and he is leading the fleet operation for John Lewis Partnership. He is also the director of Low Carbon Vehicle Partnership, the chair of the Centre for Sustainable Road Freight executive committee and a member of the Freight Transport Association national council.

- **OCADO - DAVID SHARP**
  Head of Ocado Technology 10x
  David heads up a multidisciplinary group of skilled practitioners in AI, software, robotics, electronics and mechanics to create disruptive innovations in grocery ecommerce, logistics and delivery.

- **TAYLOR WIMPEY - DAVID KAVANAGH**
  Project Director for Greenwich Millennium Village

David has been leading the development of Greenwich Millennium Village since 2016. He has varied experience, both in the private and public sectors in the infrastructure industry. He was previously a consultant for the Environment Agency.

- **FREIGHT TRANSPORT ASSOCIATION - CHRISTOPHER SNELLING**
  Head of National and Regional Policy and Public Affairs
  Christopher has been working for the Freight Transport Association for more than 10 years producing policies for the logistics industry.

- **GS PLUS - Gurmel Singh**
  Chief Executive Officer
  Gurmel has worked for the public sector for over 31 years managing a wide range of front line services. He set up and successfully managed two trading companies (GS Plus Ltd and GSS Ltd) for the Royal Borough Greenwich for eight years. He is passionate about new technologies and was enthusiastic about being preparing the companies transport services for operation of autonomous and semi-autonomous vehicles and for the fleet maintenance services to skill up in emerging vehicles technologies.

- **KNIGHT DRAGON - NEIL SMITH**
  Head of Planning
  Neil has more than 10 years of experience in planning and he is currently leading all the planning applications for the regeneration of the Greenwich Peninsula. This development includes 15,720 homes combined with 48 acres of open green spaces, and a commercial district encompassing 3.5 million square feet of shops, hotels, schools and public facilities.

INTERVIEW STRUCTURE

The interview was structured around six themes and also captured free from feedback. The themes were as follows:

A. Context
Introduction of GATEway Project
Description of Trial 3 study
Presentation of Cargo Pod Findings
Cargo Pod Video

B. Background
Company Background
Candidate Role
Candidate Background

C. General Perception
Knowledge of the technology
Benefits and impacts perceived
First implementation of AVs /sector/operations

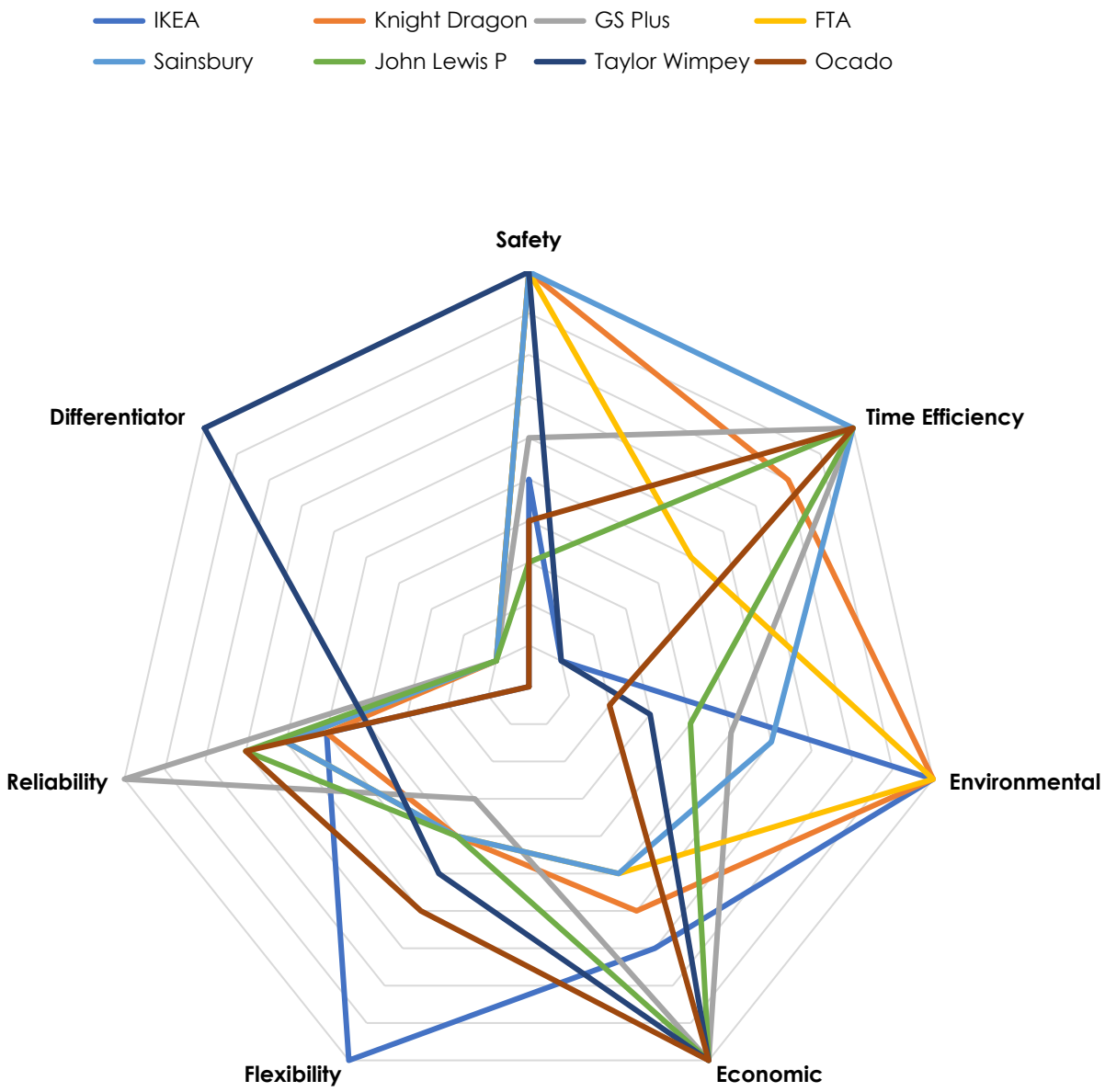
D. Business Interest
Business interest in AVs
Opportunities and challenges
Investing
Business model change

E. Public
Public Sector Role
Policy Change
Public Acceptance

F. Urban Change
Infrastructure change
Urban design and planning change

6. Findings

6.1 Perceived Benefits



Radar 1: Perceptions mapping on the main benefits of autonomous vehicles in logistics

The radar above represents the main findings on interviewees perceptions of the benefits of autonomous vehicles. Seven categories have been identified through our analysis. The key benefits stated most often by businesses were safety benefits, economic savings and time efficiency gains:

- Most business expect that driverless vehicles, once fully implemented, will be safer than traditional vehicles driven by human beings. Pedestrian, cyclist and driver safety and reductions in collisions and car accidents are identified as the main potential gains of switching to Connected Autonomous Vehicles.

- Interviewees identified potential economic benefits of CAVs, including the opportunity in logistics to reduce the labour cost of driving the vehicle which are acknowledged as a significant portion of the cost in the delivery chain. The reliance on European labour could be affected by Brexit and driverless cars could be an ideal replacement solution for logistics.

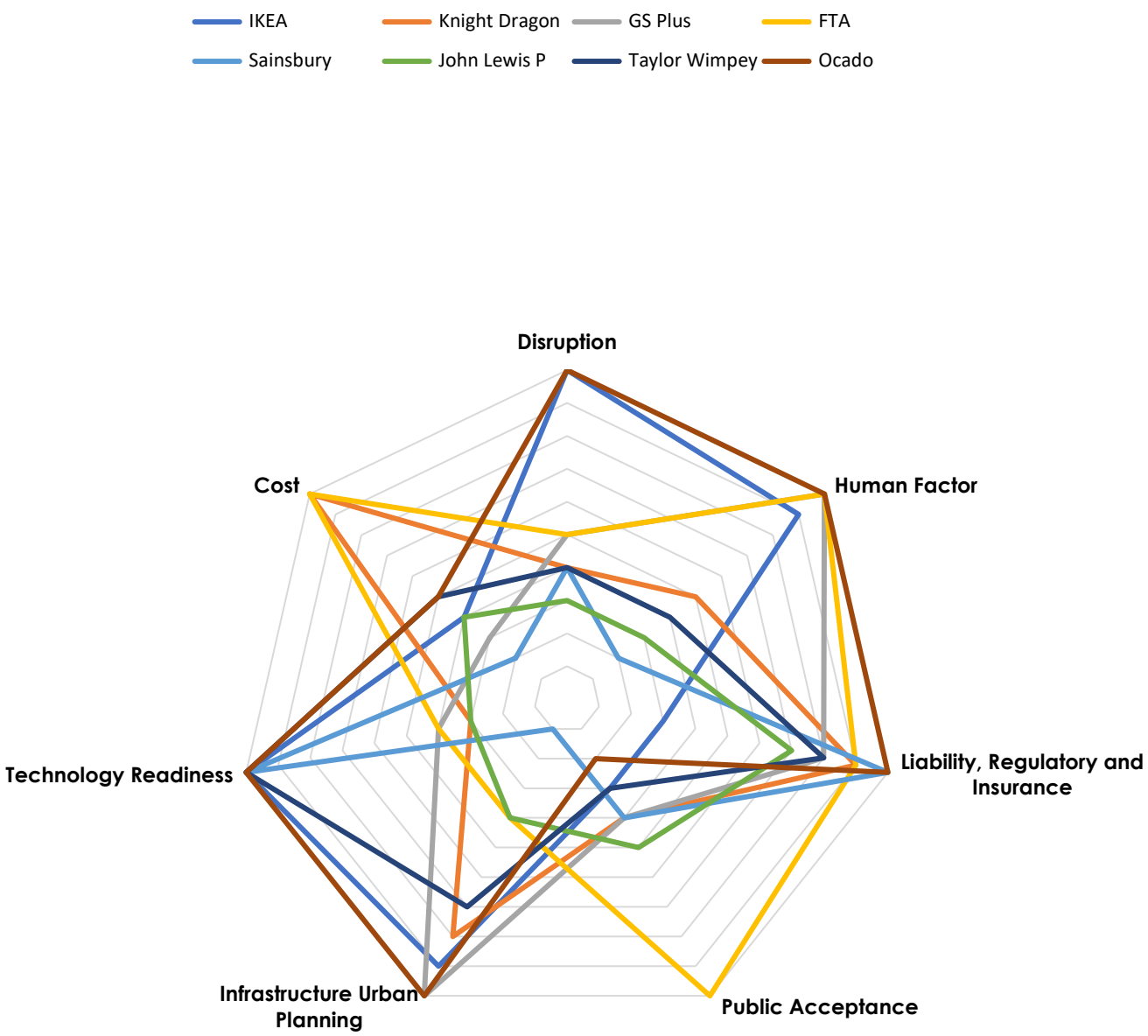
- Time efficiencies represent a key advantage of CAV technologies. Due to the ability of these vehicles to be 'connected' and 'electric', a global CAV upgrade in the logistics industry could avoid idle time, predict best routes for deliveries and save time by optimising charging time during delivery downtime.

- Environmental benefit were also identified if CAVs are also electric, bringing about cleaner transport, thus improving air quality and reducing businesses' carbon footprint. IKEA sees CAVs enabling flexible and responsive solutions to fluctuations demand as they can operate 24 hours a day.

- Reliability is another benefit stated by GS Plus. Without the need for a human driver and with vehicles being connected and having access to real-time data, more accurate and flexible delivery models can be implemented.

- Taylor Wimpey identified CAVs as a potential differentiator in the construction industry with the added value of adopting an autonomous fleet being a potential business benefit.

6.2 Perceived Barriers



Radar 2: Perceptions mapping on the main barriers of autonomous vehicles in logistics

Radar 2 above displays the mapping of perceived barriers discouraging investments and interests in the private sector**.** Technological, regulatory, insurance & liability obstacles were the most often stated:

- Most companies interviewed believe that the technology is not yet ready to be fully deployed in the logistics chain. Businesses are currently sceptical of the value that autonomous vehicles will offer in a last mile delivery scenario and how vehicles will behave in a complex and fast moving urban environment. Basic questions still arise, such as vehicle entry to depots if drivers are not present as well as the ability of the technology to scale up and operate in big cities like London where more than 400 000 tonnes of goods are moved daily.

- The legal framework needed to insure, regulate and tax these vehicles remains unclear. Liability if accidents do occur is a key concern and needs to be more fully addressed before the industry can commit to adopting CAVs.

- The absence of a human being was expressed by a couple of businesses as having a negative impact on the customer experience. Ocado and Waitrose see their drivers as a fundamental value add aspect of the customer experience. Similarly, a person would still be required to unload and load the packages from the pod until a time when autonomous robots could fulfil this role.

- Interviewees expressed divergent views around the disruptive impact of CAV. Some businesses claimed that driverless vehicles will lead to substantial job losses in the industry while others argued that new jobs will be created in the technology industry. Job roles could be redefined such as to enhance the customer experience or other aspects of business operations.

- Infrastructure and urban planning were recurrent topics. CAV technology is perceived as requiring major investment and changes in infrastructure including new planning models, autonomous tolling, pavement-based robots and charging points. The potential to remove segregation between road users, and street furniture, including traffic lights was also identified.

- The capital cost of implementing CAVs was also seen as a potential barrier for smaller businesses.

- Public acceptance was recognised by the Freight Transport Association as a key driver / blocker for the deployment of CAV in last mile delivery scenarios. Pedestrians interfering with autonomous pods and consequently slowing down the logistics chain were also identified as unsolved issues.

6.3 Business Interest and Implications

Most of the key benefits and barriers outlined in the market review section was reiterated during these interviews. However, three news elements were mentioned: reliability, flexibility and the human interaction.

All of the organisations interviewed had significant interest and awareness of CAVs and noted that they had the potential to transform the logistics industry. There was appetited expressed to develop a CAV knowledge base by piloting more trials and research projects to better informed as to how CAVs could be used within the industry. There was also acknowledgement that CAVs, and especially electric vehicles, presented and opportunity to embrace new sustainable urban mobility models to meet the goals of the Paris Agreement set at the COP 21.

Currently, however, none of the organisations we interviewed are ready to be the first mover in implementing CAVs within their fleets and businesses because both the technology and the regulatory landscape are not ready to accommodate such technology.

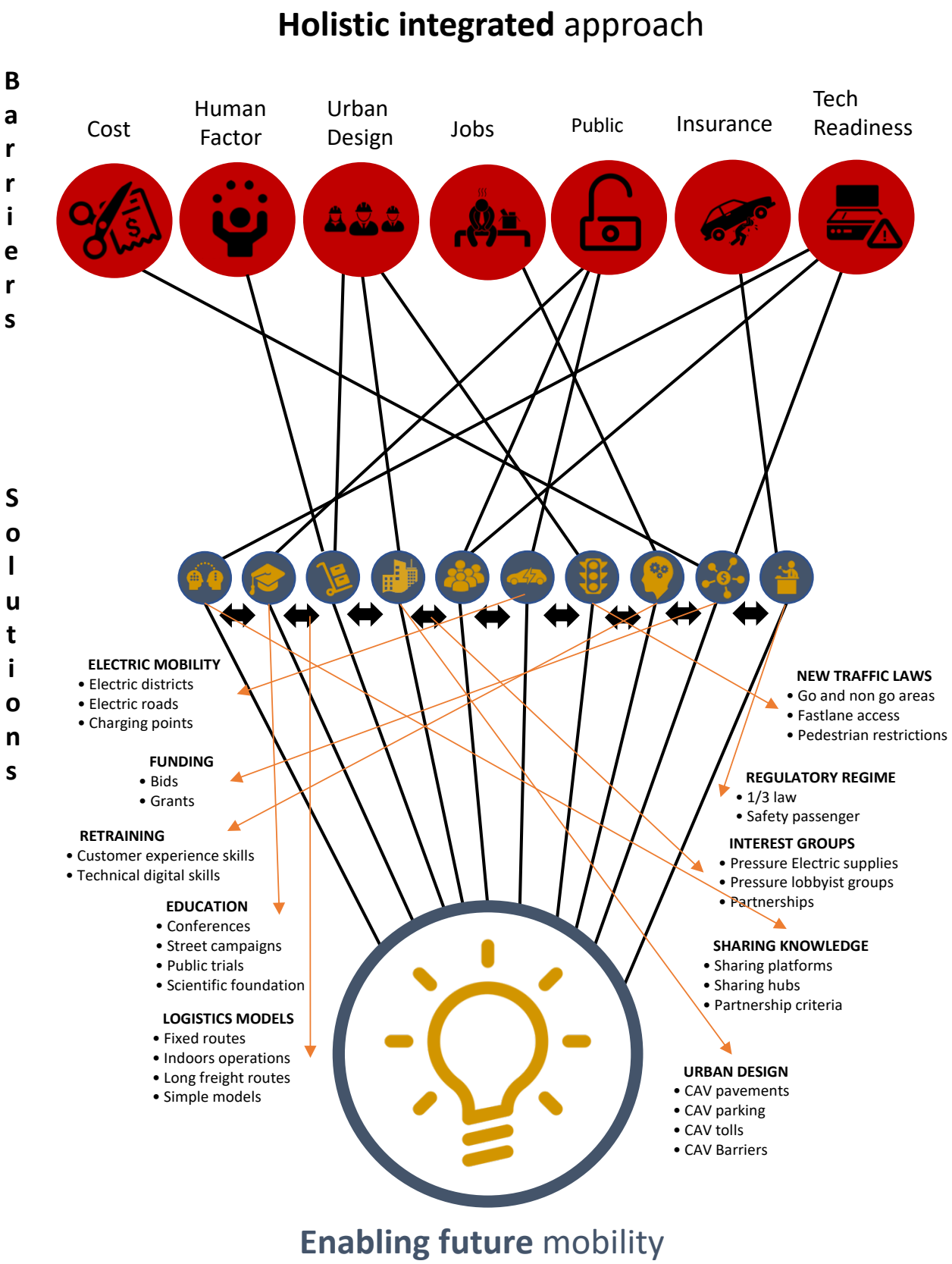
Importantly, for logistics companies, the case for CAVs in last mile delivery scenarios is still not clear. Some organisations see their driver as a critical part of the overall customer experience and see the loss of a driver as a business and customer dis-benefit. There were also concerns raised about the lack of infrastructure, such as secure drop-boxes, that could enable CAVs in the last mile element of deliveries.

Conversely, logistics organisations are particularly interested in CAV technology for long haul freight. Highways and trunk roads are seen as a potentially easier environment in which to operate partial or fully automated trucks. Drivers also account for up to one third of the overall cost of operating long-haul freight, and thus CAVs for freight journeys are seen as a potentially significant cost saving in the long term. In the construction industry, there is a more circumspect perspective on the use of CAVs within construction sites. Health and Safety as well as the relative infancy of CAV technology mean the technology needs further proving before it could be considered for adoption in this setting.

All organisations interviewed expressed concerns around the potential for job destruction that could come with CAV implementation. IKEA, for example, have a strong focus on job sustainability which flows through to all their outsourcing contracts. Job sustainability will therefore be a key theme across industry in developing new CAV driven models for last mile logistics. The deployment of CAVs also represents a significant cost hurdle for small businesses, which could drive further consolidation in the freight and logistics industry away from small players to a fewer number of larger players.

All of the organisations interviewed expressed the opinion that large scale adoption of CAVs within both the logistics industry, as well as broader applications, is at least 10 years away as the technology needs to be developed and refined for real world application.

7. Recommendations



The graph above summarises this section by linking the given recommendations with the interviewees' identified barriers.

Retraining Scheme

To counter the potentially disruptive impact of CAVs, governments and companies must invest time and effort in deploying retraining schemes. As highlighted in the findings, drivers' jobs are highly valued and the driver is seen as a critical aspect of the overall service and experience.

- **Retraining scheme for drivers**: As the vehicle takes over more of the driving task, drivers could be offered re-training schemes to up-skill in customer service and experience roles or cross-train into other skill sets.

- **Retraining scheme for broader CAV technologies**: Local Authorities and Industry and Technology Companies could collaboratively design training schemes to prepare the workforce for new jobs created in the CAV industry.

Education

To expand awareness and appetite and ease public acceptance of CAVs, Local Authorities and Industry could co-ordinate media campaigns and public engagement activities. This research as shown that CAVs are expected to have a significant impact, not just on the logistics industry, but for society as a whole. To realise maximum benefits from CAVs, they have to be designed and adopted in ways that work for people and companies at the same time. Local and central governments and businesses therefore have an opportunity to stimulate public education of CAV technology as follows:

- **Conferences**: This would inform various audiences about the key aspects of autonomous vehicles and their impacts and stimulate industry innovation.

- **Street campaigns**: Engaging and informative campaigns with city dwellers to increase awareness of CAV technology and it's benefits as well as capturing their views and expectations about CAVs for the future.

- **Public trials**: Engage the public with autonomous trials projects to capture more outputs and insights.

- **Scientific research**: Continue to invest in CAV technology and capability within the UK through funding bodies such as CCAV.

Knowledge Sharing

To overcome the inevitable technical challenges surrounding CAVs, a strong and efficient knowledge base and an ability to easily add to and share this knowledge needs to be established. Such an initiative would help both public and private sectors to accelerate investment in CAV technology:

- **Sharing digital platforms**: A platform should be created to enable local authorities, technology and logistics companies to transfer relevant information and cases studies between them.
- **Shared working hubs**: Venues could be created in strategic locations across the UK to gather relevant players together to work on common challenges and issues surrounding CAV technology and its implementation.
- **Expand the scope of CAV funding**: To ensure future CAV implementation works for both industry and people, funders should look for diversity in delivering key CAV related projects and programmes. This could include Local Authorities, urban planners and designers, transport service providers etc.

Urban Design

To understand the impact on urban design and infrastructure, Local Authorities and developers need to take an increasingly collaborative approach to designing future developments with CAVs in mind.

- **CAVs and Urban Design Research**: Further collaborative research into how infrastructure such as parking design, pavements, pedestrian barriers and roads more broadly, could both be affected by and enable CAV adoption, needs to be undertaken.

Traffic laws

Traffic laws will necessarily need to evolve as CAV uptake occurs. Further research is needed to better understand how the rules of the road could evolve and enable regulations and laws to keep in-step with changes as they happen:

- **Legal research**: Further research should be conducted alongside the urban design research recommended above to set out clear rules of the road to best safely enable CAV adoption in such a way as to promote the safety of other road users such as cyclists and pedestrians

Funding

To accelerate the deployment of autonomous vehicles in logistics and become a global pioneer in the technology, the United Kingdom government could offer incentives and funding opportunities:

- **Bids funding**: Additional funding should be allocated to autonomous projects, pilots and scientific bodies
- **Financial incentives and grants:** Similar to current 'Low-emission' vehicles eligible for a 'plug-in grant', the government could offer a similar option for clean and safe CAVs.

Regulatory Regime

A new regulatory regime needs to be developed to enable the impact of CAVs on areas such as insurance, liability and tax to be fully understood and solutions identified that can be embedded in law and are acceptable to industry:

- **Liability:** Clearly identify where the liability for CAV issues sits between vehicle manufacture (and supply chain), service providers and insurers. This is likely to have a significant impact on the business models of all players going forward.
- **Safety:** The legal and regulatory framework should also define minimum safety standards for CAVs and aims should be set that CAVs should increase road safety overall, putting the impetus on industry to develop CAV technology with safety being a central theme.

Electric vehicle policies

To enable the logistics industry and Local Authorities adopt electric CAVs, further investment is required in the following infrastructure:

- **Changing Points**: These are essential to enabling an eCAV fleet of vehicles. Research needs to continue into the most effective locations and methods of charging as well as ensuring clean electricity generation is used to supply these charging points.
- **Electric Districts:** Local Authorities could consider introducing 'electric vehicle only' zones within their jurisdiction to further incentivise the uptake of eCAVs

8. Discussions and Opportunities

8.1 Discussion

- **Knowledge Gaps**: Connected Autonomous Vehicles are an emerging technology and are still yet to be proven. There are significant knowledge gaps and uncertainties about the potential impacts of CAVs that need to be explored. Further research, both qualitative and quantitative, needs to be undertaken to fully understand the potential benefits, barriers and risks of future CAV scenarios. This research should also focus on the reality that CAV adoption is not going to be instantaneous and that CAVs and regular driven vehicles will co-exist for a long time to come.

- **Scientific Gap**: There is also a lack of research around the potential impacts of this technology. For example, a recent study has outlined potential hidden consequences of using connected autonomous vehicles. Big Data has also been proven to be consuming a substantial amount of energy and land space (The Guardian, 2017). Fully connected autonomous cars will have to deal with an enormous amount of urban data, especially for last mile scenarios. This amount of data comes with significant cots to generate, store, process and transmit.

- **Wireless Exposure**: Another potential concern relates to the wireless technologies used by these vehicles to transmit and receive data, due to the potential risks these wireless technologies could have on humans and the environment. Possible impacts include 'cancer risk, a rise in harmful free radicals, genetic damage, structural and functional changes to the reproductive system, learning and memory deficits, neurological disorders, and a negative impact on our general well-being.' (The Epoch Times, 2018). The World Health Organisation now recognise this as microwave sickness (The Epoch Times, 2018).

- **Inactive Lifestyles**: A final potential harm of CAVs that has been identified is the tendency of these new technologies to reduce active lifestyles and physical activity. The increased usage of cars, the replacement of stairs by escalators or elevators and the time spent behind a screen and sitting in an office have dramatically reduced amount of exercise people are doing on a daily basis and have been fostering serious health issues such as obesity (Gehl, 2010). We need to ensure CAVs enable more active lifestyles rather than contribute to further inactivity.

8.2 Opportunities

- **3D Mobility**: Drones are an emerging technology attracting the interest of many businesses. “Drones could allow companies to bypass the many challenges involved with the "last mile" of delivery — the last leg of the journey when a package arrives at the customer’s doorstep.” These technologies are also a lot cheaper than Connected Autonomous Vehicles (Business Insider, 2017). There are still significant development, policy and prioritisation issues as that would need to be tackled for drones to become a widespread method of last mile deliveries.

- **3D Printing:** Otherwise known as “additive manufacturing”, 3D printing has been capturing the imagination of entrepreneurs to at-home hobbyists in recent years. There is a growing excitement from both from businesses and individuals for the opportunities that this technology may offer. However key questions remain: What impact will this technology have on the manufacturing industry? And, will 3D printing become sufficiently good quality and affordable to allow individuals to ’print’ products at home, negating the need for online orders and deliveries (DHL, 2016)?

- **Multifunction Vehicles**: Could future CAVs be designed with multiple purposes in mind? Such vehicles could perform the commute, be available for hire and even act as delivery vehicles during night time running. This could significantly reduce the number of vehicles produced for single purpose use and contribute to the reduction of vehicles on the road overall.

9. Conclusion

Connected Autonomous Vehicles are just at the start of their journey to becoming a reality. There is significant interest and excitement from individuals, governments and industry as to the benefits and applications that CAVs could unlock for society.

This study has helped to confirm that most of the identified benefits within our market review were reiterated during interviews with a cross-section of industry. These benefits include safety, economic savings, reliability, flexibility, efficiency and environmental value. On the other hand, key obstacles we identified were also shared by interviewees. These barriers include; lack of regulatory framework, public acceptance, disruption to jobs, steps backwards in the customer experience, and infrastructure and technological readiness.

Each organisation we spoke to was enthusiastic about the opportunities that CAVs may offer in industry, however none have a programme of investment related to CAVs until they are a proven and viable technology.

It was widely recognised that CAV technology could significantly impact businesses models and the urban environment. The interactions between CAVs and other road users, namely existing drivers, cyclists and pedestrians, are not yet clearly understood. As such, further research into safety will be required to enable full adoption of CAVs in any scenario.

The last mile delivery scenario for CAVs presents significant challenges for logistics companies and the business case for their adoption is not yet clear. Long haul freight was identified as a much more promising application for CAVs due to potential cost savings and efficiency gains.

Additional research is required to fully understand the impacts of CAVs, both in logistics and more broadly on society. Concerns including wireless exposures effects on health and well-being are still fairly new and require further investigation.

In 2050, more than 70% of the world population will be living in cities (United Nation, 2014); to cope with all the challenges that this represents, the UK government will have to ensure that such technology can guarantee health, safety and welfare for everyone.

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