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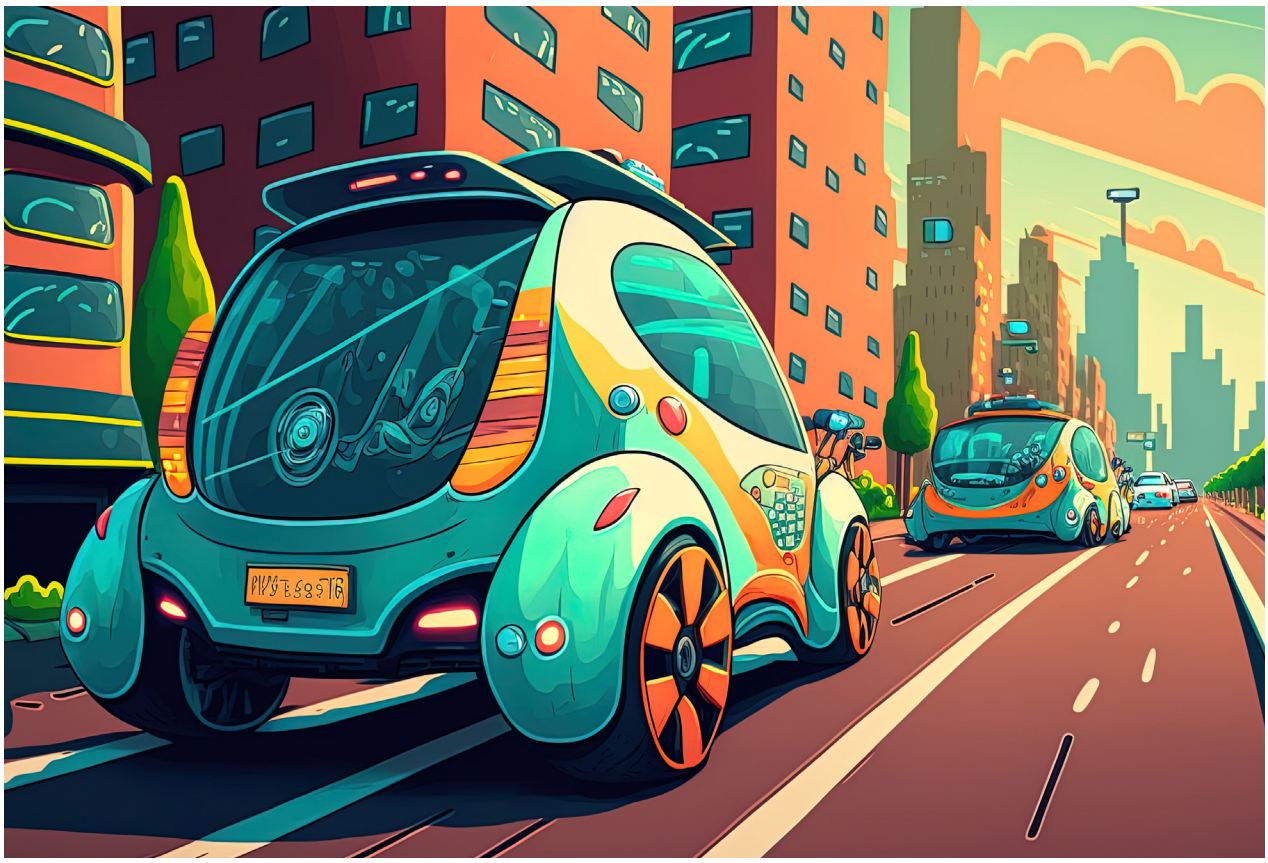
Autonomous vehicle use in practice: is the UK ready?



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Glossary

ADAS	Advanced driver-assistance system
ALKS	Automated lane keeping systems
AVs	Autonomous vehicles
CAVs	Connected and autonomous vehicles
EVs	Electric vehicles
GDPR	General Data Protection Regulation
ICE	Internal combustion engine
LAs	Local authorities
LGA	Local Government Association
MaaS	Mobility as a Service
SAE	Society of Automotive Engineers

Foreword

Hardly a day goes by without some reference in the media to climate change and the drive to 'net zero', and the impact, typically negative, our use of public and private transport has on them.

Connected and autonomous vehicles (CAVs) are one of many potential game changers that could affect regional transportation over the next 30 years. It is pleasing, then, to note the UK government's ambition to lead on CAV adoption through funding and legislation.

As a forward-thinking transport user, however, what concerns me is whether any new technological innovation aimed at meeting lofty environmental goals can be implemented in a reasonable way to meet the realities of a community's transport infrastructure and the daily lives of individuals. In other words: nice idea but will it work in practice?

For example, the availability and maintenance of local information so that a vehicle's on-board cameras can 'see' their surroundings will be the responsibility of local authorities. Without the latter, the former will fail.

This report examines in detail the complex and challenging contexts for the roll-out of CAVs and provides an understanding of how they can reach their full potential via a coordinated approach by planners, engineers and government advisers and decision-makers.

On behalf of the Property Research Trust, I am delighted that we have been able to fund this important and timely research and I encourage you to utilise its findings to the fullest extent.

My thanks to the authors for their excellent work.

Alan Dalgleish
Chair, Property Research Trust

Executive summary

Connected and autonomous vehicles (CAVs) are becoming an increasing reality as a means of transport on public roads. They are currently being tested on public and private roads throughout the UK. The UK government has identified key legislation, investment and timetables to ensure that the UK is at the forefront of the deployment of CAVs, both for public and private forms of transport.

However, despite the investment in testing and production of the technologies surrounding the development of CAVs, little research has been undertaken from the perspective of local authorities (LAs) and their preparedness for the influx and roll out of such vehicles. This study contains findings from interviews with representatives from key LAs and professional organisations to improve understanding around the experiences of, and policies used by, LAs when faced with this new and disruptive transportation system.

The benefits of CAV deployment are potentially numerous. Respondents have noted how they can partner on innovative projects, use land and space more creatively, lower transport costs over the long term, develop networks internally and externally, fulfil clean air and sustainability goals, and be part of shaping future technology implementation, rather than just passive recipients.

However, there are potentially fundamental problems and risks with CAV deployment, including an upsurge in the use of private vehicles which might increase congestion, especially in city centres. Therefore, unless managed strategically, they could act as an obstacle to more active forms of travel (e.g. walking and cycling). On a technological basis, CAVs might struggle to appreciate dynamic events and may also be vulnerable to deliberate acts to sabotage their safe use.

There are social factors, convenience aspects, and safety considerations which all feature in the LAs' considerations relating to CAV development and deployment. Other key considerations include how CAVs complement existing sustainability and active travel initiatives. Most of the LA respondents accepted that they either had to be actively involved in preparing for the introduction of CAVs, or would be expected to play such a role in the foreseeable future.

The study finds that LAs which have the most developed preparedness for CAV deployment have internal 'champions' leading initiatives, are actively engaged with both the private sector and other LAs engaged with similar projects, and have a clearly demarked strategic policy where CAVs fit into an

active and sustainable transportation programme. Another consistent feature is the development of partnerships and consortia with communities and businesses – each sharing their relevant expertise, resources and risk factors.

Finally, all of the respondent LAs understand, and are enthusiastic about, the possibilities that CAVs might bring to social and physical mobility, income and business generation in the regions, in particular where they support shared use mobilities. This is predicated on the need for joined-up strategies, and central government funding, to unleash the full potential of this emerging addition to public and transport structures.

Chapter 1
Introduction

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This report seeks to generate new insights into the preparedness of LA planners, policy-makers and practitioners for the potential introduction of CAVs on the UK's road transport network.

Existing research highlights ineffective LA responses towards the introduction of CAV transport technologies (Freemark et al, 2019). This raises questions about whether LA planners and policy-makers are sufficiently prepared to manage the impending influx of CAVs within the constraints presented by the current highways, planning, and development infrastructure. Whilst CAVs have received considerable media consideration (Bridge, 2019; Paton, 2019), there is a relative paucity of attention, broadly but in the UK specifically, regarding their wider context and the extent to which LAs are preparing for their introduction.

This report seeks to address this through two key contributions:

1. Generating new insights into LAs' strategic and operational plans, particularly the transitional arrangements for CAVs at levels 1-4 as defined by the Society of Automation Engineers (SAE); and
2. Identifying opportunities for the development and dissemination of best practice for LAs to draw on in informing their own strategic and operational accommodation of CAVs in practice.

The UK has ambitions to be a leader in the field of CAV innovation and deployment. It was the first country to legislate for the use of autonomous vehicles (AVs) on public roads (Automated and Electric Vehicles Act 2018) and has provided funds to private businesses, and for public sector use, to help realise trials of these vehicles. The government has outlined several key milestones for CAVs and associated technology use. It is commonly accepted that they will also be predominantly electric powered vehicles, and this is underpinned by the UK's commitment that new car sales from 2035 will be restricted to electric vehicles (EVs).

Most recently, the UK government announced the intention for cars on "major roads" to be permitted to use Automated Lane-Keeping Systems (ALKS) (Department for Transport, 2021), with more complete autonomous driving to feature on UK roads by 2025 (along with the promise of £100m investment to secure this ambition) (Department for Transport, 2022). This aspirational goal has been matched through changes to national legislation governing motor vehicle use (typically the Road Traffic Act 1988) and the Highway Code.

The term CAV has several connotations, being viewed by some as a form of Advanced Driver-Assistance System (ADAS), and others as a fully autonomous and self-driving system. To ensure consistency between manufacturers and legislators when preparing for CAVs, the SAE established a six-tier classification outlining the levels of automation. These are shown in Figure 1 and help to provide a universally accepted identifier of the human input and control needed when using a CAV. Essentially, the higher up the vehicle is found on the 0-5 scale, the greater its level of autonomy in the driving function and the lower (indeed none at level 5) its need for human interaction in the driving process.

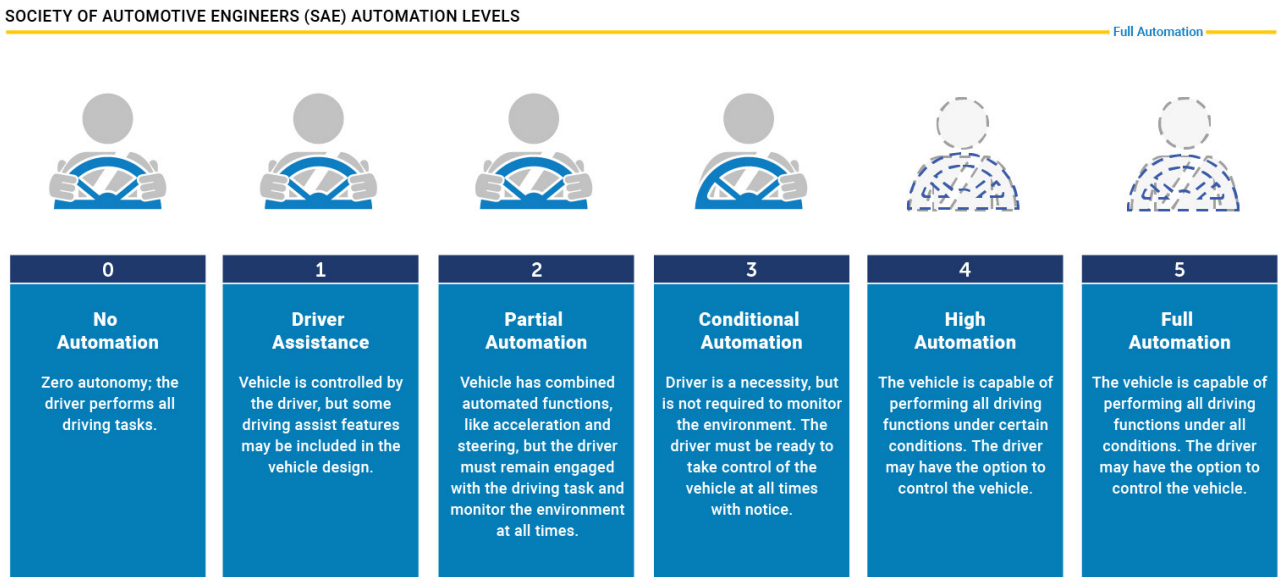

Figure 1: Levels of Automation (Image credit: Accolade Technology).

The UK's ambition to lead on CAV adoption has been supported through funding and legislation. What is less clear, however, are what plans are being created and actioned for the actual use of them on public roads. The legislative regime has created a mechanism for CAV deployment and funding has allowed for the development and testing of the technology used in these vehicles. Yet, there does not appear to be a clear and definitive policy for how LAs, which are responsible for road and infrastructure planning, use and maintenance, prepare for the advent of driverless vehicles.

Much of the existing work on CAVs has focused on the technology and 'test beds' where they can be used in simulated real-world scenarios. This appears to place an onus for the development of CAV use on the manufacturers to have a vehicle ready for use on public roads and with other human drivers. This transition is unlikely to be easy, especially with the variety of UK road types, and traversing these through on-board cameras and radars, supported by software and connectivity to surrounding infrastructure.

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CAVs will have access to local information through advanced Global Positioning System (GPS) and vehicle-to-vehicle and vehicle-to-infrastructure systems. But they will be required to use cameras to 'see' their surroundings. The availability and maintenance of this local information, along with decisions on road markings, rights of way, verges, pathways, street lighting, parking, instructional signs, designation of road works, use and placement of skips and other temporary obstacles, and additional duties, will be the responsibility of LAs.

This report presents evidence from interviews with representatives from LAs throughout the UK regarding their preparations for, and experiences of, CAV use, and their readiness for the introduction of CAVs in their regions. Respondents ranged from representatives of LAs with very well-developed arrangements, to those with little formal implementation plans, given other

priorities and a general lack of momentum to consider the introduction of true driverless vehicles on regional roads. Some authorities have focused on public sector shared vehicles as likely 'first wave' CAVs, and others have used their existing strategies as emerging 'smart cities' to ensure they have the connectivity available for both public and private-use CAVs.

We specifically sought LAs that were interested in CAV deployment or had established plans for their use in the short to medium term. Many of the LAs in our sample were therefore well prepared for CAV introduction, were actively involved in trials and developments with third-party companies, and had invested funds and expertise to be at the forefront of the roll out of these vehicles. They have also thought about how CAVs might benefit demographic groups, accepting challenges surrounding this and establishing plans around inclusivity and access.

Yet this is not replicated across all LAs in our sample. It is clear that preparedness is predicated on individual leadership, engagement and commitment. When like-minded leaders collaborate, when partnerships are formed between LAs, communities and third parties, and when commitment from senior members is present, LAs will be better placed to take the governance role needed to make CAV roll-out in the UK a reality.

Chapter 2
Literature review and context

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The move to CAV adoption, if it is to be successful and an integrated part of modern transportation systems, is unlikely to reach its full potential without a coordinated approach by planners, engineers and government advisers and decision-makers (Litman, 2017). Policies implemented by local planning authorities will have a strong influence on how CAVs will be linked with positive or negative changes and, as such, these will largely determine whether or not they are actually "innovations [that] serve the public interest" (Sperling, 2018, p xiii).

Minimal planning at municipal level

In a survey of US local governments (a leading country in CAV development), Freemark et al (2019) found that, in general, municipal planning for CAVs has been minimal, with few specific strategies and policies. Limited evidence from the UK context suggests a similar story, with localised activity in its infancy (Fuller, 2020). Freemark et al (2019) suggest that those government plans that make reference to a strategy for CAVs do so in the absence of appropriate planning actions, suggesting the prioritisation of innovation and flexibility, but, and corroborating previous studies, typically lacking specificity. Planners

identified those issues they considered important, “frequently mention[ing] increasing street safety, supporting the transit system, and improving the environmental effects of transportation. Less important to the average city in [their] sample, in decreasing order, is using AVs to mitigate congestion, expand equity, provide last-mile connections [often referred to as Mobility as a Service (MaaS)], redesign streets, and improve quality of life.” (p139).

Where detailed planning is lacking, infrastructure change is likely to prove inadequate (Lamb, 2015), and Guerra (2016) cautions against planners taking a passive role in the assimilation of this new technology in decision-making. Here they “may yet again fail to influence the relationship between cities and a new transportation technology by either misunderstanding driverless cars or seeing them as a solution for contemporary planning problems, such as road congestion or climate change” (p211).

Yet cars remain a dominating feature of our urban transport landscape and, even with the introduction of CAVs, this will likely remain so, along with the issue of private ownership and how this will impact on the public transport system. Further, much research has yet to conclude as to the consequences of CAVs introduction for public transport. Many authors assert that it will be beneficial (Bahamonde-Birke et al, 2018; Bennett et al, 2019; Fagnant and Kockelman, 2018; Gelauff et al, 2019; Lacobucci et al, 2019; Puylaert et al, 2018; and Shen et al, 2018), whilst others identify more negative outcomes (Bahamonde-Birke et al, 2018; Gelauff et al, 2019; Harb et al, 2018; Simoni et al, 2019; Puylaert et al, 2018; and Szell, 2018).

Uncertain future

Guerra (2016), in interviews with leaders of large, US metropolitan planning organisations, found that where specific long-range plans regarding self-driving cars were missing, this was not a result of lack of awareness. Instead, strong influencing factors were that the impacts of these vehicles were too removed from decision-making about whether, and how, to invest in, and maintain, transportation infrastructure, and CAVs being just one of many potential game-changers that could affect regional transportation over the next 30 years. The principal, and very strong influence, as noted by the respondents in Guerra’s research, was the uncertainty of CAVs and their future. In a similar vein, Brown, Morris, and Taylor (2009) argued that it was the city planners’ inability to predict the consequences, and impact, of private cars at the turn of the century that resulted in their domination in planning-based decision-making on vehicle throughput.

It has been noted elsewhere that CAVs at level 5 autonomy (SAE) are within reach, yet always several years away. People are typically aware of the many driver-assistance features available in modern cars, but these are far removed from the actual ability to have the car drive itself with no person behind the wheel and no back-up driver ready to take control, as necessary. However, planners have identified uncertainties around what technologies will prevail,

the levels of market penetration, whether regulation will hinder or support deployment, issues regarding capacity and safety, and the responses of individuals and users.

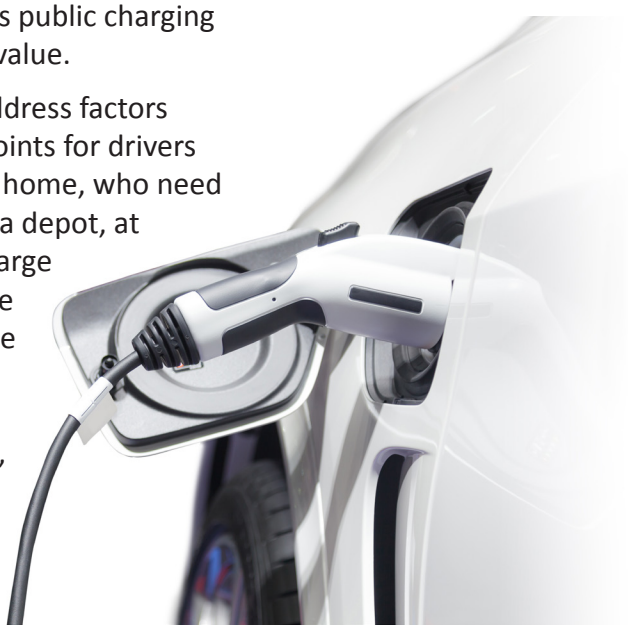
In his conclusions, Guerra (2016) warns against planners viewing CAVs as solving planning problems such as congestion, traffic accidents and pollution. Indeed, "if unoccupied vehicles circle indefinitely for free parking and run errands, any safety and congestion benefits may be substantially or entirely offset. Some planners worry about large shifts from walking, biking and transit to self-driving cars. There are also significant potential land use and equity implications" (p219).

Much of the existing research into the use of CAVs on road networks focuses on the US, and the legal (Glancy, 2015), technological (Tian et al, 2018) and infrastructural (Jo and Sunwoo, 2014) aspects. Essentially, the research has been dominated by an automobile-centric approach, which often neglects wider mobility issues (Deb et al, 2018; Hensher, 2018; Simoni et al, 2019; and Sparrow and Howard, 2017). In the UK, there has been research conducted on LAs' preparedness for this new form of transport (Freemark et al, 2019), but there is little empirical evidence to identify what planners need to do or how they can seek evidence-based data to plan for CAVs' arrival on UK streets. This research is particularly important given the stark differences between the road networks in the UK (and across Europe) and the US.

The challenges in the UK

The UK's Local Government Association (LGA) has established a guide for LAs when developing an electric vehicle (EV) strategy. Councils, including those involved in the Department for Transport's Go Ultra Low City Scheme, have been at the forefront in developing comprehensive EV strategies. And while the LGA recognises that not all LAs require this level of detailed strategy, the issues raised, including the needs of those who will access public charging infrastructure, should be considered to ensure optimum value.

Depending on the resources available, LAs will need to address factors affecting the location, and prevalence, of public charge points for drivers who do not have access to off-street parking to charge at home, who need to recharge during the day without returning home or to a depot, at car parks and train stations where people may wish to charge their vehicle after longer journeys, and for drivers who are in transit to another destination but who need to recharge their vehicle to continue their journey. The questions will then be which users and which locations are prioritised and decisions will be made as to the number of slow, fast, rapid and ultra-rapid charge points. The geographical locations of users, and the topography of the councils' responsibility, will also be crucial determinants in these strategies. Different challenges will exist for users in



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rural locations where range anxiety will be more significant than for users based predominantly in urban areas.

The move towards EV use does not stop other issues affecting LAs and town planners, including congestion and encouraging more healthy forms of transport. While reducing personal vehicle use is a positive initiative, many journeys will continue to be made by delivery drivers and other users, so moves towards providing cleaner forms of transport are advantageous. EVs and charging points should therefore form part of a sustainable and holistic mobility strategy which encompasses both private and public forms of transport.

Ultimately, the format in which CAVs will appear in modern cities also remains unclear. Cars operated by original equipment manufacturers, such as Tesla and Waymo, have a presence on the roads, and in mainstream media accounts when CAVs are discussed, but public transport will likely see the operation of truly AVs before, for example, Tesla provides a 'full-self driving' mode on UK streets. Whilst much of the existing scholarship concentrates on the use of AVs with regards to private ownership, a topic which remains largely prospective, it must be remembered that AVs are being used and trialled, nationally and internationally, with regards to public transport. Indeed, various forms of public transport are already being used on public roads in countries including Australia, Norway, Sweden, the UK and France, albeit in defined areas. The advantage is that rather than fixed-route, fixed-timetabled bus services, alternatives which provide much more efficient, effective and flexible routes are available which are beginning to utilise the whole-of-journey approach by taking passengers door to door.

Autonomous rail systems (Mezei and Lazányi, 2018) and shuttle buses (Salonen, 2018; Wu et al, 2019) may be the first examples of dedicated public CAVs, but Fagnant and Kockelman, 2018; Farhan and Chen, 2018; Gelauff et al, 2019; Iacobucci et al, 2019; Nazari et al, 2018; and Wen et al, 2019, each argue that both publicly and privately owned shared CAVs will appear in this space. Others suggest these will also develop into demand-response vehicles which can provide a more demand-driven public transport system (Liu et al, 2017; Loeb et al, 2018; Ohnemus and Perl, 2016; and Truong et al, 2017).

Whatever form these vehicles take, Hensher (2018) notes that funding for this transition will remain a challenge, typically based on investment for infrastructure changes to ensure safe operation (Chapin et al, 2017; Duarte and Ratti, 2018; Ghiasi et al, 2017; Guerra, 2016; Loeb et al, 2018; Mezei and Laza´nyi, 2018; Noruzoliaee et al, 2018; Sousa et al, 2017; and Yi et al, 2018).

2.1 Implications for cities and built environment

CAVs and EVs have the potential to act as significant catalysts for urban transformation. They may form part of a new multimodal system of travel, with increased ride-sharing, MaaS and public transport use, along with a

potential decrease in private vehicle ownership (El Zarwi et al, 2017; Fagnant and Kockelman, 2018; Farhan and Chen, 2018; and Iacobucci et al, 2019). Further, it is argued by some that the current land usage for parking spaces and car parks might be 'liberated' and repurposed, along with changes to the designs of road spaces.

Cities, and their relationships with cars, have been the subject of debate since their creation. It is not difficult to look at the design of cities, the infrastructure between them and the increased urban sprawl to see how this has manifested (see Brown, Morris, and Taylor, 2009). Indeed, this has been witnessed with every major change to transport. As Le Corbusier expressed in respect of cars, this form of transport would overturn "all our old ideas of town planning" (Le Corbusier, 1987, p123).

For car use, long, straight, wide roads, with multiple lanes and the aim of enabling an increasing number of vehicles to move in and around a city was merely an "apparatus of [cars'] circulation". Hence, with the movement towards AVs and CAVs, "… it has already become a consensus among transport planners and urban designers that they might redefine urban mobility in the near future" (Duarte and Ratti, 2018, p4). Duarte and Ratti accept the possibility for change with this new form of transport but note that the mode for change remains undecided.

City planning

With the emergence of CAVs, questions arise around the implications for cities and planners. The first is the likelihood of fewer cars being on roads and parked on streets given that people may give up their private cars for CAVs in a mobility-web where the same car is used by several people, family members or indeed strangers, throughout the day. Perhaps inconceivable 10 years ago, ride-sharing is becoming increasingly popular, and in some locations the norm. For each shared vehicle, it has been estimated that nine-to-13 cars are removed from the road (Ratti and Biderman, 2017). This may also lead to the need for fewer parking spaces given that cars are estimated to be idle 95% of the time. Will planners seek to use these spaces in different ways, and will it influence the way in which cities are developed?

Further, and perhaps as important, is the impact CAVs will have on the design of roads. Duarte and Ratti (2018) questioned whether the transition to this new form of transport would lead to more or less road infrastructure. As such vehicles will drive on a connected basis, with information being passed in real-time between vehicles and infrastructure, will traffic lights and other traditional, human-based driving regulatory systems be needed? Further, what would this mean for pedestrians and the locations of crossings?

Perhaps the movement to CAVs will provide an impetus to urban mobility, utilising synergies between urban design and innovative technologies, with larger populated cities more likely to innovate (Krause, 2011). As noted by Lu et al (2017), a Transit Oriented Development scheme was used in Atlanta,

USA, to assist higher population densities located near stations and road corridors with transport alternatives to make these viable given the increased numbers of passengers. Duarte and Ratti (2018) consider that AVs could serve a function by feeding passengers into these stations and corridors to ensure demand, and ease of access and use. They have also been identified as providing a service in cities and regions where they will operate as a 'last-mile' (a term used to denote the, often problematic, final connection for a passenger from their use of transport systems to their final destination) (MaaS) system for travellers (Ohnemus and Perl, 2016; Shen et al, 2018).

2.2 Social benefits from CAV use

There will undoubtedly be costs associated with the infrastructure changes necessary to facilitate the CAV revolution, and how these costs are distributed remains to be seen. Yet, with the emergence of these new technologies, and the consequent changes to urban planning and design to accommodate them into an existing and developing structure, social benefits are anticipated to offset these costs. A macro analysis of a CAV transport system identifies a reduction in public health costs through lower pollution levels and emissions, reductions in road traffic accidents and the social care needed in their aftermath, lower energy consumption and fewer vehicles on the roads, which will have implications for road maintenance. The reduction in the need for parking spaces may result in a planning scheme with increased social housing, parks and mixed-use areas.

The emergence of CAV use in both the public and private sectors will further enhance mobility for many members of the population who are currently not well served by public transport. When used as part of an integrated MaaS system, CAVs will enable more seamless door-to-door (whole of trip) journeys which will ensure that various demographic groups can enjoy access to more facilities. Public transit with CAVs may lead to greater efficiency, lower costs, reduced emissions, and increased accessibility and mobility (Bennett et al, 2019; Bösch et al, 2018; Fox-Penner et al, 2018; Hensher, 2018; Mezei and Lazányi, 2018; Shen et al, 2018; Sousa et al, 2017; and Wen et al, 2018).

KPMG's *2019 Autonomous Vehicles Readiness Index* identifies the adoption of CAVs across regions and explores many of the benefits to cities by moving towards AV use. The first, and most obvious, is the adoption of EVs. Whilst AVs and EVs are neither the same, nor mutually dependent, it is likely that future AVs will also be EVs due to the developing technology and, notwithstanding an international dimension and as mentioned earlier, the UK will require all new vehicles sold after 2035 to be electric. Therefore, there will be a shift away from fossil fuel and the internal combustion engine to electric-powered vehicles – which will require the necessary infrastructure to make the transition feasible.

A second benefit will be the ability of LAs to track and optimise the flow of vehicles. This will require compliance with national and international

principles, for example the General Data Protection Regulation (GDPR). This came into effect in May 2018 and, despite the UK's exit from the European Union, will continue through a 'British' GDPR. Several academic studies have discussed the various implications of privacy and data being generated by AVs (Marson et al, 2022), but assuming that the requisite protocols and safety measures are put in place, such a data sharing environment would enable much greater collaborative work between the government and private industry in the development of AVs.

The KPMG report continues that, beyond CAVs improving road use efficiency, it is also feasible that they will lead to less car ownership and therefore decreased urban space for roads, parking and garaging. The benefits for population densities and green space development and use are self-evident. Even in respect of those who would rather own their AV, this may result in individuals living further from work, leading to low-density suburbs, and the need for daytime parking, and the increase in road traffic could be avoided through edge-of-city parking, park-and-ride schemes and the whole-journey approach to transport provision.

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The report uses four headings for its evaluation of countries' readiness for AVs: policy and legislation; technology and innovation; infrastructure; and consumer acceptance. Interestingly, the first-placed country for readiness of CAV use – the Netherlands – scores less highly under the heading of technology and innovation, but scores very favourably (first place) for infrastructure. Thus, while the country would benefit from better supportive regulations, exposure to AV testing, an increased market share of EVs, consumer adoption of the latest technology, and more EV charging stations, it is recognised that starting autonomous driving in urban crowded areas will be very difficult to achieve and the Netherlands is leading the way through its road network (KPMG, 2020, p14).

On a comparative basis, the third-rated country – Norway – scores relatively low on its infrastructure, yet is placed second for its technology and innovation, due to legalising AV testing that resulted in several cities delivering a small-scale autonomous bus service (Lovdata Foundation: https://lovdata.no/dokument/NL/ lov/2017-12-15-112). Ståle Hagen, director and head of transport and mobility for KPMG in Norway, notes how the bus tests involve a variety of environments, including business parks, urban streets and even a service from a shopping centre to a beach. "The feedback on AV technology has been quite positive. Passengers are not afraid of using this kind of transport," he says (p16).

The UK ranked well in policy and regulation, helped by its establishment of the first legislative provision to regulate the compulsory insurance of AVs and data-sharing. Yet it scored quite poorly in terms of its infrastructure. It is facing particular challenges regarding both digital and physical infrastructure, including 4G network coverage, global connectivity, the quality of its roads – especially small roads – and its logistics infrastructure. However, promises by the UK government to deliver investment across its road network, and collaborative endeavours between central government and industry in the deployment of AVs, should result in network and infrastructure development to improve positioning in the near future.

2.3 Challenges to CAV adoption

As this report examines the readiness of LAs for CAV introduction, it is important to highlight potential challenges for adopting such a new and developing technology. The discussion around CAVs is often predicated on the 'auto dimension' rather than mobility. It is also often researched from the perspective of CAV as a discrete issue rather than as part of a broader conversation around active transport methods which include walking, cycling and other physical methods of travel (Blau et al, 2018; Guerra, 2016; Harb et al, 2018; Puylaert et al, 2018; and Szell, 2018).

Freemark et al (2019) noted, following empirical research, that despite widespread commentary to the contrary, several respondents disagreed that CAVs would help to increase the quality of peoples' lives, with nearly 32% of respondents perceiving that the introduction of CAVs could pose a serious risk to their cities. The rationale included concerns over reductions in transit ridership, local government revenue, employment in transportation, and social equity; and increases in urban spawl, traffic, congestion and segregation levels (p. 145). Further, Freemark et al (2019) explain how "governments reliant on parking tickets, speeding fines, vehicle registration, and fuel taxes could lose revenues, challenging cities to find alternative funding sources" (p134). Countering these issues, the literature also notes that reductions in parking and driving spaces allow for further investments in living and working environments (Duarte and Ratti, 2018; Ghiasi et al, 2017; Hawkins and Nurul Habib, 2019; Nourinejad et al, 2018; and Meneguette et al, 2016).

Several academics have expressed concerns around adopting CAVs, including decreased mobility, accessibility, security and safety matters. Further, shared mobility may receive less take-up due to safety and security concerns. Also, researchers have questioned the veracity behind the claim of reduced vehicle accidents, and have proposed that any such assertions will be non-provable in the first 100 years of operation (Bösch et al, 2018; Cohen and Cavoli, 2019; El Zarwi et al, 2017; Harb et al, 2018; Hensher, 2018; Kalra and Paddock, 2016; Legacy et al, 2019; Liu, 2017; Millard-Ball, 2018; Rahwan, 2018; Salonen, 2018; and Szell, 2018).

Kassens-Noor et al (2020) note a general lack of work on alternate mobility

scenarios, land-use interactions, liveability, transition periods when both CAVs and human drivers occupy road space, and impacts on the natural environment. They explain how CAVs represent a new form of mobility, but one which will have its impact assessed on how they are governed and used, which will depend on decision-makers' abilities to harness the benefits and minimise the disadvantages.

Managing the transition

Moving towards more detailed and pragmatic problems in transitioning to a CAV-based transport system, the first issue facing planners is the enhanced standards of road maintenance necessary to ensure that CAVs can identify and 'see' their environment effectively. Carriageways, traffic signs, stationary and mobile signals, lane markings and traffic cones all need careful consideration if CAVs are able to traverse modern, complex traffic systems in the UK. As noted by Johnson (2017): "CAVS are unlikely to develop to their fullest potential without advanced planning by transport policymakers, planners and engineers to ensure infrastructure change is adequate" (p v). This will require joined-up approaches from local government, county councils, Highways England (along with their counterparts in the other regions in the UK) and so on, to plan and operationalise road enhancements, scheduled maintenance, strategic investment, and asset management strategies (Houses of Parliament POST, 2013).

First, roads will require preparation and detailed maintenance to accommodate CAV adoption and avoid a piecemeal, incremental approach (Johnson, 2017). Ahmed Khan et al (2019) identify road infrastructure as being crucial to successful deployment. Road surfaces, markings, widths, speed traffic management systems, curbs, cycle paths, dedicated lanes for buses and taxis are all aspects to be considered. CAVs will take a specific path on the road and will each likely follow other vehicles, thus there is a likelihood of specific tracks being formed by vehicles following the same route and road positioning. Road condition also presents concern when CAVs are at level 5: that is, fully performing the driving with no human interaction. Potholes, for example, have the potential to cause damage and accidents where vehicles may not 'see' them. Such problems will quickly be exacerbated by all CAVs driving over the pothole without necessarily attempting to avoid the damaged road.

Albeit within the context of the aviation industry, Johnson (2017) explains how the approach to maintenance must change as automation increases. For safety purposes, the infrastructure must be better kept and, as this process becomes more sophisticated, the workforce needs upskilling, resulting in increased costs to pay for the service (Bernhardt & Erbe, 2002).

Detailed road network schemes, along with strategic planning for their roll out, are requisite features of CAV operational functionality (Rodoulis, 2014; and SWOV, 2015). Johnson (2017), citing Gill et al (2015), asserts that such

infrastructure planning will work on a 30-year cycle. New road design will also need consideration of the use of gradients and their effects on AVs, and different lanes with specific functionality (Bergenhem et al, 2010).

Beyond these geotechnical issues, planners focusing on practicable solutions for CAV use (Vock, 2016) will need to design communications units (perhaps in areas where accidents are prevalent, Land Transport Authority of Singapore, 2016) which bring substantial upfront and continuing maintenance costs (Weeratunga & Somers, 2015). These include traditional communications, including road signs and markings, and traffic lights, along with electronic communications through mobile networks. Issues around latency with 4G connectivity, and network connection associated with built up and dense urban areas (Desouza, 2016), will need to be costed into future programmes.

Finally, and generally, there are relatively few publications which provide any meaningful discussion as to the likely effects of CAVs, and their impact on, larger-scale matters, including the natural environment, climate change, and energy consumption (Kassens-Noor et al, 2020).

2.4 Planning and urban development

Ahmed Khan et al (2019) produced a 'CAV readiness index' to determine whether cities were prepared for, and in a position to respond to, advancements in CAV technology. They gauged a city's readiness against three metrics: policy and regulatory situation; physical infrastructure; and cyber infrastructure. While this was a US study, covering 13 major cities and based on questionnaire data, it did raise interesting dimensions, including the necessity of local authority buy-in, and establishing a dedicated CAV department (as they note exists in New Zealand, the UAE and the UK) to boost the scores in a CAV Readiness Index.

More recently, the LGA (2021) completed a UK scoping exercise regarding the EV charging infrastructure which will be crucial for the effective take-up and use of CAVs. It transpires that LAs had researched their EV charging infrastructure, but did not have a clear vision of their role in ensuring residents' access to vehicle charging. They found that current LA funding from central government was very short term and consequently, it made strategic planning substantially difficult. Even so, it may also be the case that LAs making these strategic plans risk 'locking' themselves into a future before fully understanding the impacts (Stone et al, 2018). Clearly, a national strategy that LAs feed into is needed to ensure the UK remains capable of CAV deployment when the technology and the environment are ready.

Chapter 3
Methods

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This study focuses on the strategic and operational practices of LA planners and policy-makers as key stakeholder groups in the assimilation of CAVs on UK roads. Its findings come at a pivotal time for LAs, given the commitment of the UK government to introduce CAVs onto national roads by 2025 and the competing demands on LAs' already squeezed and dwindling resources (Gray and Barford, 2018; Dickinson et al, 2019).

As our study investigates, LA preparedness for the introduction of CAVs, and responses and strategies for implementation and continued development, are crucial. As noted in Chapter 2, many infrastructural aspects are required to facilitate such a dramatic change in road use. This research focuses on case studies in a country in Europe where the urban road landscape is markedly different from the US (where most similar research has been conducted) and therefore identifies key elements in the approaches taken by LA officials in achieving CAV roll-out.

Our choice to pursue a qualitative paradigm for this study is informed by our ambition to produce a holistic, detailed and pragmatic account of subjective behaviours and approaches of the actors and their institutions within the study population. While Creswell (2014) notes the viability of quantitative methods due to their inherent rigidity, a qualitative approach is particularly useful in this study as interpretive methods provide flexibility to adapt

our questions and the parameters of our research according to emergent patterns in real-time (Yin, 2017). The nature of research in this area, and the approaches taken by LAs, are idiosyncratic and subjective, albeit underpinned thematically, and the detail and reflections provided by respondents would be lost with a numerical method (Creswell, 2009).

Our intention is to ascertain the use of planning, modelling and testing in gauging perceptions of the need, use and future of CAVs in urban and regional, public and private, and individual and interconnected transportation systems. In presenting a rounded and layered interpretive rendition, and exploring how it manifests in everyday social locations, our chosen methodology provides the most valuable and compelling evidence from which to draw conclusions (Harrington and Yngvesson, 1990).

Multiple-situated study

To investigate the potentially complex issues around LAs' preparedness for CAV introduction (Bryman, 2016) within the real-world context, the research programme comprises a multiple-situated study (Yin, 2017) with eight LAs across the UK. These were identified from a scoping and benchmarking exercise based on available literature and policy documentation. The study adopts a convenience, non-probability, approach where participants are sampled because they are 'convenient' sources of data (Lavrakas, 2008). Convenience sampling is most effective when accessing populations where developing trust to access these populations is important.

It is also particularly helpful in the context of this study as we are interested in LAs that are actively engaging in CAV development and implementation in existing and forthcoming planning strategies. These LAs are more likely to be among the most 'prepared' areas and bodies for this emerging technological development; produce detailed planning documents; and will know when, and how frequently, such documentation will be reviewed and assessed. Therefore this sampling method is justified in this regard (Stratton, 2021).

LAs were selected according to criteria including the extent of publicised work in the trialling and use of CAVs on public roads; the existence of dedicated research institutes working with the LA; the size and strategic importance of the location; and the complexity of the local topography.

We acknowledge that the adoption of a convenience-based and multi-case study sampling method (Yin, 2018) necessarily limits the generalisability of our findings (Bryman, 2012). The choice of study sites raises issues regarding how representative the data collected is to a wider population (Creswell, 2003) and whether the interpretive insights generated from any one location might be transferable to others (Ford, 1998).

Yet some generalisations will be produced through contemplation of the evidence presented in the available literature; thorough coding and analysis of data to identify themes from LAs at the cutting-edge of CAV deployment in

the UK; and with reference to international studies which make our findings potentially applicable elsewhere. International audiences may find our conclusions useful in their considerations (Stake, 1995).

We supplemented the responses provided by representatives from the LAs with interviews from experts involved in another project run by a member of the research team investigating CAV use and the challenges facing cities and regions. This project was titled 'Connected and Autonomous Vehicles: The Challenges Facing Cities and Regions', and was funded by the Regional Studies Association. The interview data from that study has been reanalysed for this work to provide broader policy perspectives where appropriate, and are not conflated with the evidence provided by members of LAs. For clarity, responses from these individuals presented in Chapter 4 have the designation 'specialist' following their main area of expertise. For example, one respondent with a specialism in CAV risk management is designated as a 'risk specialist'.

Participants were sourced from LAs and associated organisations in the following departments/divisions: climate change; data and digital innovation; decarbonisation; economic development and regeneration; highways, roads and transport; planning; transport planning; transport operations; and transport innovation planning. When quoting these respondents, and to ensure anonymity, we have designated these individuals as 'LA 1' and 'LA 2', and so on. We intentionally focused on seeking responses from officials such as directors and innovation leads, while acknowledging that policy promotion is an activity shared among many individuals (at varying levels of authority). However, we considered that where LAs develop and operationalise policies related to CAV use, such officials will play a strategically important role, being informed of policy-setting and formulation (Marsden & Reardon, 2017).

Insights from interviews

To understand group consensus (Savin-Baden and Howell Major, 2013) and yield rich insights (May, 2011), the research draws on data collected from semi-structured interviews (Jones et al, 2008). This amplifies the intensity of this research design by enabling the collation and analysis of data (Bryman, 2001; Piatt, 1988; Cresswell, 1998; and Yin 2003). What's more, these empirical perspectives allow for the integration of methods in a way that improves the overall understanding of the phenomenon of interest (Creswell, 1998; Hakim, 2000; Ritchie and Lewis, 2003).

In total, data from 21 interviews is included in this analysis. This includes 11 from LAs collected over three months in the summer of 2022. Data from a further 10 interviews with respondents from associated organisations (part of the separate aforementioned study) were undertaken in autumn 2021. All interviews were recorded electronically, transcribed and edited to omit non-essential personal information.

The data was collated in notes and audio recordings, and transcribed. We used qualitative techniques to undertake the coding and analysis process.

A multi-level, inductive thematic analysis was adopted with themes drawn directly from the data collated and their arrangement informed by the literature (Glaser and Strauss 1967). Sets of open thematic parent nodes were created, centred around the relevant empirical frames. Sub-nodes were then established to represent a more nuanced understanding of the responses regarding: planners' understanding and awareness of new technologies and their impact; the need for planning based on current and projected CAV use in the region; the issues surrounding certainty and available implementation based on current knowledge; and the impact and reflection on existing strategies and their efficacy.

The data was reviewed for commonalities and dissimilarities and, once the thematic arrangement was complete, we coded the data in open and inclusive forms with the resultant data reduced into thematic groups. This process aided the thematic arrangement and discovery of patterns within the data pool. These data was then triangulated, with the interview data compared with wider observations to identify any conflicts with the aim of amplifying its consistency and veracity. The findings are presented in the following chapter.

Chapter 4
Results and discussion

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The findings from our research both complement the existing work on CAV preparedness through the operational and strategic policies enacted by LAs, and raise new and emerging trends which help focus the attention of planners who are, perhaps, at an earlier stage in their preparations and decision-making.

Whilst previous studies have recognised a tendency for planners to adopt an automobile-centric understanding of CAV deployment, our findings demonstrate how broader concerns about transport and mobility more generally are very much part of the thinking and decision-making that is guiding policy development. These approaches are supplemented by engagement with communities, awareness of the need for infrastructure and technological developments, and considerations of how and where CAVs may fit into existing transport systems.

Our in-depth interviews with respondents provide significant and novel insights with regards to the work of LAs, their involvement in 'test-bed' projects and in preparing the infrastructure for the deployment of CAVs,

and those individuals and groups involved in leading and championing the preparedness for CAV roll-out.

A key theme that emerges from the interviews, and a starting point of our investigation, is the extent to which CAVs feature in strategic policy planning and decisions of LAs. The policy context is crucial in explaining whether investment and commitment to CAV deployment happens through clear strategic decision-making, or if it is, perhaps, left to smaller groups and interested personnel to investigate and operationalise. It is recognised that LAs are key players in this realisation. Rather than simply waiting for central government's lead, the respondents are engaged with some form of CAV deployment strategy, even where this is not to be explicitly found in a formal policy document.

4.1 Policies and practices: Towards the use of CAVs on public roads

Our in-depth interviews encourage respondents to guide conversations based on their own experiences, their work with colleagues and external partners, as well as the specific, and sometimes unique, topographical make-up of their local region. We consider this to be a significant contribution to this emerging area as it has so far not received this level of attention.

Of the respondent LAs to this project, many had begun to embrace the concept of being a smart city and had sophisticated plans and structures in place for the incorporation of 5G networks. These are essential for the connected aspects of CAVs and to enable real-time tracking of vehicles, communications between vehicles, and communications between vehicles and infrastructure. Some authorities are also developing plans to harness the information from CAVs, similar to how they use tracking devices through CCTV to identify traffic issues and ensure efficient and effective responses.

> *"Our current local transport plan has a fairly strong nod to the role that CAVs could make... Now we're starting to think about our next local transport plan, and very much it's now coming into mainstream that CAVs will have a role to play... [We] looked at a timeline of when we think these things are going to manifest themselves within the city and we recognise you can connect to vehicles, connect to systems and building infrastructure in the city to support that connectivity. Our last project in this area was working to create a 5G network so that we could start connecting vehicles and everything that moves over a real-time information base. So, recognition that connectivity, smart parking, and smart traffic signals etc… is already emerging in cities." (LA 1)*

… recognition that connectivity, smart parking, and smart traffic signals etc… is already emerging in cities.

Above all, short- and long-term planning, a strategic approach which involves key partnerships with external actors, sufficient and available funding streams to plan and operationalise infrastructure support, and key personnel to champion and lead development policies, are required for successful CAV preparation and deployment. Thus, our findings add to the evidence base

for research-informed practice which, according to Freemark et al (2019), had been lacking around LA preparedness for this new form of transport. Yet, we note that for several LAs, CAV preparation has not reached a point of sufficient critical importance to establish itself as a feature in formal planning and operational employment.

> *"I think it's quite difficult for an LA to understand exactly where everything is with autonomous vehicles. I think we see a lot of glossy stuff either from large American companies and the European-funded and DfT-funded projects. From the LA perspective, we don't get any questions about autonomous vehicles, it doesn't really come up yet." (LA 2)*

> *"I just think everyone is still trying to understand the timelines, what preparation they may need, and how their strategies will need to evolve to cope with this kind of technology. I think there was a feeling that it was around the corner at this time about three or four years ago. But I think people have become a lot more realistic in their thinking and I do think that it has slipped down the priorities." (Smart specialist)*

The lack of specific CAV presence in strategic policies is not, at least for some LAs, the result of ignoring CAVs as a feature of new and existing transport strategies. Rather, there is a strategic movement away from private-use cars, often to achieve policies including clean air strategies and to promote more active forms of travel.

> *"I think the bigger challenge is we've got to take 36% of the cars off the road and we've got to do that quickly. We need to go through a huge behaviour change programme. We'd prefer people to be more active [than to transition to CAV use]." (LA 3)*

> *"We don't love electric vehicles, because they're still cars. In suburbia, that's a good way of reducing your CO2 and your particulates etc, but once you're in the city centre and you're starting to think about place and how vehicles and having road space impacts on something else you could do with that land, we probably still don't want cars in the city centre, whether electric or not." (LA 2)*

It is very possible that with the introduction of CAV technology, LAs will be faced with changes to key aspects of mobility generally, and car use in particular. Influential studies note how cities have largely been established on the basis of car use, and road structures, road and building developments, and income-generation strategies have often been formulated around the basis of private car use.

Perhaps one of the most compelling aspects of CAV use was summed up by Duarte and Ratti (2018) who remarked how, in respect to CAVs "... it has already become a consensus among transport planners and urban designers that they might redefine urban mobility in the near future" (Duarte and Ratti, 2018, p4). While Duarte and Ratti found a consensus among transport planners and urban designers that CAVs might redefine urban mobility, this

is not particularly seen in our research. However, our findings do, in part, corroborate their further point that CAVs are likely to be the catalyst for change, yet the nature of the change is far from decided nor necessarily obvious.

> *"We are looking at it all cohesively, pulling it all together, gradually getting there but it's small steps... It's really hard to convey the significance of it to people internally. We don't really quite get it, all this smart city business, lots of people, the chief executive included [asks] 'where's the benefit coming to us now', and it isn't now, it's in the future. So that's the worry really because it is so long term. But I feel we've made enormous progress with what we've done, but it's not looking like the sort of fancy project that you might say 'here's a team of people with autonomous vehicle in their titles', it's 'here's the traffic regulation team, here's the permit team, here's the CCTV team and this is the bit of software that joins them together'." (LA 8)*

Such thinking surrounding CAV policies and their propensity for change is often predicated on technological uncertainties...

> *"With connected and automated vehicles, we still think the technology has got a little bit of a way to go, but in the near term are the connected rather than the automated [vehicles]. The potential for us would be at some point starting to see things like demand-responsive transport being able to be done through an automated vehicle." (LA 3)*

... and on the nature of the likely controlled roll-out of fully automated vehicles.

> *"We're not 100% certain that [CAVs] will have a role to play in the city so we're still at the relatively small scale. We're getting close to an operational service to deploy and that will build confidence in LAs to invest some money in these areas. If it's a cheaper option or a better option to subsidise and create these services rather than continue to subsidise traditional buses, if we get more return on our investment and can demonstrate that, that's when cities will start investing more heavily into these types of services and be braver in what it does to enable them to happen." (LA 1)*

Thus, longer-term planning is impacted by current, pragmatic, realities.

> *"We've also got a high percentage of properties that don't have off-street parking ... So even if you're looking at things like [charging] hubs [to facilitate electric vehicles, and thus more likely CAVs], it's not straightforward for us. We're very interested in getting involved [but] it's about trying to predict what's going to happen, it's about trying to pick up what's already out there." (LA 4)*

While the respondents note the need for infrastructure change, improvement and maintenance (especially with regards to paths and curbs, traffic lights, road widths and road markings), these often are not advanced to the point of incorporation as CAV-specific initiatives. This remains a stumbling block to

the successful roll-out of CAVs (certainly private vehicles at SAE levels 4 and 5) which use their cameras to identify their surroundings and anticipate other users and risks. Not only is this a limitation to CAV deployment among the respondents to our study, it is an impediment to the seamless travel of such vehicles around the UK.

Motorways will soon allow limited CAV use for vehicles approved for ALKS, but the strategic implementation of infrastructure compliance (at whichever SAE level this may be set) is needed to enable their use without the need for a driver or to enable a door-to-door travel strategy to be implemented.

> *"We're looking at all our city centre car parks... we've got a clear direction of what we want to do with that and we've started putting chargers in car parks incrementally. But then, of course, you hit the thing of you can't just add another charger when you fancy it, assuming you've got the money you've got to make sure there's a supply coming to that location which would mean a complete redesign." (LA 4)*

> *"[A private organisation collaborator] did a piece of work for [UK government body] and... every LA is to develop an EV strategy which should be a partnership working with an external provider unless the LA can cover all the costs. [But] our [power] grid can't cope, our grid's folded basically... we need four times the grid capacity. (LA 5)*

"It's still perhaps too much of a leap of faith for a LA to spend significant amounts of money to enable CAV implementation.

Uncertainty as to government intentions for CAV deployment is also holding local authorities back...

> *"I'm shying away from writing an infrastructure strategy for EV across the whole city for the public as well as private [vehicle ownership] because, to be honest, it could change next week as we don't know what the government's doing." (LA 4)*

... and the inevitable issue of costs and financial commitments continues to impede full-scale initiatives.

> *"It's still perhaps too much of a leap of faith for an LA to spend significant amounts of money to enable [CAV implementation] to happen. I'm sure of the technology, the public response to it and the return on investment, it's still far easier for LAs to invest in what's understood... bus services or walking and cycling." (LA 1)*

> *"[CAVs by 2025]. The challenge for us, it's not unrealistic but it needs to be backed by funding. The problem is as a combined authority or even an LA we don't have the money to initiate one of these trials or projects or services on our own, at some point we hopefully will have a business case to say it's better to run an automated vehicle rather than a tended bus service. If you've been speaking to LAs you know everybody's cash-strapped and risk-averse at the moment, so I think there's got to be lots of investment now to potentially make some of these trials happen, to create them, to put them in front of the public and start to build those business cases – start to mainstream that technology. Then you start to unlock the opportunity for others to utilise it." (LA 3)*

Several respondents comment on the benefits of CAVs for aiding the mobility of ageing populations and for those with disabilities.

> *"Research identified stakeholder mapping [and] clearly disabled groups, [and the] less mobile were areas that we need to ensure are catered for. But we also recognised that we wanted to give greater mobility to not just disabled people or the less able, but our ageing population that we wanted to keep mobile and active. We've engaged with those groups and younger people, because we also recognise that those coming through the school cohorts at the moment are the people who are really going to be using these vehicles. So for both ends of the spectrum, we needed to understand and work with our community around what their view on CAVs were." (LA 1)*

Yet, LAs are mindful of how CAV transport can entrench inequality, especially through trials and use in regions which are deemed 'safer' than low-income areas.

> *"It should be a way of getting past inequality because certain areas, low-income areas, tend to not have good transport or bus links and stuff like that, [they] kind of get left out. So, that's the balance between inequality in the service, the availability of the service, and how it can either be used to entrench inequality further or alleviate it." (Engagement Specialist)*

Respondents note that CAVs, while perhaps increasing commute times through strict adherence to speed limits and largely autonomously determined routes, might prove favourable to travellers. It is envisaged that passengers will use their commute to engage in work without distractions, or enjoy entertainment in more readily accessible ways than when using public forms of transport.

> *"What will likely happen is that there will be a shift towards vehicles that are cleaner, more automated, but remain personal vehicles, and that will cause more congestion, and that will become a disincentive to people using those modes. I think it will become harder for LAs to embed that personal travel from people's everyday lives. The air quality argument would have gone, but the comfort and the independence of that personal travel mode will become even more difficult to shift. People will be happy to sit in their car for longer – their 30-minute commute becomes a 50-minute commute because of congestion, but they don't mind because they're watching Netflix, or playing games, or doing their work, sleeping etc." (Ethics Specialist)*

"What will likely happen is that there will be a shift towards vehicles that are cleaner, more automated, but remain personal vehicles, and that will cause more congestion, and that will become a disincentive.

Furthermore, commuters may avoid the negative aspects of traditional forms of travel, for example, switching trains, alighting from buses or using park-and-ride schemes. But the ease and use of CAVs may lead to an extending of journeys away from urban city centres, having negative consequences for workers on lower incomes, or key workers whose occupations are in the city.

> *"Convenience is going to play a very big part in people's decisions on where they go. You could have a mass transport system that works,*

> *but ultimately if it takes me an extra hour, when I can just get into my car and drive there in 20 minutes, I'm going to make a decision that's more convenient for me. So there's a mass social dilemma to it." (Intel Specialist)*

Such concerns have been explored by Lu et al (2017) in respect of the Transit Oriented Development scheme through road corridors to make urban areas beyond cities viable for public transport systems (aided by the increased numbers of passengers). Transformation is evident, therefore, far beyond the clean air and environmentally friendly system of transport that CAVs are anticipated to bring.

Several respondents note that the physical framework of their region dictates their approach to CAV and EV infrastructure. One example notes a previous policy of moving street lamps from the front to the rear of pavements. Yet, with the necessity for EV charging points and the region dominated by terraced properties with no private driveways, the choice of repurposing street lamps as both lamps and charging stations, whilst not causing a nuisance or hindrance to pedestrians using such streets, is no longer viable. Hence, our findings somewhat contradict those of Freemark et al (2019) that the redesign of streets (to accommodate CAVs) is less important in planning policy.

This results in respondents using existing structures, car parks, park-and-ride stations, and so on as charging points, enabling travellers to access charging facilities when these may be less available when parking near their home. Some of these initiatives involve dynamic charging speeds, depending on the particular use of the vehicle.

Respondents spoke of ensuring that policies are in place, in accordance with government direction, for new buildings to have EV charging points, to encourage employers to install these in workplace car parks, and to collaborate closely with private sector organisations to increase the availability of charging points. Therefore, a transition to the means of using CAVs is being seriously considered. Indeed, it is well developed in several LAs. Yet the problem remains, and is not, for the respondents at least, addressed in respect of the capacity of power grids to cope with expansion of EVs on a scale of internal combustion engine (ICE) vehicles.

> *"I'll give a simple example of what we've done with one of our multi-storey car parks. We built a big performance arena and we recognised there would be a need for people to park nearby, so we built a multi-storey next door to it. On the ground floor, you've got a number of electric charge points. The car park works in two ways. In the day time it acts as a commuter car park, so people park up and charge slowly for eight hours, yet in the evenings people are coming to an event that might last two or three hours and they may be coming from a greater distance so they probably need a rapid charge. That's starting to influence our own choices around EVs and charge points." (LA 6)*

> *"We're working with [a private company] to develop electric car share so we can put those vehicles into communities and start to develop the sharing notion of vehicles. If autonomous vehicles come in the future, a sharing culture would lead to market growth, especially if they're electric. [Our concern was if the previous user forgets to charge the vehicle], we're working with [the company] to demonstrate a wireless charging solution – the vehicle will drive over a pad and pick up the charge – it's all automated and so you can start to see a situation where an autonomous vehicle would be able to do that and drive over a pad. We're working with a university to get the charge rate up to about 20kW (so it's a meaningful charge)... [This will have implications] for disability groups, they find it difficult to lug cables out of the back of the car and plug in. So it's helping with the car share market and it's helping out the use of EVs too." (LA 1)*

Despite some LAs responding that they have no policy for CAV introduction, they report, and enthusiastically discuss, their current and short-term planning and CAV-testing. This is particularly so when the LA works with an external partner to help identify, and solve, a problem not envisioned or encountered in a test-bed environment.

> *"There's a recognition that CAVs will need some support and assistance, hence the work that we did on the 5G network, because we learnt from our first deployment that the connectivity wasn't secure enough or good enough to allow you to start taking the safety operator out of the vehicle because we wanted to run the CAVs from a control centre. So rather than building lanes and upsetting motorists, could we look at it in a different way and improve the connectivity and get to the control room as a first step using level 4 and traffic controllers? That still may need some segregation on some routes to maximise safety and get through problematic junctions, but that is a natural step and we think beyond that, that's when the fully autonomous will come in, that's still probably five-to-10 years away." (LA 1)*

Significantly, the respondent continues:

> *"But we don't want to wait five-to-10 years until that's all developed and done. We want to be leading and starting to think about and integrating these services into the city now because we've identified a real need and a real opportunity to move to that step fairly quickly." (LA 1)*

> *"The guys would come in first thing in the morning, the road's clear, test it, map it, works wonderfully. Come the time to launch... and see how it operates in a real-life environment, they couldn't get out of the car park because... there's a constant flow of pedestrians. The vehicle will not go forward for safety reasons. So... we've got a solution... effectively as a normal human being would do, the vehicle starts gradually nudging out in a very, very low speed. So those were the real-life scenarios, you couldn't have tested that in a closed circuit, you couldn't have envisaged putting that technology in or envisaged developing that bit of software, this is what you do in a real-life scenario." (LA 7)*

One LA respondent explains the development of sophisticated situation-dependent systems to assess the effects that CAV deployment can have on the city.

> *"We created a scenario with set points within the city where people can be picked up, dropped off, use these [CAVs] and can be efficiently going to what effectively could be like the front of an airport, drop off, next person uses them and moves around the vehicle. We developed a transport model to look at that and how that would impact on the city and the business side of that – housing, business parks, whatever. We looked at a number of 'what if' scenarios if and when we might have 10, 30, 50, 80% of highly capable CAVs on the network and see what impact that had on the city. We also did a secondary study on this notion of could a connected and autonomous vehicle create road capacity where the all-knowing car might be able to operate on a highway better than a human? And if you have that capability, could you tinker with modelling parameters to demonstrate whether this actually increased capacity on your highways and could support a growth in CAVs?" (LA 1)*

Engagement with businesses and the local community is also a crucial aspect of planning and participation in CAV testing.

> *"We want to take a role of understanding what will develop and trying to accelerate the good things. [For example, a recent project of ours involved] a consortium across Europe looking at how cities are prepared for the introduction of CAVs. What that tried to do was understand, in a framework, where cities were in their route towards being knowledgeable and understanding the role of CAVs in their locality. We also developed approaches and ways of engaging with people, because part of this is hearts and minds and understanding what people's attitudes are towards CAVs. We looked specifically at the private vehicle and what role that might have... our view is they're unlikely to be privately owned, it's a shared resource and who would they be used by in the city?" (LA 1)*

> *"We've got very strong relationships with a number of key industry partners, so we do have a range of contacts and I tend to speak more to business contacts in my day-to-day job than I do to council colleagues because a lot of this is driven by the business models, recognising that the council hasn't got funds to throw at things. It's all well and good having nice little pilot projects that run for a couple of years then disappear. It's about sustainability. How do you build the capability that then is a sustainable service, or technology that then can develop to support industry or more mobility in the city? So our focus is very much on developing those partnerships and developing sustainable business models to move these trials to actual services." (LA 1)*

There are also examples of particularly innovative uses of autonomous forms of technology.

> *"We've got a fleet of 200 autonomous delivery robots, about the size of a small pram, in a delivering operation for four years. It was a*

deployment to see what the potential was for this as a service and we took a risk of putting these on our highways where it was very unclear what the legislation or regulation about them was. But we got over that hurdle and learnt through the deployment that our citizens absolutely love them and use these. It's delivering outputs that we only recognise after we'd done the trial, i.e. that 70% of the deliveries are replacing a short car journey of less than a mile." (LA 1)

4.2 The use of CAVs as public and private vehicles

Respondents discussed differing approaches to preparedness for public and/or private forms of CAV deployment.

It is clear that private transport is an important consideration, especially for those LAs working with external organisations in the private sector (for example car manufacturers). There is a clear distinction in approach dependent on the location of deployment, with more urban settings proving difficult to manage.

"In the longer term, I think it'll be private sector more quickly, just because probably there'll be something around HGVs sooner or later... where you've got something on the motorways because you've got a much more controlled environment. I think there's a long way to go before you've got an urban road arriving... I think you'll probably get taxi-type stuff, but it won't be a taxi as we know it, it'll probably be next, but individual self-drive I think is probably going to be longest." (LA 9)

"We can't have everybody having their own little autonomous vehicle because that's terrible for congestion and that's terrible for health. We want to see the investment in automated mass transit or automated public on-demand transit that supports the active travel and people being active." (LA 3)

With public sector vehicles becoming autonomous, the responses fluctuate between changing existing forms of public and quasi forms of public travel (buses and taxis) to CAVs, and seeing new forms of transport emerge (robotic CAVs and assistance vehicles).

"Our challenge is to reduce car use and support more people being mobile. So we have to ensure that some of these systems we're developing support all our population, support business growth and activity in the city centre, reintegrate the high street, all those aspects, so that's where we're focusing our efforts on this as a potential solution. For example, if a minibus service we currently have in the city centre shuttles business people around to get to shops and activities, would that be better and more efficient and could it be expanded if it was autonomous? You're reducing the cost with no driver and perhaps developing the system that people would be attracted to rather than asking them do you want to jump in that hot, sweaty, diesel minibus?" (LA 1)

"I think the future of autonomous vehicles really arises in two specific areas. Public transport, because both the societal benefits and the

> *economic benefits are aligned, especially in rural areas. Public transport has the benefit of lower cost per mile, even though the capital costs are higher. And it has dedicated and technical feasibility. It has dedicated routes that you can equip and specifically geofence locations… This is very good also in the general agenda for cities and rural areas because you want a modal shift away from the private vehicle to shared mobility… in rural areas a lot of services have been cut because the main cost is the driver, so hopefully autonomous vehicles can support these areas." (Mobility Specialist)*

> *"We've thought about it from a mass transit (and public transit) perspective. In terms of the private car, we're trying to push people onto shared mobility rather than everybody having their own little pod that will drive itself around." (LA 3)*

One respondent notes, however, the realisation that private CAV use is inevitable, at least for the foreseeable future, due to the reluctance of some people to use shared public transport.

> *"I can't see any reason why autonomous vehicles would only be public. If your autonomous version is only a public version, some people aren't going to get on a bus whatever, so therefore you're always going to exclude a chunk of the population. You might find, in the short term when they're released initially, they want to test it on buses as an example, because they're tried and tested. Maybe that's a useful pilot approach to take. But I don't see how it's going to achieve the benefits that are hoped for with autonomous vehicles if it was then only ever public." (LA 6)*

A particularly noteworthy aspect of the responses is the variety of perspectives with respect to the physical infrastructure necessary for CAV adoption. Some imagine cameras on the vehicle, requiring physical markings to be made available and maintained. Other respondents consider an emphasis on the vehicle manufacturer establishing the internal computing and guidance systems, in conjunction with roadside communications networks, as the primary mechanism used.

> *"Obviously how we mark out roads is going to be quite key. We haven't gone down that route, so at the moment, I'm not aware that we've got a template that says these are the white lines that go on because we know they're going to be able to be read by autonomous vehicles. We may be thinking about that, but I don't think we've committed to that sort of route." (LA 6)*

> *"It does put pressure on Parliament, authorities or regions to design their architecture, their infrastructure, so that it supports this technology better. But currently road line markings are quite supported, because a lot of it is done through vision sensors. But those visual sensors are problematic in conditions where they are occluded, so with snow, the whole thing breaks down." (Risk Specialist)*

Consistency of technology and passengers' ability to seamlessly travel from

one LA to another, is a further issue for planners.

> *"X council are going to be building their own V2X smart cities grid. That's not viable for them technologically or financially, so I think there'll probably be some kind of off-the-shelf solution. It's having a consistent approach so that if one vehicle enters one LA or town, it will understand and be able to communicate just like it would in another." (Intel Specialist)*

4.3 Social benefits from the introduction of CAVs

For the public to accept CAV use, several dimensions must be present. The public must trust the use of technology, accept its likely failures (as they do with human frailties), and be willing to use transport which has no driver, even to a point where no person is behind a wheel (for as long as they exist) to take control if necessary. This is a significant undertaking and one to which our respondents have given serious consideration. Not only on a policy basis, but also as part of dialogues with their communities, respondents explain how public information campaigns and liaising with demographic groups has allowed LAs to tailor information and education approaches to ensure the public are as well informed as possible for the introduction, or increased use, of CAVs.

An obvious aspect of CAV use is the move to EVs (given how this is strong government policy and subject to legislative action). This enables, for example, clean air strategies and associated benchmarks in both city centres and population-dense urban areas, to be met. Our findings challenge the caution issued by Guerra (2016) for planners not to take a proactive position about CAVs and their relationship with climate change. Climate change, clean air and sustainability initiatives are common themes underpinning transport strategies. They are mentioned specifically in respondents' plans, and in one case at least, are the driver for the authority's transport plans covering the next two, five-year strategies.

It is anticipated that, only at that stage, and when more fully developed, will CAV use realistically be included as a meaningful contribution to subsequent policies. Hence, Guerra's (2016) caution against planners not taking an active role in decision-making for new technology was not fully realised, but there are certainly instances where planners see CAVs as more of a clean air, predominately EV transport solution, than perhaps the transformative answer to transport problems.

This may be due to the media portraying CAVs as simply private cars or buses. Clearly, the sector is more inclusive, encompassing drones, aircraft, boats, and so on. Yet, one respondent notes the innovative use of CAVs, where the portable device has been used to provide pedestrians with greater security and help. This is one of several examples of LAs taking an active role in developing CAV technology with private organisations to trial its use.

Respondents consistently speak of the broad transport policies for which they are responsible and in which their teams function. They explain how CAVs can fit into the larger understanding of transport across their region, and their effects on existing moves to active forms of transport. Indeed, concern is often raised regarding the possibility of CAVs stopping walking, cycling and, in their private guise, reducing the use of public transport – such as buses, trams, trains – given the private and contained mode of transport that private CAVs provide.

Similarly, our findings highlight respondents who are encouraging their LA and teams to take a holistic view of transport – going beyond CAVs as merely cars and buses without a driver, and identifying a range of possible uses for vehicles which can improve the lives and experiences of their communities. Whether these involve lowering costs, improving service delivery, increasing accessibility to transport and various situation-specific forms of transport, enhancing the logistics of movement of vehicles and people, reducing car use and individual ownership or use in very population-dense areas, and repurposing land for living and social interactions, our respondents have experience of the many social benefits deriving from CAV adoption. Yet, there are challenges in using CAVs or planning for their use.

4.4 Challenges that may be experienced with CAV adoption

As shown in Section 2, the literature is replete with examples of the challenges associated with CAV adoption and negative commentary surrounding their use (Bahamonde-Birke et al, 2018; Gelauff et al, 2019; Harb et al, 2018; Simoni et al, 2019; Puylaert et al, 2018; Szell, 2018). This aligns with our findings, with respondents discussing concerns regarding CAV use and deployment, and identifying several threats from technology in various contexts. A fear exists that increased dependence on CAVs, along with the convenience and simplicity of travel offered, will intensify traffic and congestion, especially in towns and city centres.

> *"We could just end up with loads more vehicles on the road network because it makes a lot of sense to have vehicles all over the place and everyone buys one and because there's no barrier to driving any more people can own one etc." (LA 2)*

Such dependence might also negatively impact the health advantages which active travel initiatives seek to encourage.

> *"It's important that all transport policies are joined up in this area. If we have a small number of shared autonomous vehicles that people use very sparingly for certain long journeys, and as a result the overall car fleets in the UK disappear and the car miles driven reduce quite significantly as a result, that would be a utopia. Dystopia is a world in which you get your shiny CAV outside your house taking you point to point and therefore reducing the need for any walking and cycling*

> *alongside it. And it is really within the gift of policymakers to determine which of those directions we go in the longer term." (Streets Specialist)*

One respondent explains their perception of the software used on vehicles and how it might react to dynamic events such as travelling past schools, even going as far as to raise concerns over the vehicle's understanding of the Highway Code:

> *"There's that traffic management piece that sits in there as well, as a bit of a threat: so you can influence human drivers not to drive past a school, or drive slowly past a school, but without passing legislation as it were. You can't so much do that with an autonomous vehicle – it might take the shortest route, or what have you. We don't know exactly what it's like, but the set of rules that we currently apply to the highway network might need to be a bit different when it's a computer driving a car compared to a human driving a car just because of the way things get interpreted." (LA 2)*

> *"We were involved in a project and once you stop thinking about the main roads and you start to think about side roads, how does an autonomous vehicle contemplate some of those things? A person who ha puts a skip in the middle of the street, for example, and then you have to drive by, bumping your car up on the kerb, which presumably the Highway Code says is illegal, so the autonomous vehicle stops or reverses and takes a massively circuitous route, or does it 'do a human' and break the law?" (LA 2)*

There are also concerns that local infrastructure and CAVs, operating primarily through the use of cameras, pose potential problems that might be exacerbated by people with dishonourable intent.

> *"It's the ability for people to do nefarious things with the autonomous vehicle. Could I put something that I've painted outside my house that makes the vehicle do something, that makes it drive slower? Can I paint a fake 20mph sign in my garden? There's lots of these things that start to come up and there are definitely people [who] could lie on the road in front of a CAV and it would just have to sit there – you've got an instant school zone or whatever. It's reflective of how early on we are in the thinking of this side of things compared to the technology stuff... some of this technical stuff is there, but it doesn't really solve some of these on-street practical issues." (LA 2)*

However, despite these issues, our findings identify two main themes that appear to limit or restrict the respondent LAs from fully embracing CAV technology. The first is evident from the uncertainty about this new technology. Planners and managers are reluctant to devote funds to prepare for a new form of transport which is, at the time of writing, both largely untested in real-world scenarios in the UK, and dependent on legislative direction to guide LAs as to their position and responsibilities.

The second theme, consistently raised among respondents from both small

and large, urban and rural LAs, is around funding restrictions. Many note the paucity of internal funding available to support new initiatives, particularly given austerity measures and budgetary restraints, while others highlight the availability of external and governmental avenues for funding streams, while explaining how these are increasingly difficult to source in recent application rounds. Yet funding has been sourced by many respondents, and despite increased difficulties to find funds, this has not paused LAs' vigilance and readiness to progress CAV projects when the opportunity arises.

> *"A lot of the technology development requires funding and often that comes through government grants and research. So, we've taken a very active role in leading consortia defining the scope of what we want to do in the city to develop these solutions. It's actually identifying a real problem: how do you integrate some of these solutions into a city centre and provide a service that then gives you the ability to address car penetration into cities?" (LA 1)*

One respondent even mentioned the effects of Brexit on funding streams:

> *"Government funding from EU and collaborative work was undertaken whilst the UK was a member state. This has stopped since the UK's withdrawal." (LA 8)*

Collectively, the respondents are enthusiastic about CAVs and the possibilities for their use. They thoughtfully assess the nature of changes to transport, mobility, equality, egalitarianism and social cohesion, and are evangelistic about the benefits.

Their experiences of funding projects relating to CAV use is similar. They are accustomed to securing bids from public sources of finance, and note how these have dwindled in recent years as the progression to CAVs has been affected by political upheaval and global issues such as Covid-19. We wish to emphasise that this is our interpretation from our interactions with the respondent LAs. Few complain of this directly. They are subject to restricted budgets and the needs of other departments, which compound problems with securing funding to support further work on CAVs. This includes using their own time, release from existing duties, and the necessary changes to infrastructure needed to secure the safe and reliable roll-out of the vehicles.

Respondents note how their infrastructure strategies facilitate the connected nature of vehicles. They identify how this is not only an approach to secure their place as a smart city, but it also enables them to take an active role in CAV use – as a means of facilitating public and private vehicle use, and as a location for private business and investment looking to take advantage of existing infrastructure for deployment.

> *"We already have hyper-fast broadband to every household [and have] one of the largest networks in the country. So, we're in a good place structurally to allow that, the 5G elements and... the beacons and the beams. Some of this will help with CAVs... we're digitising all our traffic*

regulation orders to allow information going into and out to allow for that for autonomous vehicles to park and find parking spaces. [We have a] smart city platform that allows us to push/pull data, collect all that data and interact with censors." (LA 4)

"We have [been involved with a project involving a] public transport operator aiming to get autonomous vehicles in public transport. We are currently very interested in understanding the equity questions around autonomy and their long-term business modelling." (Mobility Specialist)

The LAs also use their local knowledge and systems for data collection as potential sources for future, CAV-related endeavours and income generation.

"We provided an area where the engineers could gather and start mapping because one of the key things was to map the route you were going to take because communication was the weak part of the technology... it's not ready yet to give us that level of confidence for this to be operated in a safe environment." (LA 7)

"In terms of the infrastructure, we've digitised our CCTV back office platform... and we've got a highway asset management system which links into the permitting system, so from an autonomous vehicle point of view, we have the ability to know what roadworks are going on." (LA 4)

Even for LAs without a clear plan for introducing CAVs into their transport strategies in a meaningful way, there is an understanding of the structural and infrastructural foundations needed, which are being incorporated to aid their eventual adoption of such policies.

"As we look at policy I don't think we're designing things and making decisions with fully autonomous vehicles at the forefront, but if we return to the version we're dealing with now in terms of electric vehicles, connected vehicles, that is starting to drive a lot of the policy thinking... So I suppose that's almost a key example of policies starting to evolve and it's impacting on some of the decisions we're taking, but it's more electric vehicles than autonomous vehicles at this point in time." (LA 6)

"What we've done is just focus on the full direction of getting us there... So it's little by little, keep in mind the overall vision, make sure you're positioned in the right place for the future so you have joined it up so that everyone understands the value of the data and what their individual process is to contribute to the whole, and make sure you have the infrastructure there so then you don't find you're way behind when the opportunity arises." (LA 8)

"Focus on the full direction of getting there... keep in mind the overall vision; make sure you're positioned for the future; that everyone understands their individual process and make sure you have the infrastructure so you don't find you're way behind when the opportunity arises.

Further, and beyond matters relating to clean air and net-zero initiatives, particular examples are offered in respect of considerations when deploying CAVs in urban areas.

"I think the problem would be pedestrians and cyclists. On the motorway you don't have casual people, animals, cyclists, as long as you follow the rules of the highway. In an urban centre I think it would

> *be much more difficult for that to happen just because there's so much pressure and movement – and so much unpredictable movement. You might get the odd busway where you get enough segregation to protect people, but whether you'd have enough space to make it something that you want to be on, I think urban's going to take time on that one." (LA 9)*

Deployment has also been linked with lowering crime and increasing safety for vulnerable pedestrians.

> *"Aside from the robot, because they run on a lot of our secluded shared pathways for cycles and pedestrians, a criticism we've had in the past is a fear of crime and people don't feel safe walking. But if they've got these routes with one of these [CAV] robots running on them, which has got nine cameras and picks up everything in the area, people are saying actually we now feel more secure because we know that these robots are on periodically and will film things. If there's an incident, it makes [pedestrians] feel safer. So these are the added benefits you only pick up by deploying these services rather than theorising them." (LA 1)*

> *"Tried to model actually what that [trajectory] picture was going to look like on the strategic road network... there will be some benefits in areas like safety. One of the things that we're hearing very much on the CAV front is a lot of accidents on our network are very much human error and introducing CAVs may reduce that considerably over time, so I think that will be one of the big benefits." (Intel Specialist)*

Several respondents note their readiness to accommodate the connected aspects of AVs through their progress as a 'smart city' or through the general roll-out of a 5G network.

> *"We are a smart city so we're investing in the telecommunications speed to get to 5G to enable that to occur across the city... Because we're a dense city that's probably easier for us to do than maybe more dispersed authorities where them getting 5G across the whole of their area would be almost impossible to achieve and that's obviously critical to have that infrastructure." (LA 6)*

Charging points, and preparing for the influx of demand on the grid with EV charging, are further issues that demonstrate the need for strategic partnerships (internally and externally) among LAs.

> *"There's also bits around capacity of the electricity network that play into this as well, you can't necessarily supply all this. There's a whole bunch of nonsense about cables on streets and we moved all the lighting columns to the back of the footway because we thought that was a much better way to do it. But actually, it would be better to have them at the front of the footway if you're going to provide electricity, so there's bits and pieces around that." (LA 2)*

> *"We had a clear objective to increase the number of EVs used in the city so we've embarked on quite a large [project to produce the] highest density of charging points than anywhere else in the country outside of London. The deployment of the infrastructure has been very much*

> *targeted, [to] where we would both see a need and growing of the market around this. So high-profile destination charging locations, having the right charging in workplaces, recognising that putting chargers on the street for people without a drive is difficult, so can we look at it in a different way by creating hubs, creating charging opportunities at the local shops, leisure centres etc? So we've created a fairly extensive network of over 400 chargers within the city, many of them concentrated in hubs and locations and that's working pretty well for us because we're seeing an uplift in growth in vehicles, ownership in the area." (LA 1)*

A key outcome is the need for external partnerships with organisations and companies in the private sector to financially support, and share the associated costs of, CAV development and utilisation. Those LAs which have made the most successful transitions to CAV preparedness have very strong co-participant relationships with external partners in the automotive and technology fields.

A consistent theme running through our respondents' views, corroborating the advice of Guerra (2016), is in avoiding falling into the trap of seeing CAVs as a means of solving existing problems for planners, such as reducing congestion, traffic accidents and pollution. As identified throughout this project, LAs do speak of CAVs in terms of ameliorating the worst effects of pollution, and removing this from city centres and areas of high traffic density (as most view CAVs as primarily being EVs). Yet for nine of our respondents, congestion is actually highlighted as possibly being exacerbated by the introduction of CAVs, given their convenience and the potential for looping around roads while waiting to be summoned again by a passenger.

The major challenge for LAs, and one which is repeated throughout the comments of our respondents, is where these vehicles fit in with established and linear plans for transport planning. Active travel is at the heart of the planners' intentions, the benefits for the health and wellbeing of individuals are evident, and this also has implications for the planning of public transport, shopping and social areas in city centres and surrounding areas.

Our findings that respondents are not fearful of CAVs posing a risk to their respective cities also appear to contradict the conclusions of Freemark et al (2019). Some of the concerns identified in the work of Freemark et al – reductions in employment in transportation, social equity and increases in congestion and, to some extent, segregation levels – are noted. Yet, rather than alarming respondents, they are seen as challenges to be faced.

The real and longer-term problem faced by LAs is perceived as a lack of definitive instruction and guidance from central government as to the UK's readiness and implementation of CAVs. It is very much the individual choice of LAs as to their involvement in, and preparedness for, this new technology. Issues raised by Parliament, and reported nearly 10 years ago, around the need for road enhancements, scheduled maintenance, strategic investment,

and asset management strategies are still individual LA decisions (Houses of Parliament POST, 2013). An important and recurring theme across respondents is the silo effect of their work and how the ability for a joined-up approach for planning and development is left to individuals and groups.

Many respondents note the importance of strategic leadership when operationalising CAV policies, and the dedication needed by individuals and groups to maintain interest and commitment, especially within increasingly restrained budgets.

> *"It's so complicated because when you're thinking about the policymaking process, it relies on someone ... trying to head towards the policy." (Engagement Specialist)*

> *"Certainly within [the authority] there's probably a couple of individuals who are championing it there. [In another authority], although they're lagging behind, there's probably three or four people that would champion connected and autonomous vehicles. Both authorities are very innovative." (LA 3)*

LAs also note how they can help each other, and be helped, when colleagues with experience offer support.

> *"It's almost like someone needs to show us the full picture first of what that looks like so we can then steer ourselves around that." (LA 4)*

> *"In [the LA] we are lucky because we have, I think, six or seven autonomous companies active [and various private companies] and the economy is very much driven by innovation. We have had other LAs asking us about our trials, how we have worked with them and how they can engage... I think people in an LA do want to understand this technology." (Mobility Specialist)*

> *"I think as an authority our approach has always been it's important to learn from others, see what others are doing. We're all on a voyage of discovery on this one so that collaboration and networking is key... highways, transport, road markings, drop kerbs, environmental impact are within the regeneration directorate which pretty much all of those different services sit under, so a number of officers sit on shared groups. As an example, [we are] working on the parking strategy that's got people from all those different consenting areas sat on, so planners are on there, transport planners are on there, highways people are on there, climate change people are on there. I think we've always been quite good as a council at working across service areas and bringing those that are the experts round the table." (LA 6)*

"We're all on a voyage of discovery... collaboration and networking is key

Reference is further made to the need for leadership from central government to crystallise the commitment to CAV introduction in a consistent and joined-up manner.

> *"There has to be a common guiding hand from central government to ensure you don't get different schemes developing in different parts of the country and therefore lose control." (Streets Specialist)*

Yet, championing is just that – a decision made because of a commitment to a new and emerging form of transport, not something that should be forced upon local authorities which are, perhaps, unable or do not consider it a priority as part of their wider transport strategy.

> *"I think the role of local authority is often massively underestimated in this because government can't impose the technology. It can't say 'do trials in this area'... [but the link between the local authority and technology partner] is essential to [deployment] effectively." (Eval Specialist)*

> *"We've got some very archaic people working for the local authorities and they will not change... So we've done that tech, we've done the innovation, we've moved forward, other cities that are now saying 'actually let's investigate that', sometimes we lose out as a lead authority because not everyone follows, or not everyone is as geared up as the innovation manager and they find it difficult to adapt to change." (LA 7)*

Finally, it is again remarked how evidenced-informed policymaking is crucial to identifying the problems facing urban transport planning and the supporting role that CAVs can play. These are necessary, without guidance from central government, for LAs to act as champions for CAVs and visualising benefits which may take time to materialise and which may not be immediately realised.

> *"It doesn't entirely feel connected up, so that's where I think policymakers need to think about the entire ecosystem. That kind of classic policy about policymaking barriers which are around lack of good evidence, so lack of evidence that describes the problem and potential solutions. So lack of evidence which is transferable and understandable for policymakers, or if there is evidence it tends to be a fairly poor quality, so it's a lack of good-quality evidence." (Planning Specialist)*

Chapter 5
Conclusions

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Throughout this report, we have highlighted the complex and challenging context that planners and policymakers within LAs are navigating with regards to CAVs. There remains considerable uncertainty as to the timeline of deployment for more highly automated vehicles. This ambiguity – coupled with limited resources and capabilities – means that for many LAs, CAVs remain a distant concept. This is not altogether surprising. For the majority, the need to address contemporary issues far outweighs any chance of contemplating future technologies that may, or may not, come to fruition.

Published literature suggests that CAVs have the potential to be highly disruptive to transport systems and cities. Our findings highlighted respondents' awareness that these vehicles could help to improve reliability of journeys, support the 'last mile' and offer improved accessibility, particularly if CAV activity is primarily focused on public and shared transport. There was also acknowledgement that CAVs could pose challenges around appropriate infrastructure (including broadband networks and electric charging points) and increases in single occupancy private vehicles, creating further congestion on road networks.

For those cities that are leading the way with CAV planning and strategising, the development of CAV-related activities is underpinned by active policymaking to accommodate such vehicles. Such cities still appear to be in the minority and this reflects the importance of leadership and policy championing in cities that are developing CAV activity. The nature of CAV development in the UK means that vehicles must currently be deployed in controlled 'test-bed' environments. Cities therefore have the ability to shape the 'real-world' testing that is taking place.

Strategic planning for CAVs does not necessarily mean that cities are prioritising such vehicles – rather they see a role for them. For other cities, particularly those less active in this area, the substantial uncertainty around when CAVs will be widely available and allowed on public roads meant that for many respondents, developing strategic planning around them was not deemed important in day-to-day operations.

Our findings demonstrate that those leading transport initiatives were very keen to be involved in such change projects and collaborate with external third-party partners. They did not identify themselves as passive partners, or their locations as merely convenient for CAV testing. Rather, they were co-participants, keen to share their knowledge and expertise, and provide manufacturers and developers with real-world insights into transport use and policy which are essential to overcome practical problems in the transition to CAV use. Their efforts, and their commitment to bettering the lives of users and communities, demonstrated the significant contribution made by LAs, and the role they play in the preparedness for CAV roll-out across the UK.

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