Connected and Autonomous Vehicles. Chapter 5, Responding to the arrival of increasingly connected and autonomous vehicles

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The Version of Record of this manuscript has been published and is available in Regional Studies Policy Impact Books, Volume 4, Issue 1 (2022), https://doi.org/10.1080/2578711X.2022.2085929

5. Responding to the arrival of increasingly connected and autonomous vehicles

5.1. Introduction

The impending arrival of increasingly connected and autonomous vehicles on public roads will have wide ranging impacts on society. The highly disruptive potential of CAVs on the existing transport system and wider built environment has been outlined in the preceding chapters of this book.

In this chapter, we turn our attention to the abilities of policymakers at different levels of government to respond to these challenges. This addresses the final two questions of the Policy Expo:

- What do best-practice policy solutions look like, and how can local and regional policy makers plan proactively?
- What do national policymakers and infrastructure providers need to do? And what must be resolved locally?

In tackling these final two questions, this chapter explores several different issues, including: the role of the regulatory environment and how local policymakers feature in this, the availability and use of guidance and best practice, the priorities for preparing the built environment, and the role of public engagement as part of this response.

5.2. Establishing a regulatory environment

As the technology that underpins more highly automated vehicles advances, the need to develop an effective regulatory environment becomes ever more pressing. So far policymakers and other industry actors have largely avoided responding with any decisiveness to the question of how highly automated vehicle should be regulated[1]. This reflects the highly complex challenge of doing so, bearing in mind the far-reaching impacts that CAVs will potentially have on multiple aspects of social, economic and cultural life and the concomitant need for regulation to address the complex interactions between them and the technology. However, increasingly regulation is under discussion and scrutiny.

National level

It is at the national level where, for most countries, the responsibility and power to develop the relevant regulatory frameworks lie. One source of insight on the status of the strengths of different regulatory environments across countries is the KPMG Readiness Index.[2] Whilst the index does have some limitations, which were discussed

earlier in this book, the KPMG report does nevertheless highlight that it is only comparatively recently – in the last two or three years – that national governments have started to act in earnest on the question of regulation.

Even in countries with a comparatively mature discussion on CAV regulation, there is an important distinction to be drawn between an emerging regulatory environment which is supportive of the technology and its diffusion, on the one hand, and one which focuses more on restricting the development or adoption of CAVs or at least certain aspects or use cases. With this distinction in mind, it is notable that the KPMG index ranks more highly those countries where regulations are already in place and where the resultant regulatory environment is supportive of CAVs and concomitantly places few restrictions on their development or adoption. So, the strength of the regulatory environment in this regard is the extent to which the regulatory environment is conducive to CAVs rather than restrictive. In the latest version of the KPMG index[1], the highest scoring countries included Australia, Finland, Singapore, and the Netherlands. The lowest scoring countries included India, Mexico, and Brazil. The contrast of Global North and South countries here is telling of the differences in preparedness seen nationally but may also reflect a normative conception of the economic and social role of CAVs and how they may best serve established trajectories in the development of built environment, infrastructure and levels of automobility.

Australia is one of the early movers on AV regulation and much of this is being undertaken through the *National Transport Commission's Automated Vehicle Program*[2]. This initiative is seeking an 'end to end' regulatory approach that can support CAVs at all levels of automation being deployed safely and commercially[3]. Spain is another country where, in 2020, the national government sought to enact changes to the legal environment to help accommodate CAVs.

In Great Britain, there have been recent developments in the form of the publishing of the long-awaited joint Law Commission report on Autonomous Vehicles[4]. This report was the result of a three-stage consultation process that began in late 2018. An initial consultation on safety assurance and legal liability was following by a second consultation (in October 2020) specifically looking at the role of CAVs in public transport. The third and final consultation as part of this process sought to consolidate the collected evidence and develop overarching proposals for next steps in the regulation of CAVs in Great Britain.

One outcome of the Commission's work has been a recommendation of changes to how driver responsibility is acknowledged in an automated vehicle. This proposal has significant implications with regards to liability and seeks to distinguish between 'self-driving' and 'driver assisted' cases.

Box 5.1: User-in-charge

User-in-charge: Once a vehicle meets the threshold of being 'self-driving' or fully autonomous, the person in the driving seat should be regarded as a 'user-in-charge' rather than a driver. This is a profound change and would mean that the user could not be prosecuted for driving offences which arise from the driving task. This would include dangerous driving, exceeding the speed limit, or passing through a red light. The user would still be responsible for other driver duties such as ensuring passengers have seatbelts fastened. (Source: Law Commission Joint Report on Autonomous Vehicles).

Cities and regions

If the progress on the development of national regulatory frameworks has been only relatively recent, the development and implementation of regulations at more localised levels has received even more limited attention to date. In part this may reflect an endogenous focus on the vehicle, its capabilities and its ontological and operational relationships with other vehicles and human operators. These traditionally form the scope of well-established national and supra-national legal frameworks, such as on vehicle homologation, which now need to be extended into the automated domain. To take an example, the UNECE's work on shaping the legal framework for intelligent transport systems, including vehicle automation, focuses principally on vehicular systems and interoperability across national borders.[5] Yet a fully developed regulatory framework which properly seeks to balance the benefits and potential negative impacts of CAVs will necessarily bring into focus local regulation especially as they relate to the use of infrastructure, the built environment, and place-based variation in the relationships – formal or implied – between vehicular traffic and other road users. Part of the challenge is that the powers and tools available to policymakers can be highly variable, reflecting differentials in the degree of centralisation or local devolution that might exist across jurisdictions.

The extent to which city and regional policymakers are empowered to make decisions and are able to establish and shape their local regulatory environment is an important factor in determining how they may respond to CAVs. In this section we highlight some examples of the extent to which local policymakers are incorporated into decision making and the challenges that emerge from balancing competing influences.

In the US, the Automated Vehicles Comprehensive Plan[6] published in 2021 sets out a plan to promote collaboration, modernise the regulatory environment, and help prepare the wider transport system for more highly automated vehicles. Again, however, the regulatory dimension to this is largely related to the regulation of vehicle designs and features. The state level is where further powers can be enacted. As of 2018, 35 US states had legislated for or issued executive orders relating to CAVs. Cities themselves can also intervene with regards to how streets and urban environments operate and the transit services within them[7]. In a recent study examining US city preparedness for autonomous vehicles, Yonah Freemark and colleagues[7] discovered that cities feared the influence of state legislatures around CAVs and how a lack of certainty prohibited effective and timely policymaking around AVs:

> *Several cities expressed concern about the role of higher levels of government. The spectre of pre-emption may limit or delay local AV policymaking; a clearer division of responsibilities among different levels of government combined with state authorization for using municipal powers to help shape the arrival of AVs might help to alleviate such hesitation.*

This potential conflict between state and city governments and how it might influence outcomes was highlighted by one of the Expo's participants, an academic with specific knowledge of the US context:

> *Some states here [in the US], Texas is one of them and maybe Arizona as well, [are] trying to pre-empt local regulations of AVs. Like the state just says you on the local level cannot regulate AVs. And that's part of creating a favourable environment [for AVs] because the vehicles are assured that they can use the roadways as the state government sees fit, which is different than what a city would do.*

In the UK, the trialling of more highly automated vehicles is possible on any UK road without the requirement for additional permits, providing current vehicle and traffic laws are complied with. The UK government code of conduct on trialling CAVs does stipulate that an organisation looking to trial such vehicles must have a driver or external operator who can take over control of the vehicle if needed, the vehicle must be roadworthy and insured[8]. Beyond that, there are minimal rules governing the testing of CAVs and local authorities have few if any powers to influence whether and how CAVs are trialled in their area.

Despite this, however, there is often significant engagement in practice between local policymakers and organisations seeking to run trials in the UK. This is something the code of conduct also advises, specifically that *"those planning tests should speak with the road and enforcement authorities, develop engagement plans, and have data recorders fitted".* [9]

The UK situation may be contrasted with that in China, where individual cities have more control over how CAVs are being trialled and deployed and may decide whether to legislate to allow automated vehicles to be trialled. For instance, Beijing was the first Chinese city to allow testing on public roads[10]. This was the result of collaboration between the city's transport commission, traffic management bureau, and the economy and information technology commission. The regulations developed in Beijing have become a model for other Chinese cities.

Key regulatory considerations for local policymakers

The extent to which regulatory tools are available to local policymakers is very much dependent on the national context. It remains an evolving area of policy and varies from country to country.

In the previous two chapters we outlined some of the key challenges facing local policymakers with regards to the arrival of increasingly highly automated vehicles. These challenges are partly associated with the uncertainties that CAVs bring for the built environment. They arise, for instance, from the extended time horizons over which CAVs will be deployed, different ownership scenarios, and what role CAVs might fulfil and the impacts they will have on transport networks and wider spatial structures. They are also associated with the risks that CAVs might pose to concurrent policy agendas that are being pursued seeking to enhance the liveability of cities – which is a key objective for many local policymakers. This includes agendas on safety, accessibility, access to employment, protection of the environment, and enhancement of public health.

Whilst much of the regulation is being developed at national or, in some cases, state level, and there is a concern over how local policymakers can influence this, it is also vital that cities and regions have tools and skills available locally to help them influence the CAV agenda to protect their own interests. Evidence from the US, for example, suggests that cities do not feel well equipped with the tools to manage these pressures at present.

Despite the primacy of national regulation, cities and other localities do provide the basic frameworks within which urban functions are managed, such as spatial planning and urban design[11]. This is important because it means local policymakers, and through governance structures local citizens, may have some ability to shape how the built environment responds to the increasing presence of CAVs. As discussed in the preceding chapter, a proactive stance on preparing the built environment for the arrival of CAVs could yield important outcomes in terms of securing the most positive and widespread benefits for local places and their populations. It should also not be forgotten that, beyond the regulation of CAVs specifically, local jurisdictions may be

able to exert degrees of regulatory control and influence in other, related ways. For example, the arrival of ridesharing platforms such as Uber and /Lyft, dockless bike sharing and electric scooter schemes has forced local policymakers to respond to these disruptive technologies and they are often equipped with local policy tools – for example licensing – that can help them influence how these services and developments unfold. Given that the future of ridesharing and increased vehicular automation are closely conjoined, this does raise the prospect that a wider set of tools in the urban governance arsenal can be pressed into the service of influencing CAV roll-out even if the regulatory framework for vehicle automation is otherwise largely centralised and permissive.

Beyond seeking to regulate or influence the arrival of CAV's, local areas can take on other important new roles. The critical role that city governments and local authorities play in creating and maintaining key data sets – for example on cadastres, land use mapping, signage, land use, and infrastructure availability and restrictions – means that cities could find themselves taking on new roles as 'mediators and data catalysts.'[12]

For local policymakers to be able to effectively manage the arrival of more highly connected and autonomous vehicles and the pressures they bring, there are some key areas of regulation that will need to be considered:

- **Road pricing, congestion charging and tolling** can be used to incentivise or disincentivise the use of particular vehicles types in time and space. Pricing schemes could cover degrees of automation in combination with other vehicle characteristics (e.g. size, noise and emissions).
- **Selective lane and turn restrictions**, which could be used to constrain CAVs to, or prohibit CAVs from, specific routes or zones – for example, school streets during certain times of the day.
- The **creation, maintenance and use of data assets**, such geofences and mapping data, may inform the way that vehicle decision making algorithms work. Through controlling data, local authorities could enforce vehicle behaviour dynamically, for example to disperse traffic away from congested areas or make space for emergency vehicles.
- **Parking regulations** may be important in incentivising the relationship between CAVs and the kerbside, and may be of particular value in promoting shared vehicle use in dense urban environments.
- **Kerbside pricing**, including for CAV loading and drop-off, may help to manage kerbside demand,
- **Electric Vehicle charging infrastructure** may – for a limited time while vehicle drivetrain technology matures – be a useful mechanism through which to encourage or dissuade stationary CAVs, given that most will also be EVs.
- **Workplace levies or taxes**, integrated into local business tax regimes, could be used to influence the use of CAVs for private commuting
- **Licensing** e.g. for taxis, ride-sharing and public transport vehicles, is a local regulatory mechanism that may also help to influence how and when CAVs of different types are used.
- **Planning rules and design codes** for new buildings could reduce parking requirements, discourage multiple vehicles ownership or single-occupancy vehicle use, and promote shared CAV models in new residential developments
- Wider **spatial planning policies and land use regulation** – aimed at influencing urban spatial structure over the longer term through policies governing the

location and density of housing and employment areas – could help to influence the economic trade-offs implied in CAV ownership and use

5.3. Guidance and learning through best practice

The growing attention on CAVs and the impending arrival of more highly automated vehicles on public roads has prompted the development of guidance and the sharing of best practice. This guidance is often developed at national level by governments or transport bodies to be accessed by those operating in the field. There is also the accumulated knowledge and insights that are shared across local government and related non-governmental bodies, through both informal and formal networks.

Across countries, variations in the existing legal and regulatory structures, the institutions that exist and the strength of these, and a range of other place specific factors (e.g., existing land-use and transport trends) means that what works in one country may not work elsewhere. Whilst it is beyond the scope of this book to examine the extent of guidance across all countries, there are some examples that we can discuss to highlight how guidance has been developed.

At a supranational level, the European Commission has undertaken a range of activities around CAVs, recognising the potential impact on European roads and the highly integrated nature of these road networks across country boundaries. Work undertaken or commissioned includes a 2018 'communication' outlining the EU's strategy on connected and automated mobility in Europe[13]. This document sought to unite a path for EU members, industry, and other partners to work together. The aim of this, as the document describes was so that the "*EU seizes the opportunities offered by driverless mobility, while anticipating and mitigating new challenges for society"*.

Some of the steps taken by the EU Commission have been the development of further guidance, including recommendations on CAV ethics[14], and guidance on the assessment and categorisation of CAVs[15]. For the EU Commission, these efforts are to ensure consistency across Member States.

In Canada, the development of a CAV 'Policy Framework'[16] for the country has sought to ensure that CAVs are operated safely in the built environment. This framework established safe testing guidance to trialling organisations and the jurisdictions where such trials might take place; attempted to align key policies and legal considerations across the Canadian jurisdictions; and extended partnerships across government, industry, and academia.

There are also other organisations and academics who are developing guidance. For instance, RAND – the global policy think tank – has published guidance for policymakers[17]. The RAND guidance is wide-ranging and notably includes guidance for policymakers that extends to risks around market failure, regulation and liability. Insights have also been provided from early adopting cities and regions in the US[18].

The CAV market is sufficiently developed that guidance is increasingly available. At supranational and national levels policymakers are seeking to shape the agenda through this guidance. More targeted and localised guidance is also available, building from lessons gathered through trials and early adopting locations. However, none of the guidance is particularly consistent and needs to account for context specific factors to each country or location. Our interviews explored how best practice guidance is, or should be, shared. One interviewee, with expertise in running CAV trials, summarised the importance of clear and accessible guidance for time- and resource-restricted local policymakers.

I think there are a few [barriers to engaging with best practice guidance]. One is the time and resource availability to fully consider twenty different sources of information to try and understand which one is the best. There's the simplification of where they access information and the quality of it, that I think is important. It needs to be really simple for them, it also needs to be available from a single location. They need to have access to it readily and it needs to convey to them in their own language what they can and should do and what they can't do and should avoid. It needs to be very simple and accessible. I also think it needs to sit in a way that it's a living document.

The lessons that are increasingly available from test-bed locations or early adopters offer important insights for policymakers who are later adopters to CAVs or lack the resources to undertaken extensive planning around them. Learning from elsewhere remains common in modern transport planning and practice [19]. Policy transfer underpins how knowledge and best practice is shared and adopted.

There is evidence of how knowledge transfer is taking place around CAVs and how this helps local policymakers to effectively plan for increasingly connected and autonomous vehicles. One dimension of this is through the trialling of AVs, which is often undertaken through consortiums of organisations bringing different skills and knowledge. For example, in Box 5.2 we feature a case-study of Project Endeavour. This project included partners such as: Oxbotica (autonomous vehicle software); DG Cities (integration of smart city technologies); TRL (safety and compliance expertise); BSI (business improvement), and Oxfordshire County Council.

Beyond specific projects or trials, knowledge transfer is also taking place between universities and firms. For example, Aston University in the UK has established a knowledge transfer partnership with the AV company Aurrigo to help develop systems to improve vehicle safety[20]. Such partnerships, whether formal or informal, were also cited by interviewees participating in this Policy Expo. For local governments who lack specific expertise or capacity around CAVs, such partnerships offer valuable ways to increase capacity to develop plans and organisations knowledge.

5.4. The built environment

The rapid uptake of the private car as a means of transportation in the middle of the 20th Century led to a redesign of cities to better accommodate this form of travel. Road networks were widened and straightened, and ultimately designed more with the vehicle in mind[21]. There is a question mark now over the extent to which cities will redesign themselves for the benefit of CAVs. There are views on both sides of this argument, and this is something that was evident in our interviews. For the majority of places, the indication is that there is limited work being undertaken to prepare the environment specifically for CAVs[22]. With questions still outstanding about how CAVs ultimately will shape the built environment, there is likely to be a reluctance to spend already constrained resources on extensive planning efforts.

The extent to which a city responds to CAVs is likely to be motivated by a broad range of factors, including their existing transport system and trends but also what the political appetite is for such technology. We have explored already (see Section 4.3) about how there is concern that CAVs might lead to the need for more segregation of users, a reminder of planning trends of the mid-20th century. This raises important questions around the prioritisation of road space for different users; car friendly cities will likely reinforce these trends through accommodation of CAVs.

One further dimension of actions needed around infrastructure and built environment is around data. CAVs themselves form a data platform with huge amounts of data being collected by and shared between vehicles[23]. Cities are also emerging as anchor

points in complex partnerships between different public and private agencies. In this role, they collect data on transport patterns and behaviours but also have a responsibility for cyber security and privacy. There is also an important role in drawing together and providing access to data that is vital for the safe operation of CAVs, including traffic lights, crossing points, road dimensions and location of curbs, street lighting and data on traffic flows. The ability to compile and easily transmit this type of data will require substantial financial investment for many cities and it is not clear where such financial support will come from[24].

In addition to this, many cities already outlay significant costs to maintain road surfaces, markings, and signs. Maintenance and enhancements of this existing infrastructure will also be important for CAVs. Much of the dialogue around CAVs and their benefits allude to a significant redesign of spatial structures. This might include a reduction in parking allocations, particularly in city centres or the need to increase drop off points as passengers alight from their automated vehicle. In addition to this, any responses around CAVs will be foreshadowed by the need to deliver widespread electric vehicle charging infrastructure, which is a priority for many cities at present.

5.5. Engaging the public

Public acceptance will be critical to the widespread adoption of CAVs and is therefore a key part of the response to the arrival of increasingly autonomous vehicles. Whilst the responsibility of communicating the potential impacts of CAVs is not solely that of local policymakers (national government and industry are also vital in this), it is an important consideration and potential challenge. Whilst much of the debate around CAVs has centred on when they might see full-scale uptake, the type of ownership models that might emerge, and the impacts on spatial patterns in cities and traffic levels. There has been only limited debate at *public* level over the role of CAVs in future transport systems.

This may in part be due to the longer-term and uncertain time horizons over which CAVs are emerging. Certainly, the most transformative aspects of CAVs, for example, high levels of automation with minimal/no requirements for drivers to intervene, will take years to be fully established. Therefore, it is difficult to explore public acceptance when we are not sure exactly what things will look like.

A range of studies have been conducted to explore public acceptance. This includes academic research through surveys and in driving simulators but also in real-world test environments. Much of the work around acceptance is linked to perceptions of safety.

One of the key pro-CAV arguments is that it will improve safety for all road users. There remains much to do in terms of proving, beyond doubt, that CAVs are infallible in this regard however, and indeed they may never reach that point. For now, this means there remains a question mark over safety in and around such vehicles and this damages public acceptance. Some studies suggest that the safety benefits of CAVs are well understood and seen as a 'selling point' for potential users. In contrast, other studies have suggested that concerns over safety are one of the overriding issues. Work undertaken in La Rochelle, France evaluating AV demonstrations in the city[25] and showed that whilst surveyed residents were generally supportive of AVs, including buses and cars, only a quarter felt that AVs would be safer than human driven vehicles.

To explore further how trials are undertaken and what impact these might have on the public, and levels of acceptance, we have included a case-study box of the Endeavour Project, which ran between 2019 and 2021 in the UK.

Box 5.2: Case-study: United Kingdom

CASE STUDY

Creating safe CAV services: Findings from Project Endeavour

Background

Running from March 2019 to Autumn 2021, Project Endeavour was established with the goal of increasing and upscaling the adoption of self-driving vehicles in the United Kingdom. This was led by Oxbotica and involved collaboration with DG Cities, Oxfordshire County Council, Immense, TRL, and BSI. It builds on previous work in the same subject area by MERGE Greenwich. The ultimate goal of the project was to expand on previous work in this study area by providing the chance for members of the public to experience the technology of AVs first-hand utilising live trials and demonstrations of the technology.

Four trials of autonomous vehicles were delivered by the consortium: two in Oxford and one each in Birmingham and Greenwich. In terms of scale the trials started with stakeholders to iron out any issues with the technology before being upscaled to include and engage the general public. The trials were publicised across a broad range of media channels, including printed leaflets and social media to broaden the potential audience. In addition to this, a virtual reality relay of the Oxford trial was made available online to engage more people.

To gather insights of the impact of the trials, the Endeavour Project utilised the following methodology:

- Online survey distributed on social media exploring issues such as perception of the technology, interest in trying it and of using it in the future as well as general travel attitudes.
- Pre-trial and post-trial surveys focusing on perceptions, experience and how participating in the trial had affected these positively or negatively.
- Post-trial interviews and online focus groups.

These were all analysed and incorporated into the findings in their report. The live trials included a short trip in an AV along with a human driver to take control if needed along a short route, whilst the virtual reality element comprised a video showcasing current AV technology and another presenting future potential of the technology.

The findings from the study suggested that whilst the technology was generally regarded as safe, the presence of a human driver to take control was important for some. Others saw the potential for the technology to be safer as it removed the risk of human error. The study suggested that trust in the automation dropped when more complex obstacles, such as junctions, were approached. It was felt that more testing should be done before they are allowed on the road in public and safety features (such as an emergency stop button) were welcome, but that consideration of the needs to people with physical disabilities was needed in the design of the vehicles.

The Endeavour study showed that perception on the safety of AVs tends to get more negative in line with the increase in age of the participants. The results of the Greenwich trial found a 15 per cent improvement in positive perception of the technology after participants had encountered the technology first hand. The study shows that the majority of the population are still unsure as to the safety of self-driving vehicles, however the aforementioned 15 per cent increase in improved perceptions from participants in live trials of the technology seem to

indicate that such perceptions could be down to lack of contact with or understanding of it. The acceptance of AVS also intersects according to age, with 21 per cent of over 55s feeling confident using an AV tomorrow compared to 35 per cent for those aged 18-35. There is also a difference by gender although this is not as clear cut with 17 per cent female participants as opposed to 25 per cent male participants strongly agreeing that autonomous vehicles will be trustworthy. The national survey also highlighted how over a quarter of people are still undecided about autonomous vehicles with safety being the main issue, particularly on roads where AVs will be merging with human drivers.

In conclusion, the study highlighted how there is still a long way to go to convince the majority of the public as to the safety of AVs, although this may be down simply to lack of awareness and understanding of it. The hugely positive increase in trust in the technology after participants have undertaken the in-person trials make a strong case for more public engagement of this kind to be carried out to build public confidence, particularly amongst participants aged 55 and over given the lower levels of confidence this age group demonstrated in the technology.

This case-study has been produced using evidence published by the Endeavour Project[26].

The relationship between CAVs and the promotion of liveable cities can also be interwoven with how we interact with, and feel about, the places we travel through, and how CAVs impact on these. One submission to our Policy Expo summarised this as follows:

> *CAVs are not simply a means of transportation but can also be viewed as an object, operated by non-human means, which intrudes into the places where we live and work. These CAVs 'coming into' our neighbourhoods include not only cars and buses but potentially also automated grocery and delivery vehicles. Whether individuals are comfortable with CAVs entering these spaces, and whether they trust or [should] 'trust' those vehicles, is potentially dependent upon how they view a particular place, and how that place is being used.*

This highlights how important it is to think about the non-utilitarian impacts of CAVs, which is often omitted from the discourse around this topic. It also serves to demonstrate the unintended consequences of this disruptive technology.

5.6. Summary

Responding to an increasing presence of CAVs will require wide-ranging actions delivered by supranational, national, and local decision makers. In this chapter we have explored how the regulatory environment is being developed and some of the conflicts that might emerge between different levels of government. Guidance and best practice remain nascent and largely only informally shared; more consistent and accessible information will broaden the extent to which later adopting cities can engage with these issues. The built environment will likely be transformed in response to an increasing presence of CAVs, but this is costly and dependent on many place-based factors. Finally, public engagement is well underway, as highlighted by the Project Endeavour case-study, through arguably there remains much to do and a wider public debate about the role and impacts of CAVs is an essential step.

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