Connected and Autonomous Vehicles. Chapter 3, The challenges posed by CAVs for the built environment

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Published version

PARKES, Stephen and FERRARI, Edward (2022). Connected and Autonomous Vehicles. Chapter 3, The challenges posed by CAVs for the built environment. Regional Studies Policy Impact Books, 4 (1), 37-51. [Article]

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.2022.2085927

3. The challenges posed by CAVs for the built environment

3.1. Introduction

In the previous chapter, we examined how existing levels of preparedness are framed and how these have been quantified to rank those countries that are progressing faster in creating environments amenable to CAVs. We also considered how this is playing out at the local level, which has highlighted that the situation is mixed. Some cities are leading the way and are ideal test beds for experimenting with CAVs. Other cities do not, or are not able to, actively plan for and consider the arrival of CAVs.

Our Policy Expo was structured around six questions (as outlined in Section **Error! Reference source not found.**) and this chapter is concerned with the first of these questions:

- How will the urban and built environment practically accommodate CAVs?

As we explore the potential of a full-scale transition to CAVs – with a specific focus on the local level - it is first necessary to understand how they will impact on the *places* where they will be used. In later chapters we consider important factors such as the regulatory and legal environment, and issues such as accessibility and equity. For the remainder of this chapter, we explore in more detail some immediate questions around the key challenges faced in accommodating CAVs in the built environment as they become an increasing reality.

3.2. Long and uncertain time-horizons, and the challenges this presents for planning and decision making

Whilst there is a slow creep of increasing connectivity and even automation being built into vehicles, there remains much uncertainty as to when the widespread adoption of more highly autonomous vehicles might take place. More optimistic predictions in relation to AV implementation suggested that by 2030 most vehicles would operate autonomously[1], although it should be noted that such more optimistic predictions have tended to be made by those with financial links to the AV industry[2].

The reality is that the time-horizons for the development of CAV technology and implementation – to the point that they would have an impact on the built environment which is materially different to that of conventional vehicles – are much more uncertain. It is likely to take many years before the technology is ready[1] let alone when there has been sufficient uptake for the majority of vehicles to be operating autonomously. Whilst in closed, controlled environments (such as airports or mines) autonomous vehicles are already operating, the timeline for use on public roads is far longer and more uncertain.

Given this uncertainty, we explored with participants their views about the likely timescales within which widespread adoption might occur. Overall, the majority views were one of some scepticism about the likelihood of AVs seeing widespread adoption quickly (i.e., within the next decade). As one consultant actively involved in vehicle trials put it:

> *I do question whether or not these kinds of CAVs that have been trialled, which are for public use like a CAV based taxi service or even privately owned CAVs, I don't expect these will be, you know, adopted and accepted within the next 10-15 years. I do think it will probably take 20 years for that technology to come online.*

Even once the technology and supporting regulation and infrastructure are in place, the slow speed at which new cars cycle through the vehicle fleet means it will likely take further decades before full-scale deployment is realised. An academic put it thus:

> *Let's say, we arrive at this magical moment where we have full automation and full connectivity, I think that's at least ten years, if not longer away, then it has to cycle through the fleet so I think we may be at least thirty, forty, if not fifty years away, from such a future and there's significant hurdles that still have to be overcome for these vehicles.*

Uncertainty also extends to scepticism over what level of autonomation might ultimately be reached. The SAE levels of automation go up to Level 5, which is where the vehicle can drive itself in any conditions, without the need for driver intervention. Some of our participants questioned whether this level would ever be achieved due to the technological limitations that may never be overcome. One interviewee, who has worked closely on the technological side for many years stated:

> *Now, ten years ago, 95 per cent of the problems were solved and everyone thought it was five years away before the next thing was, you know, addressed. But clearly that hasn't happened. The last five per cent of the problem is 95 per cent of the effort really, because it's been increasingly hard to solve the last bits that you really need to solve.*

The reason why uncertain time-horizons are problematic for local governments is linked in part to the ability to take advantage of the time window before widespread rollout to make sure that the vehicles introduced ensure greater liveability and improve streets[1], rather than being introduced to the detriment of the streetscape. If AVs are introduced more quickly local governments may not have the skills and resources to plan for them effectively, and proactively.

Current 'test bed' locations will be better placed as early adopters but these will be the 'low-hanging fruit'. Often these locations are chosen as they offer uncomplicated road systems, and more consistent (and better) weather conditions. The question is much more about how the later adopters, who make up the majority are able to anticipate the widespread introduction of CAVs.

The Covid-19 pandemic has prompted some rethinking of the role that CAVs might play in the future. This is partly driven by questions around the desire or need for personal mobility to help ensure social distancing. Although as the restrictions have been lifted around the world this is less pertinent. Perhaps more notable are issues around the increasing levels of home deliveries and online shopping that have exploded since the pandemic, and what impact these have on local environments. Coupled with this is the increasing efforts of some policymakers to redesign cities and neighbourhoods to enhance wellbeing and address changes in working patterns.

3.3. Ownership scenarios

In terms of the role of automation for passenger vehicles, much depends on the type of ownership model that emerges. Two broad scenarios have been discussed[2]. First is the **'business as usual' model**, which sees ownership patterns for vehicles continuing along current trends and where CAVs are acquired and used mostly as substitutes for conventional cars. Specifically, this is a scenario where private ownership and use of vehicles remains the dominant mode. In this scenario, there would be a gradual replacement of non-AVs with AVs as the technology becomes more available and affordable for many users, potentially allied with other parallel technologies – such as EVs and charging infrastructure. As is already being demonstrated with EV take-up, vehicle lifespan, fleet replacement policies, product research and development cycles, regulation, financial incentives and the wider economic environment will all be factors conditioning the speed and breadth of technology diffusion. Pertinently, built environment infrastructure investments which will incentivise and facilitate EV take up – such as on-street charging or mandating private charging in new developments – could potentially lock-in the single private owner model of car use for another generation and, with it, extend the dominant model into which CAV technology matures.

There are several possible negative implications of this scenario, however. Those on the lowest incomes will continue to be priced out of private vehicle ownership and, in the shorter term, only those on the highest incomes are likely to be able to afford the first generations of fully autonomous vehicles. Furthermore, there is clear acknowledgement in research undertaken to date that this scenario is likely to have significant impacts on other forms of transport, especially in the longer term[3,4,5]. As CAVs become more attractive and affordable, and particularly if they are prioritised at national and local government level, there is a likelihood that they will increasingly compete with and potentially undermine public transport and active travel modes. The potential for CAVs to offer some of the benefits that public transport offers (principally, time that can be devoted to other activities) whilst overcoming some of its limitations (principally, route and timing inflexibility) may disrupt the economic symbiosis between public and private modes within the spaces in which user trade-offs are considered. For active travel, the conflict may arise mainly on streets themselves, as walkers, wheelers and cyclists find themselves in competition against a more aggressive and efficient occupier of urban space.

For these reasons as well as the intrinsic status-signalling demand for a new consumer technology, CAVs may herald a potential renaissance of the private car which may challenge the idea that some societies may have peaked in terms of per capita distance travelled by private car[6]. Any actions by national or local governments to support CAVs through built environment measures (for example dedicated lanes or segregated kerb space) would encourage further growth in private car use to the expense of public transport ridership and active travel levels.

A contrasting scenario is one which focuses more on **shared ownership of vehicles**. Here, whilst use of CAVs would increase, the overall ownership of private vehicles would potentially decrease as the technology would permit a more seamless sharing of vehicles without incurring the same degree of transactional cost or complexity as with conventional vehicle sharing. There is much written in the literature about the potential of such a model. Authors have examined the role of on-demand or 'door to door' services to provide responsive and convenient mobility to users[7]. This could be in the shape of individual 'pods' or shuttle buses that offer convenience whilst reducing ownership costs. Within the realm of individual vehicle use, CAVs could enhance the efficiency of short-term hire or vehicle sharing by being summonable on demand, self-parking when not in use, or being used by others. CAVs have the potential to further boost car-club models, which have already been growing in large metropolitan settings like London where individual car ownership is costly or impractical[8]. Combined with digital platforms, shared service including those offered through CAVs have been conceptualised as Mobility as a Service (MaaS)[9].

From an environmental perspective, this latter scenario is one that is regarded as providing the best opportunity to (re)create cities and regions that better support sustainability goals[Error! Bookmark not defined.]. In part this is due to reducing the number of vehicles operating in the built environment and thereby freeing up space normally reserved for vehicles (i.e., parking). This is – it is argued – a window of opportunity from an urban sustainability perspective to reimagine the built environment[10].

Our interviews provided insights on the kinds of questions that cities and regions feel they are grappling with. One interviewee, who is involved in smart cities planning for a UK local authority, described how they saw the question of ownership models:

> *There's a whole load of questions around what would the future look like, are we talking about private vehicles? Are these shared vehicles? There's this model about vehicles cruising around cities and people calling them up as and when they need them, and then when they're not needed, they just circle around the city and you know you get all these empty vehicle miles or if they're not circling, where are they parking? So there's a whole load of stuff that needs to be worked through.*

3.4. A lack of certainty over what roles CAVs might fulfil

It was highlighted at the outset of this book that the discussion around CAVs tends to centre on private passenger vehicles. Certainly, the focus of media attention and popular discourse tends to emphasise this view. Yet it is important to keep in mind that the development of CAVs – and certainly much of their potential in the near-term – extends to other vehicle types, which might include driverless shuttles or buses, autonomous freight or trucks, and last-mile delivery vehicles.

Whilst visions of widespread CAV adoption might assume that these different types of vehicles will coexist and interoperate at a technical level, there remain many practical questions for policymakers in considering how these can be planned for within the built environment and wider urban systems under 'real world' conditions where the logic of the market might be preeminent. Under the 'business as usual' scenario outlined above, other forms of transport such as buses, rail, or active travel risk being squeezed out by increased demand for private CAVs. This itself presents a challenge for those wanting to protect alternatives to private automobility for reasons of promoting social equity, environmental sustainability or liveability. In contrast, some literature[11,12] suggests that under a shared use model, services such as automated buses and ride-sharing of smaller (automated) vehicles would likely increase, alongside a greater demand for walking and cycling.

Our interviews demonstrated that there is a recognition that it is quite likely that private passenger vehicles will continue to form a prominent part of the traffic mix. However, some respondents argued that it is shared passenger and freight modes where more highly automated vehicles might emerge more rapidly. One respondent working for local government justified this through the alignment of social and economic benefits:

> *The reason…is both the societal benefits and the economic benefits align. In terms of the societal benefits, especially in rural areas public transport has the benefit of lower cost per mile even though the capital costs are higher and has dedicated and technical feasibility. It has dedicated routes that you can equip and specific geofence locations. If you're making a vehicle for public transport be it a*

shuttle or a bus, you're really looking to use it as specific routes and therefore you can factor in the dependencies of a Level 4 vehicle.

This is very good also in the general agenda for cities and rural areas. For cities, because you want a modal shift away from the private vehicle to shared mobility, which would support better and healthier cities, better transportation in the cities, while in rural areas there are a lot of services [that] have been cut because the main cost is the driver, so hopefully autonomous vehicles can support [here].

One of the case-studies we commissioned focused on a pilot study conducted in Barkarby, Sweden on the role of automated shuttle buses. This project looked at how AVs could be implemented to help meet the transport needs of new urban developments in the case-study city and involved trialling AV shuttle services and an on-demand service. This exemplifies one important potential role that CAVs can plausibly play in the near term: supporting shared use options to provide peripheral first/last-mile connectivity to arterial public transport networks. A combination of smaller vehicles, slower speeds, and a quieter, simpler and less cognitively-taxing built environment in relatively low densities may suggest earlier uptake. It's also interesting to note that these same environments are those in which the economics of providing traditional 'staffed' public transport has become more challenging, further underscoring the potential of CAVs for public transport.

Box 3.1: Case-study: Barkarby, Stockholm

CASE STUDY

Piloting autonomous shuttle buses in public transport, the case of Barkarby, Stockholm by Kelsey Oldbury (VTI, Sweden)

In 2018, a collaboration was established between three main actors: the municipality of Järfälla, Stockholm's regional public transport authority (RPTA), and the private bus operator Nobina. The project was named "Modern mobility in Barkarbystaden" (MMiB). Barkarbystaden (in English, the city of Barkarby, or Barkarby from here onwards) is a large housing development in Järfälla municipality in the north-western part of the Stockholm region.

The MMiB collaboration was set up between these three main actors, as well as two innovation companies connected to the municipality and bus operator. The collaboration aimed to work with new solutions and concepts developing in the transport sector. This focused on public transport for a major urban development project, where considerable new housing construction will take place along with an extension of the regional metro system.

The three main components of this collaboration were:

(1) the development of a bus rapid transit (BRT) line,
(2) the piloting of autonomous shuttle buses, and
(3) the piloting of Mobility as a Service (MaaS).

Within the collaboration, the bus operator had the main responsibility for delivering these three services.

Between the launch of the project in autumn 2018 to its end in December 2020, pilots for various services were set in motion. A series of pilots developing autonomous shuttle buses started in October 2018. A MaaS pilot was launched in October 2019, involving an application ("Travis") owned by the bus operator. The BRT line was launched in August 2020 and follows a route which approximates the connection the regional metro line extension will create when it officially opens.

In the MMiB project context, the development of the autonomous shuttle buses as a pilot was the second stage of a pilot undertaken in another area of Stockholm (Kista). Unlike the previous pilot, this time the buses were tested directly within the bus network, as a clause in the procurement contract for bus services allowed for the piloting of new ideas during the contract period.

The autonomous shuttle buses were launched in October 2018 as a limited service provided in the local area under development in Barkarby. During the following two years the service developed in a series of pilots and as the technology advanced the route was extended and altered. The technology the buses use to navigate is a combination of navigation Lidar (laser imaging, detection and ranging) and a localisation and mapping system. Swedish legislation also requires a stand-by driver on board in pilots for autonomous vehicles, ready to take over in situations the technology cannot manage.

The piloting of this service was motivated as a process to explore the role of autonomous shuttle buses in public transport and investigate how smaller automated vehicles can play a new role in an area under development on smaller streets not suitable for larger buses. This pilot has given the shuttle buses the privileged position of being an experiment taking place within public transport, while simultaneously operating as a service under development. A critical question is therefore where piloting ends and how far the parameters of testing will support the development of automation in public transport.

At the time of writing the pilot is set to continue and has received new funding from the Swedish Innovation Agency to continue the development of autonomous shuttle services in Barkarby. This time there is a new focus on developing on-demand services in public transport. The aim of the project is to develop the processes to operate the shuttles via a control tower without a standby driver on board. The new project, named FOKA, will focus on the different chain of events from a person ordering the on-demand service through to the arrival of the bus at their location. This project includes the same actors involved in the MMiB project as well as researchers from the Royal Institute of Technology in Stockholm. New partners involved include a telecom operator, working with how information is sent between the sensors installed on the buses and a control tower (e.g., questions of security), as well as an organisation working with cloud-based video surveillance.

Overall, the MMiB collaboration builds upon existing relationships and responsibilities connected to public transport. For instance, the bus operator involved in this case was already the operator of more ‘ordinary’ services, providing public transport for the municipality in question procured by Stockholm’s RPTA. While the actors themselves are not new, the project context marks a separation from usual patterns of working. The focus around new services is also (relatively) new territory for the actors involved. The relationship between the automated shuttles and the existing procurement contract is significant in this case as an example of how an existing policy tool (the procurement contract) is used to facilitate the development of new technologies within an existing contract. This case additionally illustrates the influential role the bus operator holds in terms of driving and shaping the development of automation in public transport.

The second area where respondents felt impact might be realised more quickly was in terms of freight. For freight, the potential role of CAVs extends to both public roads (particularly strategic roads such as motorways and highways) and on private or controlled settings such as docks and industrial estates where goods are moved regularly and repetitively. One of our interviewees, an academic working across different aspects of CAVs and future mobility, considered the potential role for CAVs in freight:

> *I think that movement of goods, especially with what’s happened over the last eighteen months, is probably something that will be prioritised, the way you control a vehicle that has no occupants and is designed not to have occupants, is probably something that is seen as a lower risk, and it can be operated in ways that you might not choose to be, you wouldn’t design a passenger vehicle to move in the way that a freight vehicle might operate, so yes, I certainly think for commercial reasons and for risk appetite reasons, that movement of goods is probably a higher priority in the short term.*

This suggests that as a vehicle carrying goods rather than passengers, there may be more appetite in the shorter term to utilise higher levels of CAVs to fulfil roles within freight.

3.5. The role of existing spatial structures and transport trends and how CAVs might impact on these in the longer-term

> *Autonomous car providers, their kind of 'future vision' for how autonomous vehicles would operate in the system and, you know, some of it sounds interesting. But some of it frankly wouldn't be anything that we wanted in [our city]. I've seen people talk about having separate lanes for autonomous vehicles, and again, we just don't have the road space for that, nor would we want it. And you know that we wouldn't need traffic signals because you know these vehicles would just glide through the city, but that affects permeability. So how do people cross roads?*
>
> *Strategy manager, local government*

Cities and regions have been shaped and reshaped over centuries in order to accommodate new forms of transport – indeed transport options and technologies have been significant drivers for the locations and initial growth of many of the world's principal metropolises. The existing spatial structure of the built environment and transport trends will be crucial considerations for understanding how the adoption of CAVs will play out in real-world urban and rural contexts (figure 3.1).

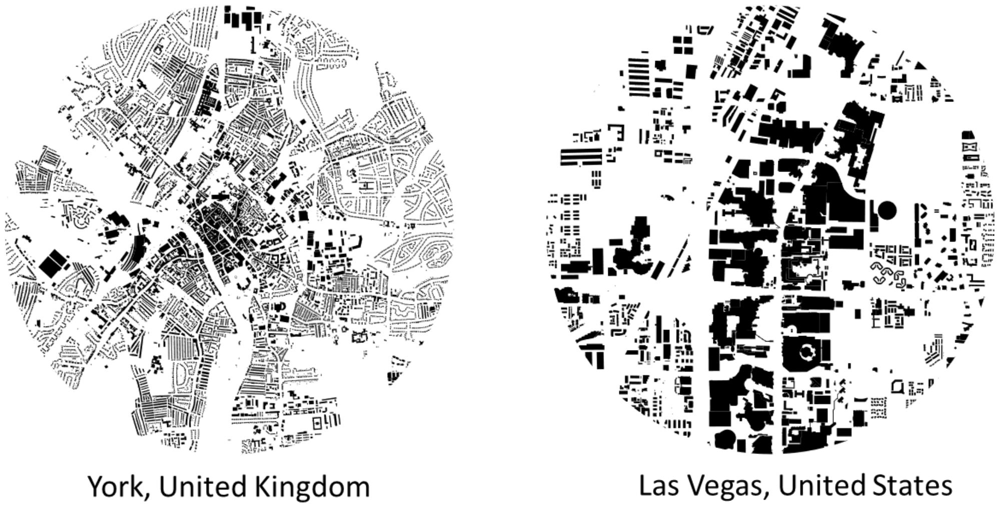

Figure 3.1
The fundamental differences in urban scale revealed by these 2 km radius figure ground diagrams exemplifies the challenges in accommodating segregated CAV infrastructure in some urban environments.

Diagrams produced using *figuregrounder* at hanshack.com. Data © OpenStreetMap contributors.

To some extent, the relationship that CAVs will have with humans and their built environments will relate to transport dependencies that already exist with the urban context and that could therefore be further reinforced. For instance, it is argued that places that are traditionally more dependent on vehicles and offer fewer alternative transport options will find their populations more willing to travel further as a result of CAVs[13]. This contrasts with places that have sought – or have needed – to offer a more diverse transport system where significant investments have also been made into other modes such as public transport, walking, and cycling. These places are seen as more likely to continue to offer a more diverse set of transport modes to their population, reflecting diverse social and economic needs as well as the requirements to service very large trip generators (such as in dense central employment districts).

The development of these urban models and the legacy transport systems serving them have been driven by planning policy and by the politics and practices of investment in the development of the built environment. In particular, the pattern of spatial relations between points of origin and demand in the metropolitan context – most notably, houses and jobs – will have an impact on the extent of CAV uptake, the types of vehicles that may be automated, and the types of challenge that these taken together might imply. A decentralised spatial structure with comparatively low densities and a dispersed employment and housing land use model may increase the attractiveness of privately owned, single-occupancy CAVs by increasing the marginal value of time whilst being technically easier to accommodate (figure 3.2). This may stand by way of contrast to older built environments which significantly pre-date the automobile age, where a centralised spatial structure based on the traditional city centre may be the norm. In such contexts there may be a more complex and constrained urban environment with more interactions with non-road-users, presenting a different set of challenges for planners in comparison to the CAV uptake in a more decentralised structure. Add to this the fact that countries have different legal and regulatory traditions governing road use and vehicle and pedestrian behaviour – with high levels of codification and regulation for drivers and other road users in some contexts and a more informal or negotiated approach in others – including on key aspects of the driving task such as giving way to other traffic or the actual and implied hierarchies of road users. Again depending somewhat on the age of development of the built environment, road systems may either obviate or otherwise necessitate varying degrees of conflict: consider the role of grade-separated highways, signal-controlled intersections and jaywalking laws in seeking to minimise conflict and the need for negotiation, and contrast these (for example) with narrow mediaeval or rural street patterns or the engineered use of shared spaces where negotiation, cognitive heuristics and informal rules become more important. This latter set of cases are likely to present a much bigger challenge to CAV use. One possible outcome if computation progress cannot keep up with consumer demand of, and industrial promotion of, CAVs could be pressure to simplify road infrastructures and reform legislation to make streets more auto-friendly.

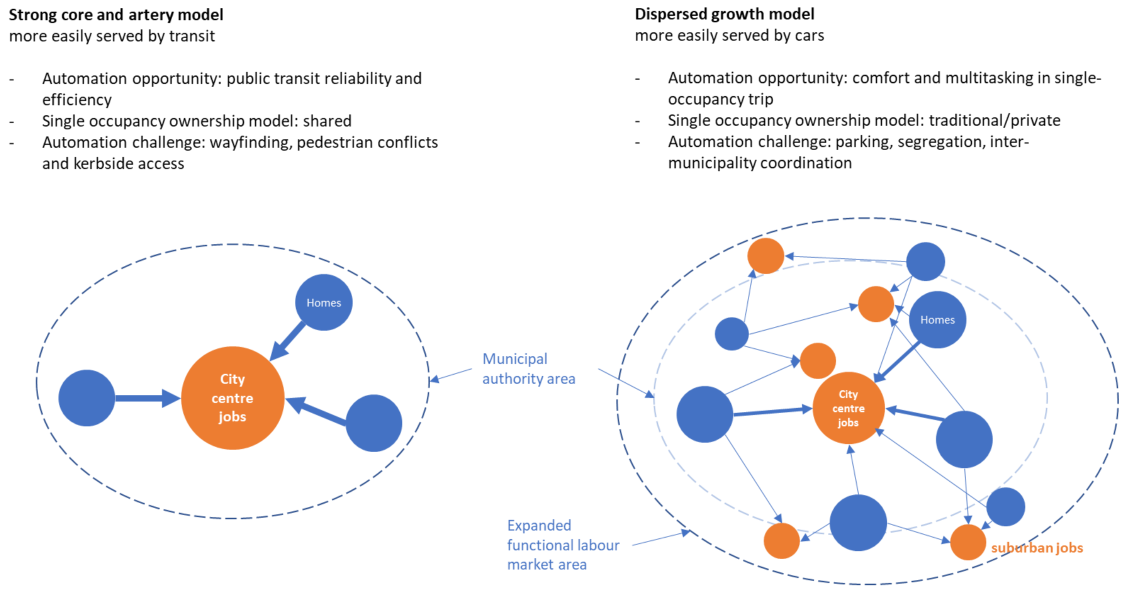

Figure 3.2.
Different urban spatial structures could lead to different automation models and imply different challenges to overcome.

Working against this trend – where CAVs 'suit' lower density environments and deliver greater marginal benefits to their residents – we might also anticipate impacts in other types of urban environment. The value of *using* (but not necessarily owning) a CAV – for example through automated ride sharing services – could be expected to be enhanced in higher density urban residential environments where it may be difficult or impossible to park a private car.

There will also be significant social and economic gradients to CAV uptake, which may have a distinct spatiality (figure 3.3). Again, this pattern may vary according to the different international contexts and experiences of urbanisation: the archetypical US city with comparatively unfettered development of land together with the sociocultural valorisation of automobile ownership has typically suburbanised affluence and residualised urban cores; by contrast the experience in some major European cities is of a high amenity, high value urban core and the peripheralisation of poverty. Whilst simply stylised facts, these extreme examples nevertheless demonstrate the very different contexts into which CAV adoption, ownership and use will play out, with radically different marginal utility gains resulting from factors like workplace location, income, parking availability, public transport quality and availability, and active travel use.

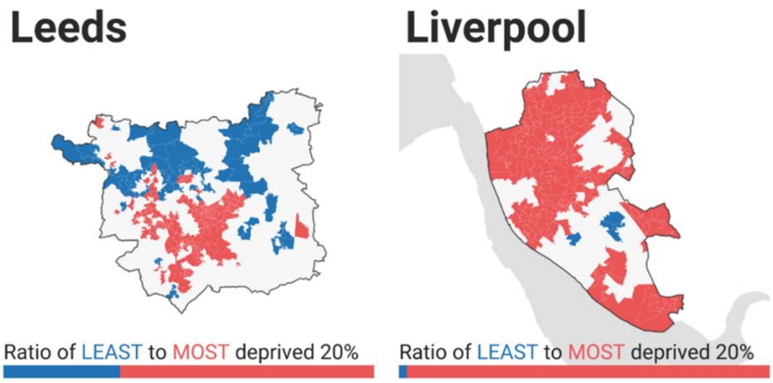

Figure 3.3.
Different patterns of social deprivation and affluence within cities will affect the extent and pattern of CAV take-up and the trip demands they might accommodate.

Image source: Rae & Nyanzu (2019) An English Atlas of Inequality, Nuffield Foundation.

The extent to which the ability of CAV users to undertake other activities will drive demand for their use may in part reflect the maturity and accessibility of existing and potential public transport infrastructure. In situations where there is frequent long-distance travel between dispersed locations – such as in the US or Australia – CAVs could potentially offer an attractive option for trips not serviced by rail or where air schedules are inconvenient.[14] Alternatively, in urbanised countries like Japan with very mature high speed rail networks, CAVs will not likely be competitive against rail for long distance journeys on either speed or time-effectiveness grounds. In urbanised countries with poor high-speed infrastructure and congested roads, CAVs may be expected to offer comparative speed advantages against rail as well as comfort gains for motorists, whilst utilising congested road space more efficiently. In such scenarios CAVs can be expected to erode modal share from both long-distance rail and conventional cars, whilst automated long distance bus services may also become an attractive option.

Within urban areas, CAVs also have the potential to impact upon how roadside property and kerb space are conceptualised and valued. More use of automated ridesharing and at-home delivery services could lead to more emphasis being placed on property accessibility for loading and less emphasis on on-street parking.[15] Pricing and access control models that, where they exist, tend to regulate parking more heavily than other uses may shift – for example, towards using technology to price vehicle stopping for goods loading and passenger pick-up/drop-off. Irrespective of the precise mechanisms used to regulate future use of the kerbside, the codification necessary to integrate kerb management with CAV algorithms may be at odds with the socially constructed and negotiated norms which have grown up in many local jurisdictions and urban cultures. Whilst this may bring some benefits (CAVs are unlikely to block cycle lanes unless programmed to do so), there is also the prospect of ‘real risks that the role of streets as places for people as well as sites of curbside [sic] transactions will be lost in the competition for access.’[16]

Although the future of CAVs’ relationship with the built environment is uncertain and contingent, on balance the fundamental role of the automobile in shaping cities in the past century predisposes them to a certain path dependence. Whilst automobiles have been central to urban sprawl, the prospect of CAVs will assert a significant disequilibrating force on the relationship between housing space/location and travel time, as the value of each shifts relative to the other. Taken thus, and all other things being equal, in parts of the world where urban sprawl has become culturally entwined with lifestyles, CAVs will likely lead to an increase in vehicle miles travelled, further reduce public transport use, and lead to the continuation of dispersed urban growth patterns[17]. This will be particularly relevant under the ‘business as usual’ ownership model noted earlier. As well as changing the form and design of roads, CAVs may plausibly lead to the demand for more road building even taking into account their more efficient use of road space at higher levels of market penetration. Even assuming that most CAVs will be electric vehicles, more traffic and more road infrastructure will nevertheless yield negative environmental and public health externalities, for example through rubber and brake disc particles and the carbon footprint of road construction.

The final set of issues to which we turn relate to public trust in CAVs, in terms of both CAV users and others. Whilst the technology within CAVs can be developed to a level of sophistication and reliability that would permit high degrees of trust to be placed in the operation of the vehicle within the parameters of its instruction set, it will be equally important to ensure public trust in the ways CAVs 'understand’ and interact with their wider environment. One submission to our Policy Expo stressed the importance of more research into public understandings of place and on public views about CAVs entering the places where they live and work. As they say, ‘people will not necessarily trust CAVs if these vehicles and the infrastructure which supports them cannot grapple with human meanings of places.’ This includes perspectives drawn through the lenses of gender and age on issues like safety, how the built environment is ‘read’, privacy, and vehicle routing. Would a CAV slow well beyond the legal speed limit and drive more defensively outside a school when parents begin milling around the school gate? In seeking trust in a vehicle within such an environment, the hard-coding of such behaviours into vehicle software is unlikely to be an adequate substitute for the intuition and heuristics that humans would use.

3.6. Summary

The uncertainties and contingencies that have been noted in this chapter provide a critical barrier for local and regional policymakers seeking to plan for CAVs, also make such proactive planning all the more important. Local policy can, to a degree, help influence the role that CAVs might fulfil within a particular city. **However, this is also dependent on external influences, such as national government policy and regulation, or how consumers and the market respond to new CAVs becoming**

available. Within the built environments of different cities and regions around the globe, the spatial expression of cultural, social, economic and technological histories as overlain by transport investment and infrastructure will condition both the prospects and possibilities for citizens' positive coexistence with CAVs at the street level. This prompts the need for policymakers to consider how the autonomous automobile, alongside other forms of CAV, might fit into long-term transport plans and strategies at the local and regional level. Tighter integration will be required between transport policies and spatial planning policies which govern urban development patterns for land uses like housing and employment - arguably in itself requiring a reshaping of the logic underpinning transport policy appraisal away from seeing transport as something which simply serves inherent or even induced demand to one which fully appreciates transport's role in shaping urban futures and mobilities. To challenge the inevitability of automobility in tension with other urban goals such as liveability, equity, and accessibility to services, will require political nuance and conviction.

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