Connected and Autonomous Vehicles. Introduction

PARKES, Stephen <http://orcid.org/0000-0002-4379-2058> and FERRARI, Edward <http://orcid.org/0000-0002-5506-7670>

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.2022.2085925

1. Introduction

1.1. Introducing CAVs

The past decade has seen substantial progress towards the development of CAVs. Accompanying the technological developments there has been much dialogue around the potential for CAVs to help solve a range of economic, social, and environmental issues. Such benefits being gained through, for example, greater efficiencies on the road network, increased capacities, improved safety through removing human error, and enhanced inclusivity. Throughout this book, we predominantly use the term CAVs, and do so to incorporate increasingly connected vehicles that are common on the road network now alongside more highly automated vehicles that are beginning to emerge. This recognises that this is a broad and transitioning area of study with vehicles at all degrees of connectivity and automation having implications for city and regional policymakers.

A large number of vehicles currently on the road network have some degree of connectivity and/or automation. **Connected vehicles (CVs)** include those with advanced communication technologies, which might include navigation and entertainment systems linked to mobile phones, in-built road-side assistance services (common in the United States[1]; US), and antitheft tools such as remote engine stopping and locking[2].

In 2018, it was estimated that 66 per cent of newly registered vehicles in the United Kingdom (UK) had some degree of connectivity[3]. This increasing integration of this technology is partly through legislative changes driven by a desire to further increase safety. For instance, in 2018 new regulations in the European Union (EU Regulation 2015/758) were brought in mandating that the vast majority of new passenger and light vehicles must include 'eCall'. This is a system that detects when a vehicle is involved in an incident and contacts the emergency services automatically.

Box 1.1: Connected and Autonomous Vehicles

Connected Vehicles (CVs) are those equipped with advanced communication technologies that allow the exchange of information between the various elements of the transport system, including vehicle to vehicle and vehicle to infrastructure communication

Autonomous vehicles (AVs), which are also interchangeably known as automated, driverless, or self-driving vehicles, are able to undertake driver tasks such as steering, braking, and acceleration with minimal or no human input and are able to navigate the environment and other road users. The level of automation influences the degree of human intervention required.

Connected and Autonomous Vehicles (CAVs) is a catch all term used to describe both connected and autonomous vehicles. Whist connected vehicles exist now and may have no automation, automated vehicles will by design have some degree of connectivity built in and therefore AVs and CAVs are terms often used interchangeably.

Connectivity is also increasingly seen through more use of vehicle telematics, which are used by car manufacturers and the insurance industry for understanding (and pricing) risk associated with driving. Crowd sourced data also forms part of this increasing connectivity of vehicles. For instance, the use of smartphones and satnav applications, which are used to collect and distribute data on mobility, particularly with the purpose of Informing of live traffic data and incidents to enable more responsive vehicle routing.

There are also growing levels of automation available in vehicles being deployed on the road network with driving automation systems taking responsibility for a greater proportion of the dynamic driving task. Such systems include autonomous emergency braking, Lane Keep Assist, park assist, and adaptive cruise control.

As of 2018, 61 per cent of new vehicles registered in the UK were at 'Level 1' of the SAE 'Levels of Driving Automation', which indicates some degree of driver assistance, including those listed above[1]. In the same way as CVs, much of these driver assistance measures form part of requirements in new vehicles to enhance safety. For example, in 2022, the EU Commission is mandating a range of safety features for new cars and vans such as: advanced emergency braking systems, driver drowsiness and attention warning systems, and lane departure warning systems[2].

Ultimately, it may be possible for vehicles to operate on public roads without a human driver. Some developers, such as Waymo and Cruise (passengers) and Nuro and Gatik (deliveries), are trialling such services. The commercial deployment of these vehicles at scale is likely to be part of a transformative, yet disruptive, change to the transport system. These vehicles remove the need for a driver to be in place, or allow for them to complete other tasks whilst travelling, for example, working, or even exercising.

The race to introduce CAVs is akin more to a marathon than a sprint and will include a slow, transitional period with much uncertainty. This uncertainty creates a challenge for policymakers grappling with a range of issues within their boundaries.

1.2. Typologies and impacts of CAVs

CAVs can be divided into three groups or typologies based on their purpose[3]. Firstly, ***passenger transport***, which includes private vehicles but also shared use shuttles and buses. Private passenger vehicles are where the most disruptive impact of a transition to CAVs is likely to occur, as far as built environments go. As a result, much of the attention currently centres on such vehicles.

Figure 1.1: Passenger transport

Smaller autonomous shuttles are likely to feature in future transport systems. Trials of such vehicles are already underway.

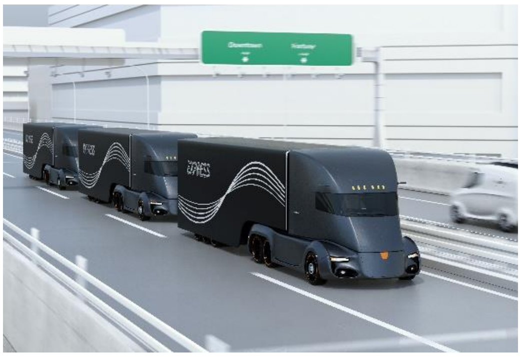
Image source: Chesky/Shutterstock.com

Passenger transport will also encompass private vehicles where driver tasks are handed over to the autonomous vehicle.

Image source: metamorworks/Shutterstock.com

In addition to passenger vehicles, a second typology is ***freight and cargo transport***. This includes inter-city deliveries along strategic roads such as motorways, but also intra-city movement of goods. Freight deliveries in urban areas are fraught with challenges owing to the often dense and congested network of roads. Last-mile deliveries are a particular challenge for city transport planners (exacerbated by the rapid increase in online deliveries during the Covid-19 pandemic) but also an area where CAVs may contribute effectively.

Figure 1.2: Freight and cargo transport



CAVs might come in all shapes and sizes, including this artist impression of AVs for freight deliveries.

Image source: Chesky/Shutterstock.com

Completely autonomous vehicles are already being utilised for ‘last-mile’ deliveries.

Image source: Suwin/Shutterstock.com

The final typology, as outlined by Ryan Jones and colleagues at the University of Sydney[4], is ***precinct and facility services***. This typology centres on CAVs that operate in controlled, largely closed, environments such as airports, university campuses, or business districts. The vehicles might include both passenger and cargo, and they tend to travel shorter distances whilst interacting with a variety of pedestrians and other obstacles. Whilst private passenger transport is likely to post the greatest challenge for policymakers, when these typologies are considered together, the potential disruptive impact of CAVs is substantial.

It is also important to note that the arrival of CAVs doesn’t necessarily simply mean a like for like replacement of non-CAVs with CAVs. An introduction of CAVs will not have a neutral effect. Some suggest that the arrival of CAVs will attract more people to private vehicles thereby increasing traffic volumes. Others suggest that, under a shared model of ownership, numbers of vehicles will decline. There is also discussion in the literature of how CAVs might help to increase accessibility, particularly for those with mobility constraints[5]. It may also prompt a rethink of how road space is used, particularly for parking and whether there are efficiencies to be gained[6].

This prompts us to think about the broader impacts of increasing automation of vehicles and how this might play out in cities and regions. Dimitris Milakis and colleagues[7] framed these potential impacts under first-, second-, and third-order implications, the premise of this being that those first-order effects of CAVs will have a knock-on effect to the second- and third-orders.

The authors describe these emerging as a 'ripple effect' with the first-order impacts occurring first (followed by the second and third) as the ripple moves outwards. It is important to note that these effects can happen with no time lag between them and there can be feedbacks to previous orders. This is elaborated on by the authors: "*changes in travel cost (first ripple) might influence accessibility, then subsequently location choices, land use planning, and real estate investment decisions (second ripple), which in turn could affect travel decisions (e.g. vehicle use) and traffic (first ripple)".*

Table 1.1: Likely effects of automated driving

	Possible effect
First-order implications	Travel cost (cost of vehicle, travel times)
	Road capacity
	Travel choices (miles travelled, modes used)
Second-order implications	Vehicle ownership
	Location choices and land use
	Transport infrastructure
Third-order implications	Energy consumption and air pollution
	Safety
	Social equity
	Economy
	Public health

Source: Adapted from Milakis et al. (2017)

The effects demonstrate the wide-ranging potential impacts that CAVs are likely to have. Much of the focus in academic and grey literature, and within the press has been focused on utopian visions of the widespread adoption of CAVs and the benefits they will bring. The discourse tends to be more focused on the utilitarian dimensions of CAVs, such as regulation, safety, and efficiencies.

This type of focus can tend to ignore, or at least underestimate, the wider social impacts of such vehicles[8], including impacts on other road users (particularly those more vulnerable) and who benefits or who might be excluded. This is also wrapped up in a potentially long transitional period where users of non-CAVs will be forced to interact with increasingly highly automated vehicles in the same road space. Whilst for now the majority of CAVs remain at the testing phase and operate within controlled environments, there are examples where higher levels of driver assistance are currently being utilised on public roads but with concerning or even fatal consequences[9].

This reaffirms the point that CAVs do not offer a like for like replacement for non-CAVs and why it is important for local policymakers to be informed of their impacts to better plan for them.

Our intention in the Policy Expo and presented in this book, is to provide a broader perspective on the impacts–- both technological and social – of CAVs and how these might play out in local and regional environments. Whilst some towns and cities are leading the way and form part of an 'early adopting' group or 'testbed locations', for the vast majority, the evidence is that there is a distinct lack of preparedness and knowledge around CAVs and their implications[10]. As vehicles become increasingly connected and autonomous, these issues become ever more pertinent, and this forms the core of our Policy Expo, and which will be explored further throughout this book.

1.3. About the Policy Expo

In 2020 we launched our Policy Expo with the aim of studying the current state of play with regards to the rollout of CAVs and their impact on the built environment. We had a particular focus on advancing the dialogue around how towns and cities beyond those early adopters might fare, and how CAVs might interact with other important policy agendas facing such places.

The Expo was global in scope and therefore sought to draw on evidence from a range of people and places. We recognise that the CAV field is extensive and multi-dimensional. The Expo therefore did not seek to be a comprehensive assessment of the CAV market and future trajectories. Several market assessments and horizon scanning reports have been published to serve such a purpose[11]. Instead, we have sought to view these developments through the lens of local policymakers and the towns and cities they represent. We are interested in what the impacts on these places might be, and how they might respond. Our work has as a result been structured around the following questions, which are addressed in this book:

1. How will the urban and built environment practically accommodate CAVs?

2. What problems might arise, and will there be 'winners and losers' – if so, who and in what ways?

3. How will different policy agendas – across geographic scales or policy domains – align or conflict as the urban environment begins to accommodate CAVs?

4. Will policies promoting or accommodating CAVs help or hinder other urban agendas including but not limited to active travel, zero carbon, health and wellbeing, social and economic inclusion, and liveability?

5. What do best-practice policy solutions look like, and how can local and regional policy makers plan proactively?

6. What will national policymakers and infrastructure providers need to do? And what must be resolved locally?

1.4. Our approach

To gather evidence as part of our Policy Expo, we engaged broadly with those working across policy, practice and academia. 34 participants in our project provided evidence and input, providing perspectives from Africa, Asia, Europe, the Middle East and the Americas. Participants engaged with the Expo through a number of different channels. These included:

Call for Evidence

Recognising our objective to hear about developments and challenges from a range or people and places, we launched a global Call for Evidence (CfE) in 2021, which ran between January and May. This CfE sought detailed submissions from policymakers, practitioners, and academics across the Expo questions outlined in the previous section.

The CfE received ten in-depth submissions with detailed evidence and sources, including information relating to low- and middle-income countries as well as more advanced economies. These submissions highlighted several areas of concern amongst our respondents. This included: public acceptance, safety, infrastructure gaps, and legislative and regulative concerns. These issues and their impacts are explored further in this book.

Expert Interviews

We undertook 15 interviews with experts working in this field, whose work intersected with issues around CAVs. The interviews covered a range of questions relating to the Policy Expo, grouped around these three broad topics:

1. The accommodation of CAVs (practical considerations, time horizons, what journeys might be most affected, who stands to win/lose).

2. Impacts on competing policy agendas (for example, active travel, liveability, spatial impacts).

3. Best practice solutions to the above (and how this might be disseminated/communicated globally).

Interviewees are anonymised in the analysis presented in this book but they included representatives from policy, practice and academia, which provided a range of insights that we can report on here. We sought responses internationally, reflecting our aim to examine these issues across both the Global North and South. Notably, we were particularly keen to include perspectives that include other road users, and the broader implications on these groups of the likely transition to CAVs.

Workshops

We convened two workshops at successive RSA Regions in Recovery Festivals (2021 and 2022) to engage academics, practitioners, and policymakers in our emerging findings. This provided an opportunity for feedback and refinement of potential policy recommendations. We also presented emerging findings at the Royal Geographical Society Annual Conference 2021, receiving further input to guide the Policy Expo activities.

Literature review

In addition to our primary data collection through the CfE and Expert interviews, we have also undertaken a review of the current literature, which feeds into the evidence presented in this book. This includes both academic and ‘grey’ literature (including policy documents, reports, and news articles).

Case-studies

Throughout this book you will encounter several case-study boxes that feature a specific CAV project or example. The purpose of these is to showcase a range of real-world examples of where and how CAVs are being deployed, and the impacts they have had. We have sought to include diverse case-studies from different countries and dealing with different dimensions of CAVs.

These case-studies include:

- Piloting autonomous shuttle buses in public transport, the case of Barkarby, Stockholm by Kelsey Oldbury (VTI, Sweden).
- Autonomous Vehicles in Nigerian Cities: Environmental and Policy Issues by Aliyu Kawu (Federal University of Technology, Nigeria).
- Creating safe CAV services: Findings from Project Endeavour, UK.

1.5. The remainder of the book

The focus of the remainder of this short book is to provide an introduction to CAVs and, in particular, discuss what the implications of a transition to more highly automated vehicles are likely to be. We explore some of the key challenges facing policymakers locally and how CAVs might align or conflict with other important agendas seeking to enhance the liveability of cities. We then discuss some of the key components of the response to the arrival of CAVs and the role of local policymakers within this. Finally, we offer concluding thoughts and a series of recommendations for policymakers.

1.6. References

[1] For example, OnStar in the United States (www.onstar.com).
[2] Deng J, Yu L, Fu Y, Hambolu O and Brooks RR (2017) *Security and Data Privacy of Modern Automobiles*, in Chowdhury M, Apon A and Dey K (eds) Data Analytics for Intelligent Transportation Systems. Elsevier, 131–163. doi:10.1016/B978-0-12-809715-1.00006-7.
[3] Society of Motor Manufacturers and Traders (2019) Connected and Autonomous Vehicles 2019 Report: Winning the global race to market. Available at: http://www.regulation.org.uk/library/2019-SMMT-Connected_and_autonomous_vehicles.pdf
[1] Society of Motor Manufacturers and Traders (2019), see Reference **Error! Bookmark not defined.**.
[2] https://www.consilium.europa.eu/en/press/press-releases/2019/11/08/safer-cars-in-the-eu/
[3] Jones R, Sadowski J, Dowling R, Worrall S, Tomitsch M and Nebot E (2021) Beyond the Driverless Car: A Typology of Forms and Functions for Autonomous Mobility. *Applied Mobilities*, 1–21. doi:10.1080/23800127.2021.1992841.
[4] Jones R, Sadowski J, Dowling R, Worrall S, Tomitsch M and Nebot E (2021), see Reference 3.
[5] Faber K and van Lierop D (2020) How will older adults use automated vehicles? Assessing the role of AVs in overcoming perceived mobility barriers. *Transportation Research Part A: Policy and Practice*, 133, 353–363. doi:10.1016/j.tra.2020.01.022.
[6] Duarte F and Ratti C (2018) The Impact of Autonomous Vehicles on Cities: A Review. *Journal of Urban Technology*, 25, 3–18. doi:10.1080/10630732.2018.1493883.
[7] Milakis D, van Arem B and van Wee B (2017) Policy and society related implications of automated driving: A review of literature and directions for future research. *Journal of Intelligent Transportation Systems*, 21(4): 324–348. doi:10.1080/15472450.2017.1291351.
[8] Bissell D, Birtchnell T, Elliott A and Hsu EL (2020) Autonomous automobilities: The social impacts of driverless vehicles. *Current Sociology*, 68(1), 116–134. doi:10.1177/0011392118816743.
[9] See https://edition.cnn.com/2021/08/16/business/tesla-autopilot-federal-safety-probe/index.html

[10] Freemark Y, Hudson A and Zhao J (2019) Are Cities Prepared for Autonomous Vehicles? *Journal of the American Planning Association*, 85(2): 133–151. doi:10.1080/01944363.2019.1603760.

[11] See, for example, KPMG (2020) 2020 Autonomous Vehicles Readiness Index.