Connected and Autonomous Vehicles. Chapter 2, the transition to 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.2022.2085926

2. The transition to connected and autonomous vehicles

2.1. Introduction

This chapter provides a brief introduction to CAVs and what the transition to a more widespread adoption of these vehicles might look like. This chapter firstly elaborates on what we mean by CAVs and how the different levels of automation are distinguished, to provide an understanding for readers less familiar with the detail around them. The chapter then moves on to consider the evidence on levels of preparedness for the actual accommodation of CAVs across different places both at country and local levels. This helps to set the scene for the subsequent chapters of this book.

2.2. What are Connected and Autonomous Vehicles?

The technology underpinning CAVs can be traced back through successive developments from the middle of the 20th Century onwards. Vehicles such as the 'Stanford Cart', which was fitted with cameras and could autonomously detect and follow a line on the ground, and vehicles with on-board computers that could process images of the road to help them navigate were early precursors to the vehicles considered in this book[1].

Development of CAVs accelerated in the early 21st Century. Much of this progress – particularly around private and public passenger vehicles – has been fuelled by technology and vehicle manufacturers developing the physical vehicles and underpinning Artificial Intelligence (AI) software. This was in response both to government sponsored challenges (such as the DARPA Grand Challenge[2]) and efforts by vehicle manufacturers to expand into new markets. As a result of this activity, attention initially was largely focused on the advanced vehicle technology itself; and the abilities (and limitations) of it , rather than the broader environment such vehicles might impact upon.

CAVs can come in all shapes and sizes. The concept of a driverless car might conjure images of sleek, futuristic vehicles. In reality, however, CAVs are already here and they often look very much like what we see as a 'normal' vehicle. CVs, are far more established on road networks, owing to their lower technological complexities. These vehicles might simply include an ability to connect your mobile phone to your vehicles navigation system to receive real-time updates on traffic conditions and route options. AVs, which have higher technological requirements, are being increasingly seen on our roads.

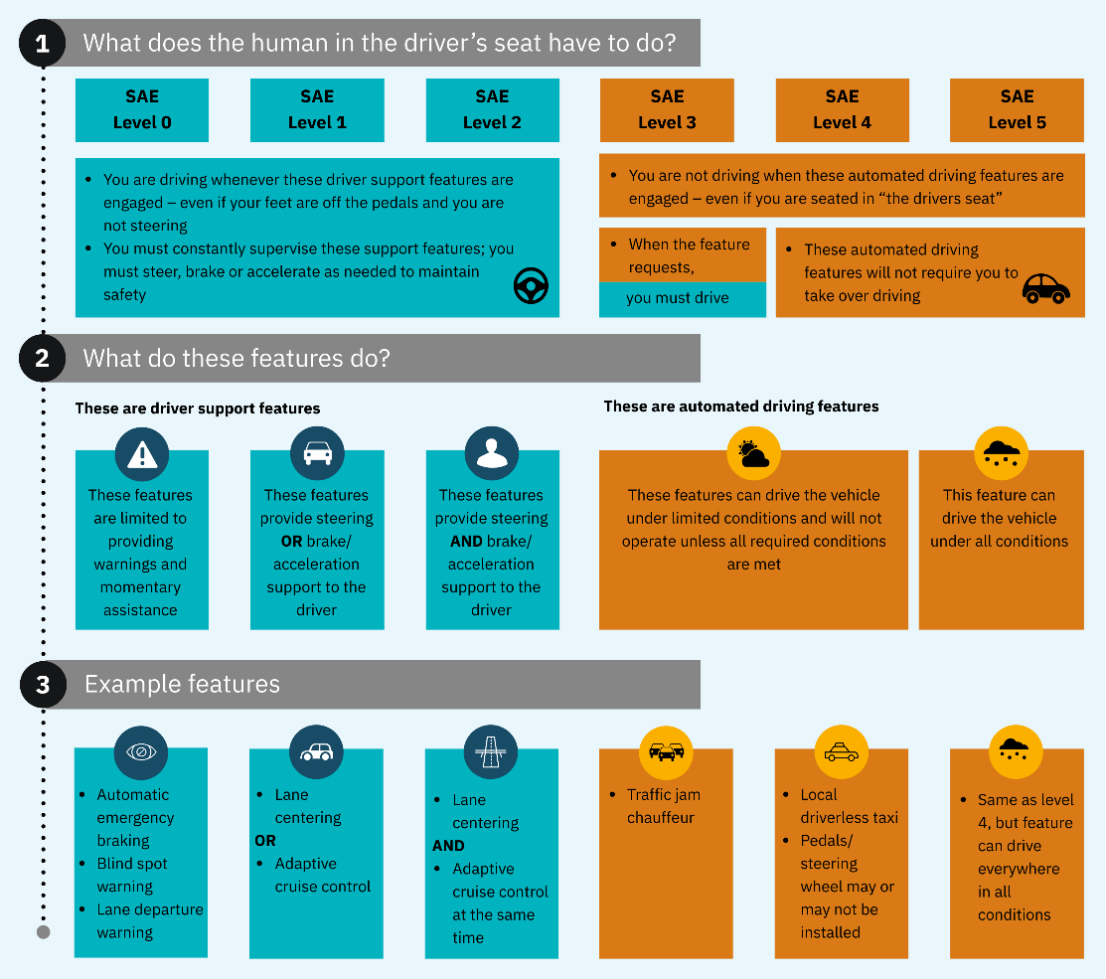
Proponents of CAVs argue that there are a range of benefits that the development of more highly automated vehicles might bring. This has been debated across the transport community and explored as part of a range of studies into the topic. These idealised outcomes centre on the potential of CAVs to reduce the number of collisions;

reduce congestion and improve capacity; lower emissions through more efficient driving; reduce vehicle ownership but also increase access for those in our communities with mobility issues; and help to support freight transport, and increasingly, the last mile delivery problem in towns and cities. Improvements in safety (for those both inside and outside the vehicle) is a key driver of EU legislation around this topic. Of course, much of this assumes an on-going desire for individual mobility and we will explore the different scenarios of private versus shared ownership models in this book.

2.3. Levels of automation

At this point, the 'levels of automation' are crucial in helping us understand how the technology underpinning CAVs is anticipated to gradually remove the need for a human driver to control a vehicle and navigate it safely. SAE International, based in the US, have developed the Levels of Driving Automation to standardise the different levels of automation across a fast-developing industry. These levels have proved to be influential and are widely referred to across the sector.

Figure 2.1: SAE Levels of Driving Automation



Source: SAE International

Levels 0-2 are increasingly present on public roads. Nearly two-thirds of new vehicles registered in the UK in 2018 had capabilities in line with Level 1 automation[1]. Arguably, many of us might not see this as a sign of increasing automation in vehicles, but rather just the result of improvements in assistive technology designed to make us safer. Whilst this is true, it also suggests there is an element of 'slow creep' towards the

highest levels of automation (particularly Levels 4-5), but little public understanding or debate about the implications of this. This matters because there is widespread recognition that CAVs are likely to be a 'disruptive technology' that brings about a step-change in how we travel around towns and cities (and between them)[2,3]

Figure 2.2: Levels of automation

Vehicles at Levels 0-2 have driver support features that can be engaged but ultimately, the driver remains in charge.

Image source: aslysun/Shutterstock.com

CAVs utilise AI to assess the built environment and navigate around obstacles. Level 5 sees the vehicle able to consistently drive safely under all conditions.

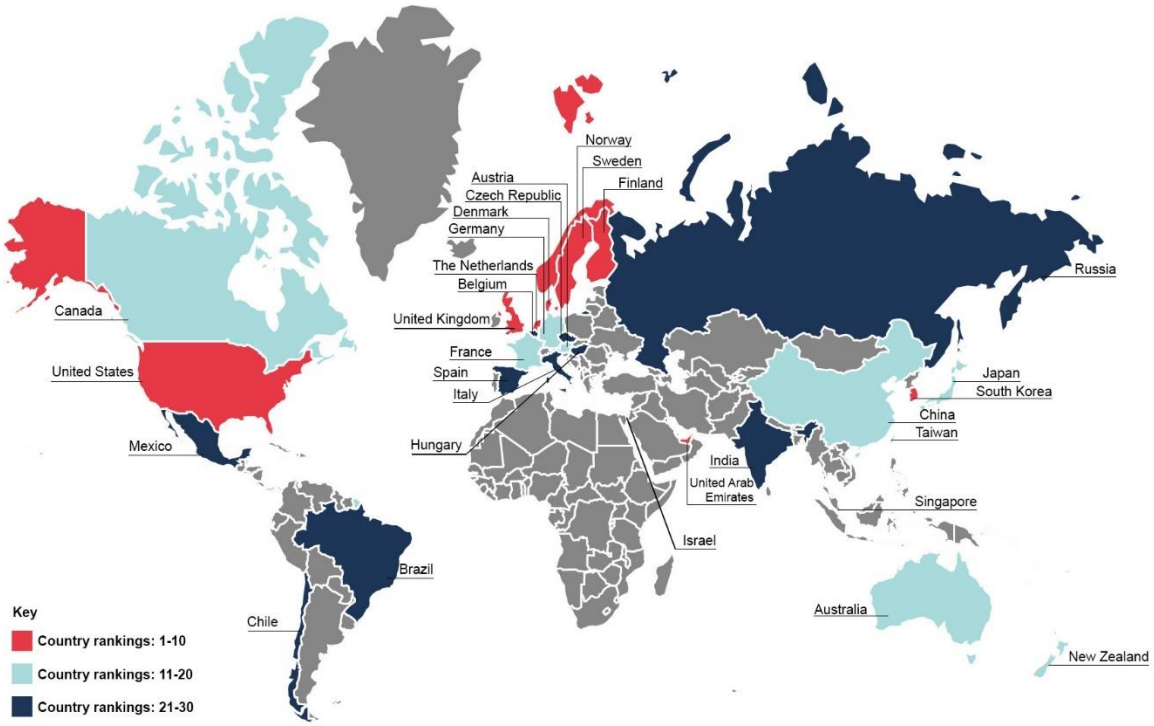
Image source: Scharfsinn/Shutterstock.com

2.4. Existing levels of preparedness

Country level

As technological developments have made the higher levels of automated vehicles an increasing reality, attention has shifted to beginning to explore what preparedness looks like across different countries. The KPMG Autonomous Vehicles Readiness Index (AVRI)[4] examines preparedness across the countries leading on CAVs. As of 2020 this includes 30 countries or jurisdictions, which are shown in Figure 2.3.

Figure 2.3: World map displaying top 30 countries of KPMG readiness index



These countries have been ranked in the order shown based on 28 different criteria, which are grouped across four broad categories: policy and legislation, technology and innovation, infrastructure, and consumer acceptance. The KPMG AVRI is a core document outlining national level preparedness and therefore is worth unpicking further. The four categories are useful in understanding the factors that underpin preparedness at national level for the accomodation of both CVs and, in particular, AVs. It is important to note that readiness here is very much about the creation of environments conducive to CAVs. For example, countries with regulation environments that are supportive of AVs score more highly on this index.

Policy and legislation

This category covers factors such as the regulatory environment within each country around CAVs. It also includes the extent to which governments are supporting pilot programmes, and whether there is a dedicated government agency that is responsible for supporting a transition towards CAVs. Strategic planning by the government and a readiness to change are also seen as important in this area, as well as an open data sharing environment that supports more widespread and transparent sharing of data.

Technology and innovation

The extent to which partnerships between different parts of the industry (for example, between vehicle makers and technology firms) are important for this category and score highly where strong partnerships exist. Related to this is the presence of AV firms within the country, particularly where these firms are headquartered, with such proximity deemed important. Other factors relating to preparedness linked to technology and innovation include the level of industry investments in AV, the country's capability to innovate, and the strength of cyber security in the country.

Infrastructure

Important factors linked to infrastructure that help underpin a country's preparedness for AVs including the presence of electric vehicle (EV) charging infrastructure (essential for EV AVs). Also important in this is the strength and coverage of 4G/5G mobile data networks, as well as the broader technology infrastructure. Finally, the quality of the road network, as poor-quality highways can impact on the ability of AVs to navigate safely.

Consumer acceptance

Consumer acceptance is the final category in the readiness index. Factors important to this include the proportion of the population near test areas. The rationale for this being more awareness and exposure to AVs in active environments increases acceptance of the idea of them. Other factors include broader use of technology across society and digital skills amongst the population, which includes measures on individual readiness.

Based on these four categories, the KPMG report ranks the following countries by their readiness for AVs, as outlined in Table 1.1.

Table 1.1: Ranked list of top 30 countries in KPMG readiness index

1. Singapore	11. Japan	21. Belgium
2. The Netherlands	12. Canada	22. Spain
3. Norway	13. Taiwan	23. Czech Republic
4. United States	14. Germany	24. Italy
5. Finland	15. Australia	25. Hungary
6. Sweden	16. Israel	26. Russia
7. South Korea	17. New Zealand	27. Chile
8. United Arab Emirates	18. Austria	28. Mexico
9. United Kingdom	19. France	29. India
10. Denmark	20. China	30. Brazil

The leading countries offer the most advanced examples of applying the higher levels of automation in real-world (or close to real-world conditions). For example, three bus routes in Oslo, Norway are now driverless. These countries are also characterised by extensive testing; 81 per cent of people in the Netherlands live close to AV pilots. Advanced levels of infrastructure to support CAVs are also in place, including digital infrastructure.

It is notable that the list mainly includes countries in the Global North, which is understood as Europe, North America, and developed parts of Asia. This bias towards the Global North is not surprising but shows how developments around CAVs are being driven and shaped by a selective group of countries.

Countries in the Global South on this list, which includes China, India, Brazil, Chile amongst others, are generally in the lower half of the list, which indicates a lower level

of preparedness. This will continue to change, of course. The AVRI reports that China is moving quickly into this area. Although this is contrasted with India and Brazil whose AVRI reports suggests there is minimal or slow progress being made. Level of preparedness is very much dictated by national level agendas. As such the KPMG AVRI largely takes a country level view and reports on nationwide developments.

Cities and regions

The previous section has considered preparedness to accommodate CAVs at a national level. Whilst the national context is crucial to enabling more effective accommodation of CAVs, the national and local levels are intertwined and dependent on one another. This means it is important to consider the role of cities and regions too. This is particularly pertinent given such places are ground zero for the roll-out of CAVs.

Where national level activity is advanced around CAVs, this invariably leads to increased activity in cities and regions. Places chosen, or promoting themselves, as 'test-beds' where trials are undertaken become early adopters to the technology. These cities and regions understand more about some of the considerations for the effective accommodation of CAVs in their local environments. However, a transition towards integrating more highly autonomous vehicles into the built environment will be highly complex and pose many challenges for both these test-bed locations and other cities and regions who have progressed even less on this journey.

To date, there has been only minimal research on how cities and regions might accommodate CAVs[5] although there is some evidence we can draw upon. Research conducted in the US[6], which ranks 4th on the AVRI, suggests that there are indeed differences across cities in terms of their preparedness. This work found that only a small number of local governments in the US had initiated any form of planning for AVs. It was the larger cities and those with higher rates of population growth that were likely to be more advanced in this regard. Furthermore, there was a variation in responses identified based on factors such as political ideology, per capita government expenditures, and population density. From an infrastructure perspective, there are acknowledged gaps in levels of readiness of road infrastructure to safely accommodate CAVs in the future[7]. With the process of upgrading road and other supporting infrastructure long and costly, the risk is that a poorly anticipated disruptive technology such as CAVs can lead to an exacerbation of barriers and undermine other urban policy objectives, such as those related to enhancing liveability.

With much of the activity and 'test-bed' environments being in Global North countries the focus gravitates towards them, which is understandable. However, we would argue that this potentially alienates countries that might lag behind with such developments, or whose priorities are not presently CAVs. There are parallels to this problem with other recent technological innovations. For instance, the roll-out of fixed broadband connectivity has occurred unevenly. For instance, research from the Asia-Pacific region shows that as improvements coverage and quality in high-income countries have helped to rapidly increase those with access to it, uptake amongst those in the lowest income countries has remained static[8]. This digital divide is emblematic of the challenge of rolling out new technologies evenly.

There is a lack of work that is being undertaken that focuses on countries in the Global South. The informal road environment, and the economic activities that are undertaken within it, that perpetuates in Global South countries is problematic for CAVs[9]. Furthermore, a lack of standardisation of signage and traffic signals, along with significant limitations in real-time data availability pose further barriers to effective roll-out. Motivated by the concern that there is not enough attention on the Global South

in the CAV dialogue, we commissioned a case-study that provides a focus on a country in the Global South to shed light on the challenges that might be faced there.

Box 2.1: Case-study: Nigeria

CASE STUDY

Autonomous Vehicles in Nigerian Cities: Environmental and Policy Issues by Aliyu Kawu
(Federal University of Technology, Nigeria)

CAVs and the informal economy of Nigerian cities

For CAVs to be deployed in Nigerian cities, large scale urban road expansion and renovation will be required. At present, most urban settlements in the country are lacking in functional and well-maintained road networks. This necessitates the procurement of improved and expanded road facilities, and the accompanying infrastructure - as recently undertaken in Abuja and presently occurring in Kaduna and Maiduguri.

This construction and reconstruction is likely to be viewed as attacks on the 'striving' informal economic activities that take place in these urban areas. Although, the widespread informal economic sub-sector has been facing increasing pressures for formalization and proper integration, efforts to integrate CAVs will place further pressures on this. Low capital for operation and limited access to shops, coupled with weak law enforcement, has led to these informal sector operators (mainly traders) to operate on and by the roadsides. Such attempts to formalise this aspect of the economy in the past have failed; not just because the informal sector is the dominant source of livelihood for city residents, but authorities are confronted with the consequences of relocation, resettlement, and funding amidst lack of efficient federal and local policy backing.

Processes leading to rebuilding of existing urban landscapes for CAVs may likely expose the weak structural development controls at city and city regional levels. These have long allowed widespread unhindered intrusions on roads and similar facilities thereby incurring additional expense. However, dwindling finances can limit access to the tools and resources to modify existing road networks to avoid serious physical and social backlash that may occur between the formal and informal activities.

CAVs may lead to an end to under-performing commercial and public transport systems, which are dominated by informal commercial motorcycle activities. The current system may also face further policy and city administrative interventions that might altogether exclude them from the city centres and similar areas. However, since large parts of sub-Saharan African cities are informally settled, this ubiquitous urban economic sub-sector will be forced to relocate and can only strive in areas largely lacking requisite infrastructure for CAVs. In places where CAVs are introduced, there may be a boost in more formalised retail activities and increases in revenue as increased safety and reliability of CAVs help to alleviate congestion and other traffic bottle-necks that often hinders the functioning of retail and viable economic centres.

CAVs – Supporting more effective and affordable urban transport?

Abuja and Lagos serve as administrative and commercial capitals respectively in Nigeria. These are amongst the cities that have been subject to more formalised planning in recent times. Many other urban areas have been left with minimal planning interventions, particularly in terms of road infrastructure. At present, most residents of Nigerian cities are faced with poorly integrated multi-modal transit systems, characterised by high costs, and social and environmental stress. The potential of automation to help deliver a functional, integrated mass transit operations may help to usher in an era of affordable and dependable transit that eliminates stress of unguided and largely unregulated multi-modal city transport for most trips.

Policies promoting and accommodating CAVs

The city of Abuja is known to have more advanced urban development policies than other cities. Along with Lagos, Abuja has become a city where innovative transportation and urban management issues are continuously propagated and easily adopted. Processes of the introduction and management of Bus Rapid Transit (BRT) in Lagos for instance, has shown similar cities (for example, Kano) the inputs required and has helped pave the way for overall improvement in the country's urban management policies and programmes. This has helped propel the inclusion of innovations like CAVs, foster the institutionalisation of the entire programmes of efficient urban management in towns and cities, and, the phenomenon will no longer be an ad hoc exercise as in the past.

The development of policies and regulations on CAVs will herald a stronger basis for improved urban liveability through adequate security provision. Proposals for instituting digital surveillance in cities have always been at the drawing board due to lack of finance and avoidance of infringement on privacy. However, efficient digitisation being part of CAVs will help accelerate the process and related matters of zero carbon transport, and, general wellbeing of urban dwellers.

Proactive local and regional policy on C/AVs' infrastructure plan

Local community organisations are people-oriented and demonstrate the ability to look inwards for solutions. This helps to give a voice to stakeholders at multiple stages across urban development activities in the Global South. Seemingly intractable issues of land management: acquisition, entitlements and rights, are best handled by these organisations, by addressing social, cultural and environmental hurdles that have in many instances stalled developmental efforts by governments and aid agencies. However, by de-emphasising their roles, many governments and urban authorities in Nigeria are often deficient in approaches known to effectively resolve socioeconomic fall out of policy implementations. Hence, the lingering issues of claims of rights, local taxations, differences in price regime, and policy duplications across regions and cities. This can be avoided if existing and potential trade unions, residence and civil organisations have inclusive and participatory roles in development programmes at all levels; particularly in tackling the persistent policy issues of territorial delineations, infrastructure finance and management, and regional empowerments.

In summary, the development of CAVs in many countries of the Global South presents different challenges compared to locations where the accommodation of CAVs is much more developed. There is a need to formalise and strengthen institutions so as to better support urban development (including road building) and find ways of accommodating the dominant informal economic activity that is undertaken in cities. Automation of transport may form part of a transition to more integrated and formalised transport networks and associated digital infrastructure. There remain many challenges however before this can be realised, and as progress is made the local community must have a strong voice in this.

By not including these countries such as Nigeria in the conversation now there is a risk that progress continues to be Global North centric and at the detriment of a more cohesive and effective transition to CAVs.

2.5. Summary

This chapter has extended the introduction to CAVs that began in Chapter 1. The SAE levels of driving automation discussed demonstrate the breadth of the CAV technology and the step-change that its introduction potentially brings to the existing transport system. Countries of the Global North are leading the way in terms of preparedness for the introduction of more highly automated vehicles, although a number of Global South countries are placed in the 'top 30' of the KPMG Readiness Index.

There is less certainty around the preparedness of cities and regions to a transition towards CAVs. There is a dearth of information at this level. Increasingly, testing of more highly automated vehicles is taking place across a range of cities and regions. However, the studies undertaken looking more widely beyond such test-bed locations suggests that preparedness and the ability to respond to the arrival of CAVs is limited.

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