Autonomous vehicles

The future of transport: A brave new world?

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Contents

Introduction

The way in which people and goods travel is changing rapidly. Over the past decade, we have witnessed fundamental social development and technological advancements. The 'sharing economy' has resulted in the growth of car sharing and ridesharing, where journeys are made using vehicles that people share rather than own directly.

Meanwhile, the automated shuttle train, operational without a driver, has become ever more commonplace in airports and for public transport. And self-steering drones, used for tasks such as security and surveillance, are no longer relegated to the pages of popular science fiction.

This trend is being fuelled by the growth of telematics and connected vehicles capable of collecting and sharing data – and will only grow as autonomous and driverless vehicle technology develops.

Today's transportation systems are normally characterised by personally owned, driver-operated vehicles. As driverless vehicles become more sophisticated, the relationship between vehicle and passenger will be redrawn. The transport system of tomorrow will be based increasingly on autonomous vehicles (AV) and shared mobility. However, we can expect to see major variations between countries in these trends depending on culture, capital investment, technology, urbanisation, the mode of transport and legal frameworks.

The benefits of autonomous vehicles to society and the environment are potentially huge. Mobility and travel are set to become faster and more efficient, improving productivity and reducing carbon emissions. This will mean that travel becomes not only cheaper and cleaner, but also potentially safer as the scope for human error is reduced.

However, that is not to say that the new era of driverless transport will be risk-free. Rather, the nature of these risks may change. Industry commentators suggest risk will move from the individual towards the manufacturer, though in truth there is not yet any certainty. This has implications for all of those in the transport value chain – from vehicle manufacturers and software developers to insurance companies and the end-users, including corporates and the wider society.

Gearing up for this new era of transportation presents many challenges, which this report explores in greater detail. With considerations across a range of transport sectors – road, rail, aviation and maritime – we have looked at how the application of autonomous vehicle technology across these will present unique obstacles and opportunities.

Consumer research methodology

To help us assess the changing transport landscape, we commissioned Cicero Group[1] to perform two phases of research. The first of these involved undertaking an online survey of over 6,000 adults across six markets[2] – Australia, China, Hong Kong, Singapore, United Kingdom and United States – to help us assess the current state of public opinion in each jurisdiction and to identify common concerns and potential barriers to the adoption of new driverless technology.

Market practitioner consultation

The second phase consisted of undertaking a range of in-depth interviews with market practitioners across different transport sectors and industries to identify potential technical and legal obstacles to adopting the technology.

Throughout the course of our research, we engaged senior practitioners across Australasia, Denmark, Singapore, UK and US representing the following sectors:

- Aviation
- Automotive/road
- Insurance
- Public transport
- Shipping

A full list of the market practitioners interviewed can be found in the acknowledgements at the back of the report.


Executive summary

The world is on the cusp of a transport revolution: one in which machines will increasingly take control from humans. That shift raises fundamental concerns around public safety and where liability rests when accidents occur. It also means a major shift in the amount of data that is collected by vehicles, and how that data is stored and used. Faced with these challenges, the views of end-users will be integral to deciding the scale and speed at which markets choose to adopt autonomous vehicle technology.

Strong support for increased autonomy – but support is qualified

Most people support the prospect of further automation of road vehicles, though there are fairly wide differences by market:

- The majority of people within Hong Kong (81%), China (75%) and Singapore (74%) support the concept of partially automated vehicles – though this falls slightly within Australia (59%), the UK (48%) and the US (48%).
- Not only are there differences by market, we see support far higher among young males aged 18-34 (see Appendix 1) and those living within an urban setting. However, it is people's self-reported levels of understanding of autonomous vehicle technology that drives support above all else. In the UK, for example, 57% who feel they have a high level of understanding support partial autonomy, falling to only 17% among those with no understanding.
- We are, however, by no means approaching the point where people would be comfortable with the idea of vehicles that drive themselves with no possibility of humans overriding the computer. Only 3-4% of people within each market covered in our study supported this type of autonomous vehicles.
- What drives support differs by market:
  - Key drivers in more heavily urbanised locations – Hong Kong, Singapore and China – reflect the issues faced with regard to congestion, parking and road infrastructure. Cars collecting people on demand, cars not getting lost, knowing the quickest/less congested route and being able to park themselves are of high significance.
  - Within Australia, the UK and US there is more of a focus on the benefits of elderly/disabled people maintaining independence, the potential falling cost of car insurance, fewer accidents on the road, and rural communities being less reliant on public transport.

The perception that autonomous vehicles will not keep people safe is the key issue for non-supporters of autonomous vehicle technology.

Public trust remains a key barrier

Many of the barriers cited by people not offering support for fully autonomous vehicles demonstrates that public understanding does not necessarily reflect the technological reality:

- The perception that driverless vehicles will not keep people safe is the key reason – reaching a high of 68% of people in the US not supporting fully autonomous vehicles.
- People trusting human judgement over that of a computer is also a key reason – with this highest in the UK (63%).
- Concerns around data security and data hacking is cited by around three in five people – reaching a high of 66% in Singapore. Such concerns are felt less acutely in China (41%).

While there is clearly a public demand for semi-autonomous vehicles that retain the potential for human override, a significant minority of people within each market have concerns about this handover process. With only 3-4% of people supporting Level 5[3] automation, we might expect to see 95%+ of people supporting the need for motorists to be able to take control of the vehicle. This, however, is not the case:

- Between around 80% and 90% of people within each market support the need for motorists to be able to take control of the vehicle – reaching a high of 89% in China, and the lowest in Hong Kong at 79%.
- Of those not supporting the concept of human override, the following concerns were highlighted:
  - It wouldn't be clear who was at fault in the event of an accident (a high of 54% of non-supporters in Hong Kong).
  - Switching between driver and computer might lead to confusion and accidents – something that we have seen in the case of Tesla, for example, where in 2018 a car on autopilot crashed despite warnings from the vehicle for the driver to put their hands on the wheel - which is required of drivers in the autopilot feature. (a high of 53% of non-supporters in Singapore).
  - There may not be sufficient time to respond in a safe manner (a high of 42% of non-supporters in Australia).

People react differently to the range of forms of automated travel

When looking at different kinds of road transport – private car ownership, driverless taxis, commercial vehicles such as trucks travelling in platoons (the linking of two or more trucks in convoy) and driverless buses – there is very little difference within countries in levels of public comfort.

With regards to the transportation of people, we see people across countries generally more comfortable with the concept of automated rail systems – likely reflecting the wider adoption of this technology:

- People are more comfortable with the concept of driverless trains than they are in owning their own driverless car in a number of countries - Hong Kong (32% compared to 19%), Singapore (58% compared to 35%), Australia (36% compared to 28%) and UK (31% compared to 26%). However, this does not hold true for China or the US.

The public are, however, clearly less comfortable with the prospect of pilotless planes and ships:

- Less than 1 in 5 people in all countries are comfortable with the idea of pilotless aircraft. China is the notable exception to this, where 50% of people feel comfortable with the concept.
- Around 1 in 5 people in all markets are comfortable with the idea of ships without a captain. Again, China is the notable exception here, where 48% state being comfortable with the concept.

People trusting human judgement over that of a computer is also a key issue for non-supporters.

People envisage a different future – but individual behaviours will be harder to change

In the research, we asked people to imagine how autonomous vehicles will fit into the world in 20 years' time. Despite the barriers and the concerns, our research demonstrates clearly that people find it easy to imagine a very different transport system by the year 2039. Not only is there agreement regarding a changing technology, but also in terms of vehicle ownership, commuting and insurance patterns:

- A significant proportion within each market agree that by 2039 roads will have a fully functioning autonomous vehicles network in place (a high of 75% in China and a low of 36% in the UK).
- As many as 54% of people in China agree that an increase in car schemes by 2039 will mean no one will need to own their own car – falling to a low of 28% in the UK.
- A significant proportion expect to see an increase in people taking out on-the-go insurance by 2039 (a high of 72% in China and a low of 43% in Hong Kong).
- By 2039, as many as 65% of people in China agree that due to the increase in flexible working, the daily commute will become a thing of the past. This falls to a low of 40% in the UK.

Practical considerations from industry

Clearly, views from the public give us an idea as to the communication challenges industry may face in the roll-out of autonomous vehicles on road and rail. However, our engagement with industry stakeholders outlined a number of practical considerations above and beyond public attitudes and perceptions:

- **Full autonomy is evolution rather than revolution**: The speed at which technology is introduced will depend largely on political ambition (which naturally differs by market) and mode of transport (where predictability of other vehicles and pedestrians has a significant impact both on the technology and public perception).
- **Real-world environment testing:** Pilot schemes do not offer manufacturers the opportunity to develop a strong enough evidence base to allay fears about wider roll-out. For this reason, full (Level 5) automation is not seen as something around the corner.
- **Overcoming cost barriers:** The costs associated with modernising road infrastructure, particularly in rural settings, is still seen as prohibitive. There is potential here for the onus to then be put on the technology autonomous vehicles use, which will directly impact the cost of consumer vehicles.

- **Changing patterns of transport usage:** With levels of car ownership expected to drop there is seen to be an opportunity to address the issue of the 'first mile and last mile' (i.e. the gap between public transport and departure point/destination) of commuter journeys. Autonomous public transport is seen to be a way to address this in a cost efficient manner.
- **Insurance premiums and data sharing:** The political position in many markets is that increased autonomous vehicles will eventually drive down the cost of insurance premiums – both as a result of a reduction in accidents and reduced wear and tear. This will impact insurers financially. Yet, there is the issue of liability. Bottoming out this will rely on open and transparent data sharing between manufacturers, insurers and law enforcement organisations, though the necessary data infrastructure is yet to be developed.
- **Impact on workforces:** Increased automation may positively impact businesses in haulage and public transport, where skills and labour shortages are common. However, with vehicles controlled by people, there remains the risk of human fatigue and boredom over longer journeys, meaning they are less prepared to take back control of the vehicle if required. Moreover, the concept of computers replacing human jobs is something that, politically, is a difficult sell.

Concerns around data security and data hacking are also frequently cited as a reason for not supporting autonomous vehicle technology.

Part 1: Public attitudes to driverless road vehicles

The way in which societies move people and goods will change dramatically in the coming decades.

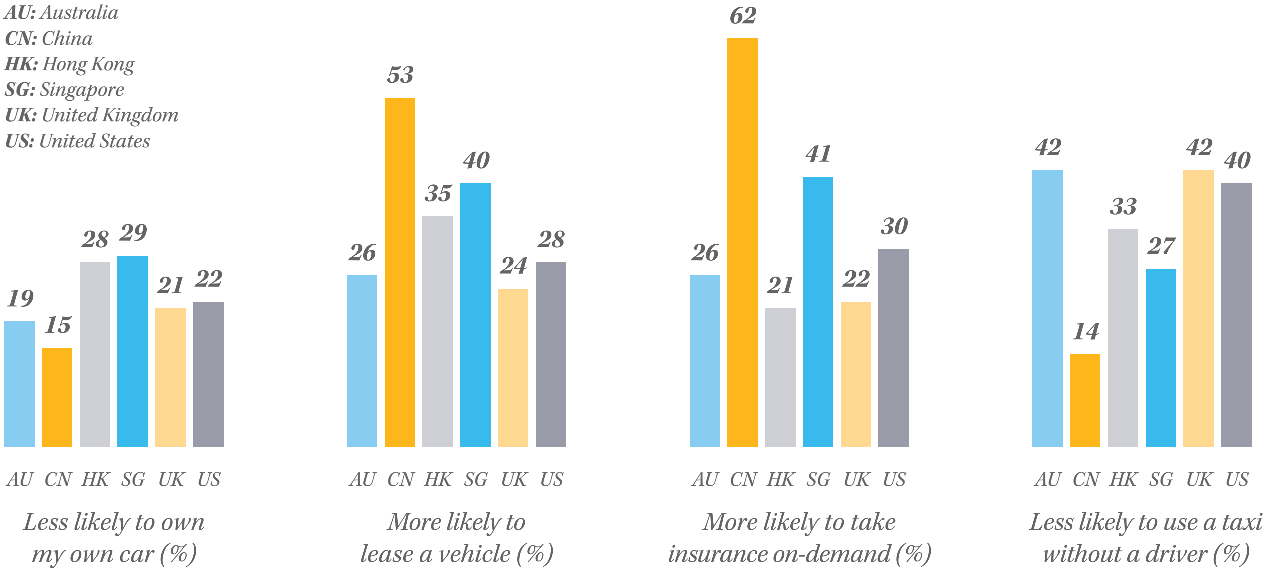
The public can already foresee how the changes in technology, working patterns and lifestyle will impact the way people access mobility, with a shift towards more autonomous vehicles, shared ownership patterns and different ways of insuring the risks associated with mobility.

As shared mobility and autonomous technology better serves local communities' transport needs, we can expect to see multi-vehicle households begin to reduce the number of cars they own. Some households will be able to abandon ownership altogether. While this general trend is predicted to emerge, the precise model of future vehicle usage and ownership is likely to vary across countries depending on geography, degree of urbanisation, culture and government policies.

Broadly speaking, public acknowledgement of these trends is far greater in Hong Kong and Singapore where people expect to own less, lease and car share more, and insure on-the-go. The questions are, what factors are shaping public opinion, and what do public policymakers, vehicle manufacturers, vehicle operators, technology firms and insurance companies need to do to ensure public acceptance and adoption of the new technology? Our research finds two emerging models of car ownership, where user preference on the purpose of transport can be a distinguishing factor:

1. **Privately owned autonomous:** Driverless vehicles may well prove viable, safe, convenient and economical, yet private ownership continues to prevail. This appears to be the more likely outcome in the US, the UK and Australia where drivers appear to prefer owning their own vehicles but seek driverless functionality for its safety and convenience. This model is likely to result in customised outcomes which better serve the needs of specific social groups whose transport needs are currently poorly served, such as the elderly and those with disabilities.
2. **Shared autonomous:** We could see a different pattern emerge in other parts of the world with the convergence of autonomous technology and shared ownership. In this model, there is a much greater role for fleet operators to manage the stock of vehicles on our roads to ensure that the needs of the whole community are catered for. This trend is already emerging in our urban centres, so it is not surprising that geographically-concentrated areas such as Singapore and Hong Kong appear more likely to adopt this model.

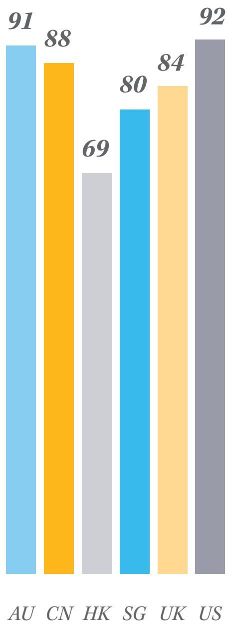
***Diagram 1:** The extent to which the introduction of autonomous vehicles would change consumer driving habits (%)*



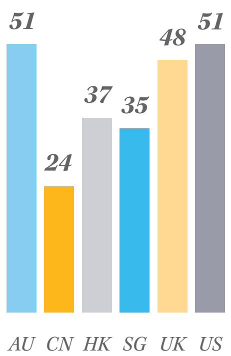
The physical and emotional connection to cars and motoring differs greatly in places like Singapore and Hong Kong from the car-heavy mentality in Australia, the UK and the US. With the two former countries both being highly urbanised and having good public transport systems, people living there are generally less reliant on cars and less attached to car ownership. This lower level of attachment may help to explain why people in these markets are more receptive to driverless vehicle technology.

- Over 90% of people in Australia and the US currently hold a driving licence. This falls to 80% in Singapore and just under 70% in Hong Kong.
- People in Hong Kong and Singapore are less likely to have fully comprehensive motor insurance, with a greater reliance on on-the-go insurance for car sharing instead.
- People in Australia, the UK and US who do not support fully autonomous vehicles cite enjoying driving (and wanting to remain in control of the vehicle as a result) as the primary reason.

Diagram 2: *Attachment to motoring varies greatly (%)*



The proportion of people holding a driver's licence (%)



Reason given for not supporting fully autonomous vehicles: "I enjoy driving and don't want computers doing it for me" (%)

As well as greater acceptance, populations in Asia are more likely to claim a greater level of understanding about the new technology.

- The highest level of understanding is found in Singapore (where 74% said that they had a high or some level of understanding).
- This compares with the UK, which had the lowest level of understanding (60%).

The benefits of autonomous vehicles: country-by-country

The levels of public understanding (as detailed in Diagram 3 on the following page) are matched by a widespread acknowledgement of the benefits associated with the technology, as shown in Diagram 4 opposite. For those in Australia, the UK, Singapore and the US, the biggest perceived benefit of autonomous vehicle technology is its potential to provide mobility to those perhaps otherwise excluded from the road (i.e. elderly members of society and people with disabilities). In Singapore and Hong Kong, the ability of an autonomous vehicle to park itself is well-recognised, with parking in these markets made somewhat more difficult through lack of spaces, assistance with maneuvering may be particularly useful. Interestingly, across almost all markets, the public is already aware of how a shift in liability will reduce the financial burden of motor insurance, with over a third of those in Australia, China, Singapore, the UK and the US identifying this as a benefit.

It is immediately clear that those in China are more likely to identify a wider range of benefits in adopting autonomous vehicles. This likely reflects a rather unique set of circumstances in the market presently. China passed the US to become the world's largest automotive market in 2009 and, in 2018, went on to purchase 70% more light vehicles than the US.[4]

However, while the automotive industry has seen explosive growth, infrastructure remains under-developed (although plans are in place to fully merge automated transport into this within the next 10 years), meaning traffic congestion and, notably, pollution have become real problems for everyday citizens in many places. Electric, and furthermore autonomous vehicles offer a solution to many of these challenges – potentially reducing the number of vehicles and removing much of the stress of car travel. Clearly, if also powered by renewable energy, the reduction in pollutants could mean both fewer and cleaner vehicles on the roads.

Diagram 3: High levels of public understanding about the uses, benefits and social implications of autonomous vehicles (%)

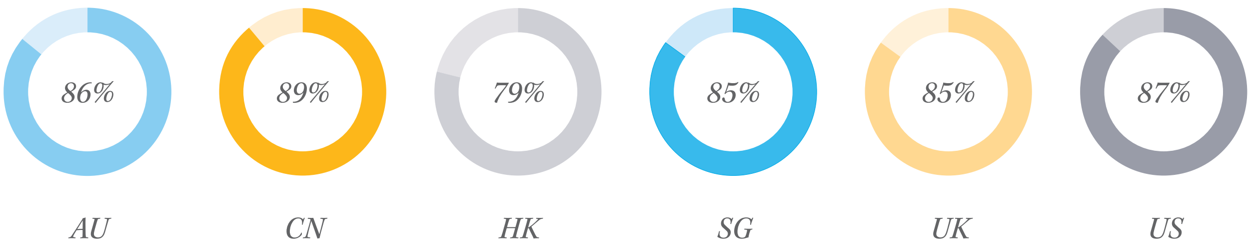


Diagram 4: Benefits of autonomous vehicles are widespread (% significant benefit)

AU	CN	HK	SG	UK	US
42% Elderly/disabled can maintain independence	**49%** People can drive when tired or unwell	**27%** The car can park itself	**40%** Elderly/disabled can maintain independence	**42%** Elderly/disabled can maintain independence	**39%** Elderly/disabled can maintain independence
39% Cost of car insurance would fall if fewer accidents	**49%** There would be fewer accidents on the roads	**27%** People can drive when tired or unwell	**36%** The car can park itself	**39%** Cost of car insurance would fall if fewer accidents	**37%** Cost of car insurance would fall if fewer accidents
38% There would be fewer accidents on the roads	**49%** The car would not get lost	**26%** The car would not get lost	**35%** Cost of car insurance would fall if fewer accidents	**36%** There would be fewer accidents on the roads	**33%** There would be fewer accidents on the roads
36% People would not get road rage	**46%** Elderly/disabled can maintain independence	**25%** Car would know the quickest/less congested route	**33%** There would be fewer accidents on the roads	**34%** Rural community & small towns less reliant on public transport	**32%** The car would not get lost
35% Rural community & small towns less reliant on public transport	**43%** The car can park itself	**25%** Elderly/disabled can maintain independence	**32%** The car would not get lost	**33%** The car would not get lost	**31%** People would not get road rage

The public's case against autonomous vehicles

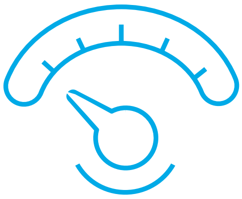
In contrast, there are a wide range of reasons given for individuals not supporting fully driverless vehicles. These include public safety concerns about vehicles being a danger to other vehicles, pedestrians and animals. A major cause for concern for the public here is not trusting the judgement of a computer over that of a human.

- 63% of UK respondents who do not support fully autonomous vehicles trust human judgement over that of a computer.
- While it is similarly high across the other markets, this figure drops by half in China, where only 31% of those not supporting fully autonomous vehicles cite trusting human judgement over a computer as a reason.

The downside of data sharing

A further common concern is data protection and data sharing. In all markets except China, well over half of those who do not support fully autonomous vehicles have concerns about people having the ability to hack into autonomous cars' computers. This is an idea we expand on further within our recommendations for public bodies. There is also a fear among many who do not support the use of fully autonomous vehicles that insurers would take the opportunity to increase premiums on motor insurance policies, peaking at 52% of those surveyed in Singapore and 50% in Australia. Those in China, which operates a 'non-fault' car insurance system (i.e. it only awards for economic damages), are notably less likely to cite either of these issues as a concern.

> The fear of what happens should the technology fail is the key reason people do not support the use of automated vehicles across all markets.



Level of public support drops notably across all markets when we move from partial to full autonomy.

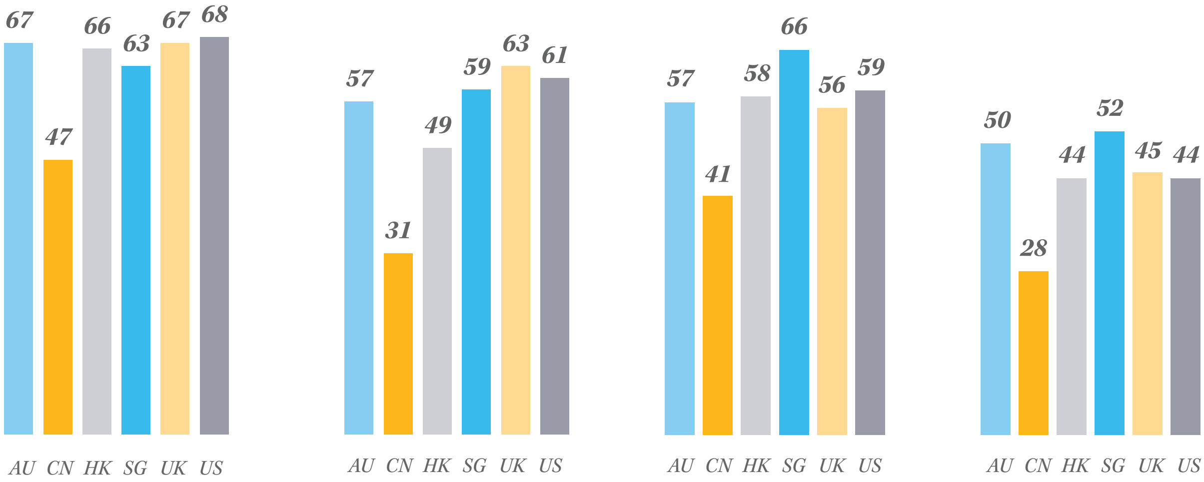
Having looked at the perceived benefits and concerns surrounding driverless vehicles, we find that most people support the prospect of further automation of road vehicles – although there is variety here:

- The most receptive are people in Hong Kong, where 81% support partial automation.
- Next are China and Singapore, where 76% and 74% respectively accept partial automation.
- This then drops markedly in our other markets to 59% in Australia, and to less than half (48%) in both the US and the UK.

Notably, the level of public support drops in all markets when we asked specifically about fully autonomous road vehicles. For example, in Hong Kong, public support drops from 81% to just 34% when people were considering full automation. In China this fall is far less pronounced – further evidence of higher levels of consumer enthusiasm in this market.

These findings, though, hide some additional nuances. It is the younger generations who are far more open to the concept of automation. This is particularly the case regarding to the concept of full automation, and also within Australia, the UK and US – notably, those markets with more of a history of car ownership and reliance on personally owned vehicles. We also, typically, see higher levels of public support among men than we do among women, and among those living in an urban setting – again, particularly with regards to full automation.

__Diagram 5:__ Reasons the public do not support the use of fully autonomous vehicles (%)



The fear of what happens should the technology fail (%)

I do not trust the judgement of a computer over that of a human (%)

I am concerned about people having the ability to hack into the car's computer (%)

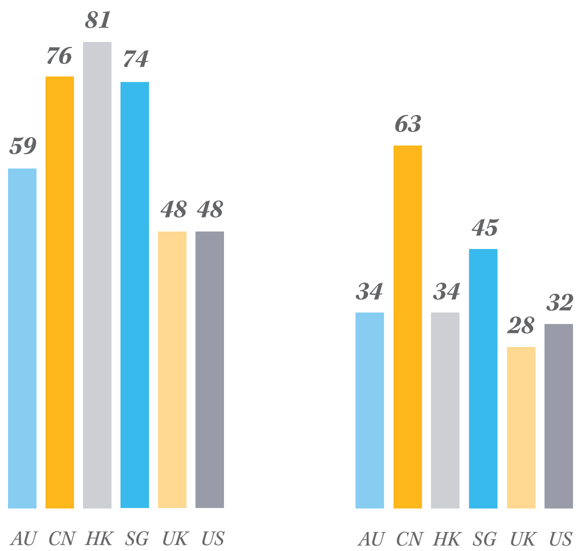
Insurers will put up the cost of car insurance (%)

Level of understanding for partial v full autonomy

However, information is key. Our analysis demonstrates that nothing influences levels of support more than people's perceived level of understanding. Clearly, minds are put at rest by having a better understanding of autonomous vehicle technology, its potential uses, benefits and social implications. Indeed, 64% of those in the US who thought they had a high level of understanding supported the concept of fully autonomous vehicles, dropping massively to only 5% among those with no understanding.

Public support falls far lower still when we defined the different levels of road vehicle automation in line with the Society of Automotive Engineers' (SAE) five-point scale of road vehicle automation (see Diagram 7 on page 14).

__Diagram 6 :__ Public support for driverless road vehicles is high, but support is qualified (%)



Support for autonomy: Partial (%)

Support for autonomy: Full (%)

__Diagram 7:__ Society of Automotive Engineers (SAE) Automation Levels for on road motor vehicles[5]

Level	Characteristics
0	Automated system issues warning but has no vehicle control.
1	Driver and automated system shares control over the vehicle. Examples would include Adaptive Cruise Control (ACC) – where the driver controls steering and the automated system controls speed – and Parking Assistance – where steering is automated while speed is manual.
2	The automated system takes full control of the vehicle (accelerating, braking and steering). The driver must monitor the driving and be prepared to immediately intervene at any time if the automated system fails to respond properly.
3	The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so.
4	No driver attention is ever required for safety. Self-driving is only supported in limited areas (geofenced) under special circumstances, like traffic jams. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip, i.e. park the car, if the driver does not retake control.
5	No human intervention is required. Vehicles can drive themselves in all conditions with no possibility of humans overriding the computer.

When asked to consider the SAE scale, we find that support for full automation in terms of Level 5 specifications (no human override) falls substantially.[6]

- Just 4% in China and the UK support fully autonomous vehicles in which the driver is not able to take back control.
- The level of public support was just 3% in all other markets surveyed.

Only **3-4%** of respondents support fully driverless vehicles with no human override facility.

Even with Level 4 automation, in which vehicles should be able to drive themselves in all conditions but with a human override, we find that between only one-quarter and one-third of respondents globally support this outcome when provided with the definition. This presents a major barrier to policymakers' attempts to move beyond Level 3 automation, in which humans should always remain in control of the vehicle in more challenging driving conditions.

However, there is a twist to this story. Whereas only 3%-4% across all markets supported Level 5 automation, when we ask the question slightly differently it is clear that concerns regarding handover between human and computer run slightly deeper. Instead of asking which level of automation they supported, we asked if people supported the need for motorists to be able to take control of the vehicle. The answer is interesting: whereas we might expect 95%+ of people within each market to support the need for motorists to be able to take control of the vehicle, we actually see somewhere between 79% and 89%.

Looking into this issue more deeply, it would appear that people also hold concerns about how this process would work in practice – both in terms of the process of this transition from vehicle to driver, and the implications on liability should there be an accident. Among the minority of people not supporting the need for motorists to be able to take control of the vehicle the key reasons were lack of clarity around fault in the case of an accident; the switch between driver and computer potentially leading to accidents; and not having enough time to respond to the need to take control safely.

Diagram 8: *Level of public support for Level 4 and Level 5 automation (%)*

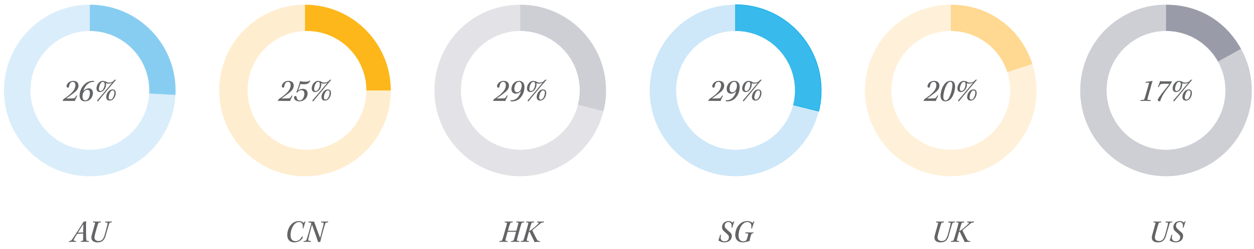


Diagram 9: *Percentage supporting the need for motorists to be able to take control of the vehicle*

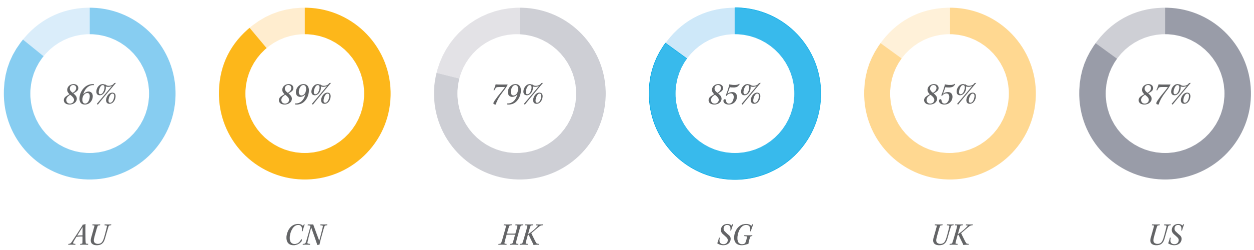
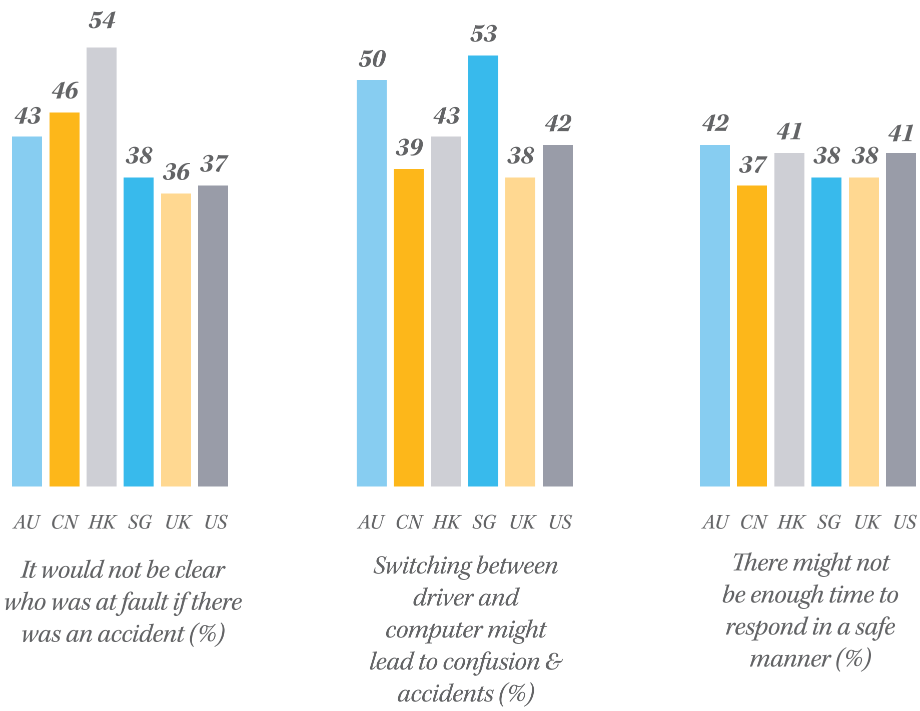


Diagram 10: *Reasons for non-support among people not supporting the need for motorists being able to take control of their vehicle (%)*



Part 2: Public attitudes to other modes of driverless vehicles

As we saw in Part 1, public opinion across all aspects of autonomous vehicle technology is still very fluid. With the technology still in its infancy, opinion will no doubt shift as this evolves and becomes more mainstream.

Whilst we so far have focused on private road vehicles, it is clear that when looking beyond this, the public makes little distinction between different kinds of road transport such as cars, buses and taxis. Even the prospect of truck platoons – a relatively unfamiliar concept on UK roads – enjoyed the same level of public comfort when compared to driverless buses and taxis. Other modes of transport however evoke a different public response, as can be seen in Diagram 11 on page 18.

Drone technology and pilotless aircraft

Again, support in China is noticeably higher, particularly towards aviation. This might come as no surprise, given the success of the industrial drone market in China, where traditional sectors such as agriculture have been modernised through the use of drone technology. Indeed, with regards to pilotless aircraft carrying people, Ehang (a company that, back in 2016, revealed the first prototype of the Ehang 184 Autonomous Aerial Vehicle for passengers) announced in February 2019 that they have been authorised as China's first pilot company to develop passenger drone programs. When compared to many other markets, practical uses for both drones and pilotless aircraft are already becoming a reality.

People across all markets are clearly far more comfortable with the concept of automated rail systems. This reflects the wider adoption of this technology (and thus our experience of it) within many countries around the world.[7] Autonomous rail system technology is used in many countries - with the most extensive use coming in Asia including China, South Korea and Japan (where the first fully driverless train system was introduced in Kobe as long ago as 1981).

Although questions of trust prevail among the public, this is notwithstanding the fact that autonomous control features are already commonplace on many road, rail, aviation and maritime vehicles across the world. Of all the different modes of transport available, public comfort with the concept of autonomous vehicles is highest when applied to rail networks. This possibly reflects the wider adoption of this technology and the more advanced use, with fully driverless train services already operating in many markets.

Autonomy in the air and at sea

The public in all countries is clearly less comfortable with the prospect of pilotless planes and ships. As Diagram 11 demonstrates, aviation is a sector that is facing significant barriers among public end-users, with only 13-18% of respondents across the six markets feeling comfortable with the idea of pilotless civilian aircraft, notwithstanding that commercial flying is, statistically, the safest way to travel and already uses a level of automation. For maritime vehicles, such as ferries and boats, the level of public comfort increases marginally, falling within a range of 17-23% globally.

As we can see from the findings in Part 1, the context in which the technology is used is a major factor. For example, whether the vehicle operates at Level 4 (where the driver can take back control of the vehicle) or Level 5 (where there is no driver override) is a major red line for members of the public.

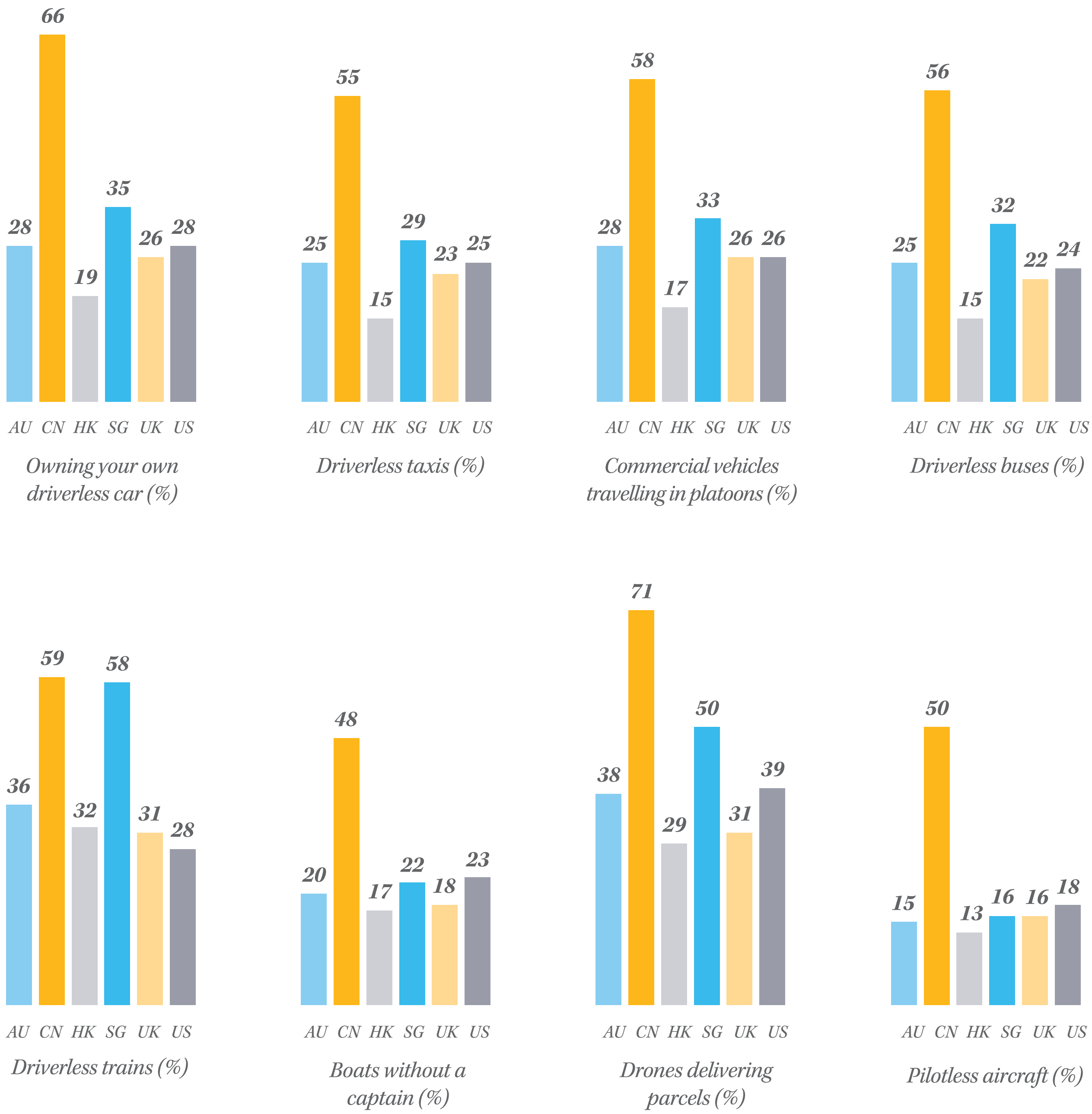
The importance of the why

While the notion of using pilotless aircraft enjoys much lower levels of public acceptance compared with other modes of transport, this does depend on the application of the technology. The safe delivery of goods naturally presents fewer public concerns than the safety when transporting humans. For example, using drones to make postal deliveries is far more popular (with public comfort levels ranging from 29% in Hong Kong to a high of 71% in China) when compared to allowing airlines to operate pilotless aircraft (where, outside of China, public comfort ranges reaches no higher than the 18% we see in the US).

> Support for autonomous vehicle technology differs by mode of transport, but particularly by market. Support in China far exceeds the other markets.

Pilotless planes and driverless boats may garner the least amount of comfort from individuals, but in 2019 we are still relatively early on in the development of autonomous vehicle technology in cars, let alone larger methods of transport. How these opinions may shift as systems become more advanced and consumers more familiar with the concept is something we explore further in Part 3.

***Diagram 11:** Level of public comfort with autonomous technology by mode of transport (% somewhat/very comfortable)*



Part 3: Envisioning a different future

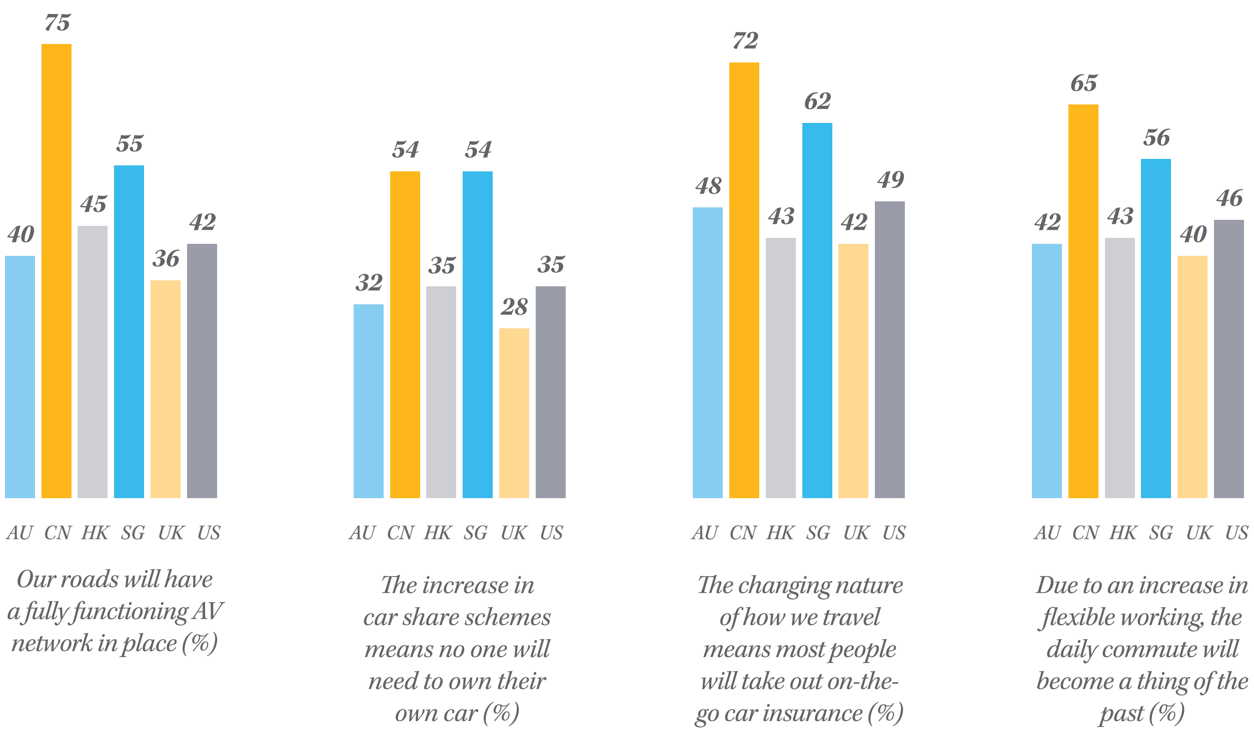
What our research shows so far is clear – consumers understand that the future of transport will look very different to the reality of today.

Considering the revolution we have already seen across transport over the past thirty years, as well as a myriad of changes in everyday activities such as shopping, banking and communications, people seem well prepared for the idea that tomorrow might look very different from today. Indeed, in some instances, the future is already here. In mainland China, for example, mobile payment systems have all but replaced cash for day to day payments.

At least a significant minority of people from across all markets surveyed agree that, by 2039, our roads will have a fully-functioning autonomous vehicle network in place. There is, however, significant variation between markets, with those in China far more likely to agree (75%) compared to the UK (36%).

A significant minority of people from across all markets agree that, by 2039, our roads will have a fully-functioning autonomous vehicle network in place.

Diagram 12: *Level of public agreement with how transport might look in 2039 (% agree/strongly agree)*



Furthermore, we see similar levels of agreement across wider related scenarios, which also will change the nature of the relationship people have with transport and vehicle ownership. Specifically, people are more likely to agree that changing travel patterns will mean a rise in on-the-go insurance and, more drastically, that an increase in car share schemes mean that no one will need to own their own car.

In the case of insurance, the extent of automation will have a direct impact. In the case of full automation, depending on future legislation, it is possible that risk may be transferred from the individual driver to the manufacturer - with original equipment manufacturers (OEMs) insuring whole fleets of cars rather than drivers insuring themselves.

However, there is likely to remain a need for personal insurance for partial automation, as human risk may not be eliminated entirely or accidents not caused by the malfunctioning of systems. The car may be able to be manually overridden and if an accident occurred in this case the liability would fall back to the driver.

As we might expect, markets with a stronger history of car ownership – such as Australia, the UK and US – are more reluctant to give up ownership.

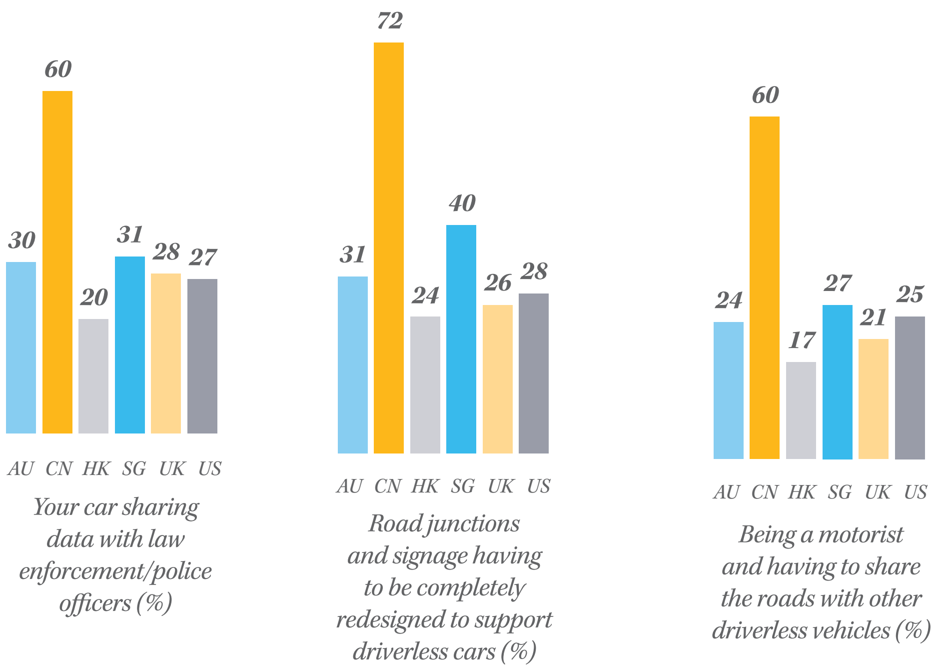
Clearly though, imagining a different future and dealing with the specific consequences of that future (or issues that arise during that transition) are two very different things. We discussed earlier the issue of trust in the judgement of a computer compared to that of a human, but there are a number of practical considerations that run more deeply.

Consumer trust in how data is shared remains a concern

With autonomous vehicles no doubt collecting a far richer data set on the habits and behaviours of drivers than the cars of today, it will also be necessary for an effective autonomous vehicle network to share data between several parties. Consumer trust in many tech firms around the issue of data sharing and data protection is relatively low. It is perhaps therefore no surprise to see that consumers are generally not comfortable with the idea of their autonomous vehicle sharing data with law enforcement bodies. With the exception of China (where three in five people are comfortable with this idea), less than one in three people within each market are comfortable sharing their data in this way.

> People are more likely to agree that changing travel patterns will mean a rise in on-the-go insurance and, more drastically, that an increase in car share schemes mean that no one will need to own their own car.

***Diagram 13:** Consumer reaction to direct implications of an autonomous vehicle network (% comfortable)*



Greater investment in road infrastructure will be required

Similarly, a fully autonomous road vehicle network would require, potentially, a great deal of investment in the road infrastructure itself. Road lanes, junctions and signage would all require modernisation that would be both potentially costly and disruptive. Our findings show that many people would not be comfortable with that outcome. China is the clear exception here, with nearly three quarters of people (72%) comfortable with road junctions and signage having to be completely re-designed. This is perhaps simply a reflection of the significant investment in road and rail infrastructure in China over the last decade, resulting in a population far more used to the idea of large scale change.

Furthermore, despite spelling out a radically different future of transport system in 2039, people are generally not likely to see this as having an impact on their own behaviours. As an example, we saw that in the UK, 49% agreed that most people would be taking out on-the-go insurance by the year 2039. However, only 22% stated that the introduction of autonomous vehicles would make them more likely take out their own on-the-go insurance policy.

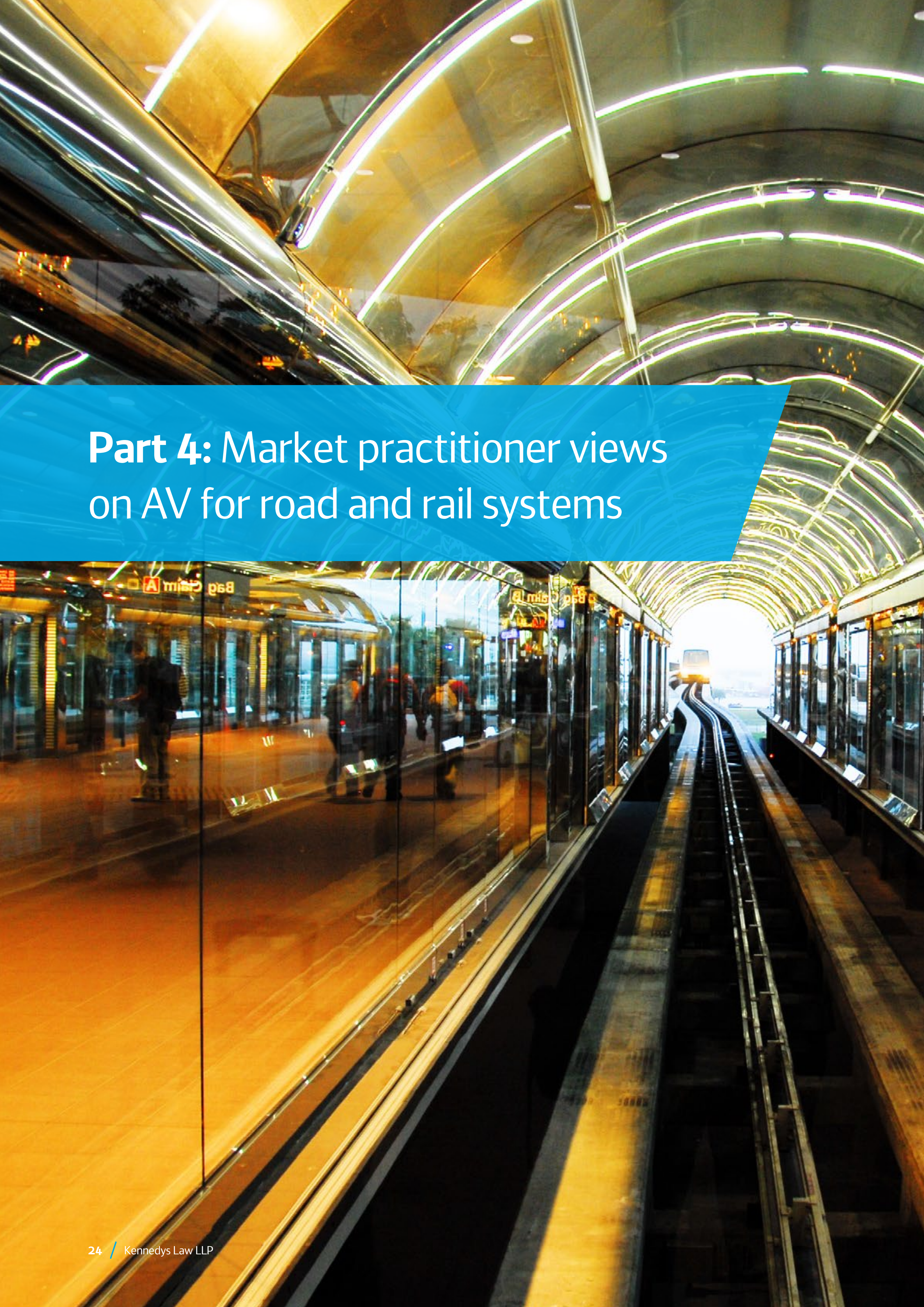
In addition, outside of China (and, to a lesser extent, Singapore), autonomous vehicles on the road would make comparatively few more people likely to:

- Use a taxi/Uber (if it didn't have a driver)
- Use a bus (if it didn't have a driver)
- Use a train (if it didn't have a driver).

Driving to a greener future

It is impossible to discuss the future of transport without considering the Green Agenda. While consumers do not necessarily think about autonomous vehicle technology in these terms, there is no doubt that it has the potential to move beyond advantages for the individual and serve as part of a systemic shift towards a greener economy. For more information about the 2015 Paris Agreement on climate change see page 42.

Diagram 14: *Extent to which behaviours would change if autonomous vehicles were available on our roads (% more likely)*



Part 4: Market practitioner views on AV for road and rail systems

To get a deeper understanding of industry issues, we undertook a series of interviews with leading market practitioners working in the transport and insurance markets.[8] This section sets out some of their main considerations in more detail.

Current progress: adopting full autonomy

> For private vehicles, the speed of adoption may simply come down to when carmakers feel confident that they can market the combination of essentially driverless systems as a 'driverless' car.

We can already see elements of autonomous vehicle technology present on our roads, such as adaptive controls and parking assistance. The question is at what point does the existing technology start to integrate with full automation? The consensus is that it will be a slow, evolutionary process, but the speed at which technology is introduced will depend on two key factors:

Political ambition

Political appetite for autonomous vehicles varies greatly between different jurisdictions with some working harder and faster to create the necessary legal frameworks and national standards for testing autonomous cars on roads, in order to foster the development of the new technology. China, Europe and the US are widely seen as being first-movers, with China placing a lot of emphasis on adopting electric and autonomous vehicles within the next ten years. This is in a bid to both reduce air pollution and to swell its car manufacturing industry. Singapore is also recognised as placing itself at the centre of developments. Indeed, Singapore, along with the UK and US have also made strides in creating legislation that deals with changing liability in addition to enabling road testing. In contrast, Australia and Hong Kong have been slower in adopting new regulations.

Mode of transport

Another factor influencing the speed of adoption is the mode of transport. Benefiting from train companies being the sole users of tracks, rail technology has been able to move ahead of other transport systems in adoption. Rail is followed by road technology which, advantageously, can be tested on private roads. Rail's development is notwithstanding the concerns held among rail unions about the potential impact of further automation on jobs and public safety. Meanwhile, given their scale, aviation and shipping are clearly set to move at a slower pace.

Even within road transport, however, there are major variations as to how quickly the technology can be implemented, dependent on the vehicle and its intended use. Whereas private vehicles may start to move towards full automation within five to 10 years, bus operators believe that this transition will take at least 15 to 20 years. Bus operators in the UK feel that this reflects the difficulties of operating buses in crowded urban spaces while sharing the road with less-predictable human drivers. A notable exception here is Singapore, where the government is working towards a target date for having autonomous buses on the road by 2022, which market practitioners in the region feel is an achievable target.

Public attitudes and perceptions

> I don't think people even realise, a lot of the time, how much is automated today. The Victoria Line, on London's Underground, has been highly automated since its inception in 1968.

Practitioners acknowledge that perceptions of autonomous vehicle technology are as important as the reality. While the public may embrace elements of automation, people still want to see someone sitting or standing at the controls before they board a bus or train. It should be noted that many airport shuttle services around the world have already moved towards full automation (Grade of Automation/GoA 4).[9] However, one practitioner commented how these transport systems have been designed from their inception to be fully automated. People accept full automation in that circumstance because it is self-contained; the shuttle doesn't share the tracks with other modes of transport, nor does it move at speed or for long distances. It is a relatively discrete and controlled environment.

In contrast, if you take a car, bus or conventional train and take the driver away, a different psychological response is prompted in humans – and this is where some of the perception problems arise. This highlights the need for greater public education and awareness:

> There is a need for greater public education about the benefits of autonomous vehicles. The public are used to seeing drivers on vehicles. The prospect of buses and taxis without drivers – if you like 'ghost vehicles' – may well invoke a sense of fear in members of the public.

Testing the technology in real-world environments

One of the big challenges for governments looking to promote the rollout of autonomous car technology centres is the need to produce a strong evidence base that demonstrates that the risk of putting the vehicles on the public highway is acceptable. Pilot schemes conducting simulations on private roads with few other road users do not provide a good guide for how the technology will work in a mixed urban environment, given its inherent unpredictability. With concerns for the safety of road users paramount, the development of unbranded real-world test beds is integral to test the performance of autonomous vehicles. In 2017 the UK government pledged investment to the creation of test facilities for autonomous vehicles, with Sweden following suit in January 2019.

Vehicle testing conducted to date reveals an inability for much of the current autonomous vehicle technology to cope with everyday operating experiences. Such tests have led some practitioners to believe that any movement towards Level 5 Pods (small enclosed driverless vehicles designed to travel short or medium distances in dedicated lanes in urban locations) is unlikely given current technological limitations. Tests prove that there is still a requirement for a high degree of manual intervention. For this reason, many of the recent pilot schemes have taken place away from public roads.

There is still a need to prove that the technology can move beyond the sterile environments where autonomous vehicles are currently being trialled and put them in real-world situations. Meeting this challenge will be greater with commercial vehicles, for example, when considering the parking procedures for buses, where the bus is placed in relation to curbs, and the ability of people with disabilities to access wherever the bus stops. Or indeed, the ability of buses to cope with other vehicles illegally using bus lanes. Naturally, these considerations do not typically occur when assessing the performance of private road vehicles.

One area that needs further development is the relationship between the vehicle and the route. In some instances, OEMs are effectively pre-programming vehicles to learn certain routes. This can be very restrictive because road layouts may change, meaning the approach is too rigid for a real-world environment.

Overcoming cost barriers

A further obstacle is the associated costs, particularly for private road vehicles. Countries with large rural communities are less likely to benefit from having a road network that is maintained to a high standard, and therefore without the costly upgrading or significant maintenance, take-up of electric and autonomous vehicles in these areas will be hindered.

The need to build extensive roadside infrastructure would prove too onerous. Converting every cul-de-sac to a smart motorway standard is a highly unlikely eventuality. Therefore, the vehicle itself will have to be equipped with sensors capable of dealing with everything from muddy country roads to driving in motorway conditions. After all, it will be the vehicle that carries the technology, not the roadside.

Achieving real-scale benefits on developing that vehicle technology will be essential in bringing those costs down to make the technology affordable for the mass market. OEMs will come under pressure to recoup their capital expenditure in developing the technology as quickly as possible. Some practitioners thought that, given this tension, it would take at least a further ten years before the benefits of economic scale can be fully realised. Given that commercial vehicles are already expensive, it could be easier and more cost-effective to make adaptations and retrofit sensors to existing vehicles on a timelier basis:

> One of the things about making a car autonomous is that we're putting £100,000 of sensors on it. For a saloon car sold at £25,000, that's a hell of a lot. But on a larger truck where a tyre costs £30,000, the economics for autonomy on commercial vehicles stack up better.

Changing patterns of transport usage

> There are no long roads in Singapore to enjoy driving. The joy of driving isn't part of the mindset here.

Many interviewees picked up on the potential shift away from private motoring as vehicle ownership drops. This was particularly notable in places like Singapore and Hong Kong, where practitioners acknowledge that urban driving conditions tend to suffer from more congestion, which creates less of an emotional attachment to private motoring. In China, meanwhile, as vehicle ownership is only a recent phenomenon, it is less embedded within the country's mentality, while its 'sharing economy' is widely promoted. As private ownership drops, we can expect to see more shared ownership and a greater reliance on new forms of public transport, such as 'Pods'. These have the potential to address the first and last mile of people's commuter journeys (i.e. getting them from their home to the train station at one end, and from the train station to the office at the other end).

> We wouldn't rule out investing in first mile/last mile solutions if that's how public transport evolves. If that's a possibility for expanding the use of public transport, then yes, we would consider it.

With autonomous vehicles, there is the potential to extend the reach of public transport to areas where it can't currently be provided. With public transport, the single biggest driver of cost is the person behind the wheel or at the controls. If we can have a situation in the future where it is possible to provide autonomous public transport services into rural areas, where the cost of operation is higher, then we will begin to realise these benefits.

> Across haulage and public transport there are clear benefits of increased autonomy. However, technology cannot yet fully replace the wider human role beyond controlling the vehicle.

Prospects for improved road safety and reductions in congestion

All practitioners accept the arguments about improved road safety. Indeed, it is thought to be the single biggest benefit of the technology, with human error said to be a contributing factor in a heavy majority of all road traffic accidents.[10] Yet, at the same time, demonstrating that it is as safe as the current technology is the biggest obstacle.

Accidents involving Tesla cars in the US and China have shifted the tone of public debate, with trepidation increasing. However, the autonomous vehicles in these fatal collisions have all been at Level 3 or below (where there is a driver present who can take control), and post-crash inquiries have found that drivers were not focusing on the road in the lead-up to the collision. While the autonomous vehicles performed as they should have in such circumstances and handed control to the driver, public perception of the cause of the crash does not always take into account the technical nuances of a collision.

While thousands of people die every year around the world in road traffic accidents involving conventional road vehicles, it only takes one or two high profile cases involving driverless cars to harden public opinion against the new technology (once again, arguably, displaying the difference between perceptions and reality). UK Atomic Energy (UKEA) has been hosting trials of autonomous vehicles within the UK, for two and a half years, during which the safety record has been extremely high. The UKEA test site has experienced just two Unusual Occurrences – or UNORs – during that time, and on both occasions human judgement was a critical factor.

Alongside the safety benefits, it was also a common perception among interviewees that autonomous vehicles would lead to more efficient usage of the road network. Autonomous vehicles would require less parking space – something considered one of the least efficient uses for urban spaces. Connected vehicles would also be able to identify less busy routes using under-utilised parts of the road network, enabling quicker journey times.

However, one practitioner did raise a cautionary note that although autonomous vehicles are theoretically able to use the road space more efficiently, if the number of single occupancy vehicles on the road rises (rather than a growth in public transport/ridesharing use), this could actually result in further congestion, not less. For this reason, there were those who felt that autonomous vehicle technology should be an enabler for shared public transport but not for single occupancy autonomy. This would clearly prove difficult to sell politically.

The changing nature of the liability market: Lower insurance premiums and data sharing concerns

After a period of time, and once the necessary data is available, insurance premiums for private road users will go down should autonomous vehicle technology result in fewer accidents. This is one of the stated reasons why governments in places like Singapore and the UK have pressed ahead in developing a legislative framework that addresses the liability issues arising when an accident is caused by an autonomous vehicle. Doing so will help support the introduction of more autonomous vehicle technology.

In the UK, for example, the Law Commission of England and Wales and the Scottish Law Commission's consultation on automated vehicles has suggested that the UK Government should consider how to establish a safety assurance scheme, as well as a forum for collaboration on the application of road rules to self-driving vehicles.[12] Particularly with regards to liability, the initial consultation responses indicated support for a model where a user-in-charge would not be liable for breaches of driving rules while the automated system is in control of the vehicle, with the potential for regulatory authorities to place sanctions on the system provider in these instances. In Hong Kong, meanwhile, the lack of regulation for autonomous vehicles means the liability debate is less developed.

It was also acknowledged that the new generation of road vehicles will encounter less wear and tear. While, in theory, this should reduce both maintenance costs as well as further lowering insurance payouts and premiums, in reality maintenance costs can be high as, typically, only the manufacturer can conduct the required servicing. This, in turn, means insurance premiums can actually increase significantly. In the short term the OEM certainly benefits, though it remains uncertain how the situation may change for the benefit of the consumer in the longer term. It would seem, however, that things will be less positive for the other parts of the automotive industry.

> // It will mean fewer moving parts, less wear and tear, fewer repairs and less maintenance, there are no two ways about that. That will impact on employment in repairs and maintenance on vehicles. For example, there are upwards of 7,000 workshops and dealerships in our market. Not all those businesses will be needed in the future.

One insurer predicted that as much as 60% of their motor premiums could disappear in a fully automated marketplace. For insurers, this simply means redeploying that capital on other business lines, such as software providers and car manufacturers. However, a more fundamental concern is the shift towards product liability and how – and whether – accident data will be made available to multiple parties following an accident.

> // Currently, most autonomous technology still requires some human oversight. So, I don't think we can say with any degree of certainty that the liability will move entirely to effectively the writers of the software (in the near future).

Removing the scope for human error entirely, as seen in Level 5 automation, removes the driver from the liability equation and weakens the relationship between the driver and the insurer. In its place, liability will shift towards product manufacturers. Insurers will have to develop their relationships with OEMs, and accordingly, the need to ensure adequate data sharing between insurers and OEMs remains a concern. With vehicles collecting masses of data, it should become easier to investigate accidents and apportion liability, as long as – critically – this data is shared with insurers via a third-party portal. However, during any extended transition period when there is a mix of autonomous and manually driven vehicles, this could become a grey area.

Not all practitioners are concerned about the shift in liability. Fleet operators currently absorb the risks associated with accidents on road and rail. Skipping ahead to Level 5 autonomy (road) or Grade 4 autonomy (rail) could see the liability for future accidents transferred to OEMs or software companies, thus relieving the burden (and associated costs) for operators. Before that stage, which could still be many years away, there remains the uncertainty. As long as Level 3 and 4 vehicles can switch real-time control between the vehicle and the driver, the liability will remain interchangeable.

Impact on employment and training workforces

The potential impact on employment has been raised in all markets. However, it has been noted among hauliers and public transport operators that skilled labour shortages are commonplace as it can be difficult attracting people to become commercial drivers due to the potentially long and unsociable hours.

However, employed drivers working with partially automated vehicles, there are inherent risks in the boredom and fatigue while they are not in control, as attention may not be at its peak should the vehicle switch to manual mode.

Furthermore, for fleet drivers having to navigate difficult terrains, the requisite training teamed with staff turnover can often be a significant business expense. And training can only go so far – it can take a substantial amount of time for drivers' behaviour to adapt to their road environment, and they may not take due care and attention. Once again, the removal of the human emotional element in a switch to autonomous lorries or trucks may be potential damage limitation – and in turn expenditure – for fleet businesses.

Politically speaking, however, reducing the human workforce in favour of machines is one of the biggest sticking points for automation generally, and practitioners noted that this is no different for operating vehicles.

> An area unproven is the public reaction to not having anybody driving a bus for example, and therefore not having anybody for their own personal security on the vehicle.

For public transport in particular, however, the humans on board do more than just control the vehicle. The driver can guide customers with help, aid and assurance, from providing directions, assisting customers who may have got on the wrong service or help passengers who have been taken ill. Importantly, psychologically they can serve as a form of protection to users, deterring deviant behaviour such as potential muggings or attacks (either physical or hacking an autonomous vehicle system) on board. And crucially for service providers, creating a failsafe automated system that guarantees all users are paying the correct fare is a considerable obstacle to overcome.

> For rail the technology is very different, as trains effectively run on a closed system. Anything that takes jobs away from the railway is very bad news in terms of hitting the headlines and causing industrial disputes. Taking drivers' jobs away and replacing them with autonomous trains is going to be a difficult step.

Part 5: The sea views - Special focus on the global maritime sector

Many of the discussions in the previous section relate primarily to road and rail transport. The adoption of autonomous vehicle technology in shipping, considered below, is presented with several distinct benefits and challenges. Clearly, the development of new technology will rest primarily with the OEMs, which is a market dominated by Asia.

The key challenge for the OEMs is the need to rapidly adopt new technologies that deliver greater connectivity between ships and the shore, as well as greater vehicle autonomy. Given the role that data can play in promoting greater efficiencies and cost savings, this matters hugely to the owners and operators in a sector that has witnessed low returns on capital over the past decade.

Regulatory challenges

Shipping is, by its very nature, a cross-border sector, which presents challenges for regulation. Vessels are covered by regulations issued via their flag states (where the ship is registered) as well as port regulations. The United Nations also plays a role in developing global standards via the International Maritime Organisation (IMO).

Meeting environmental concerns

In its role as the global regulator of international shipping, the IMO has developed measures to control emissions from the shipping sector. International shipping was the first global industry sector to be subject to mandatory, binding energy-efficiency regulations and standards designed to address greenhouse gas emissions industry-wide:

- Emissions are regulated as part of the IMO's pollution prevention treaty (MARPOL Convention) which covers air pollution, energy efficiency and greenhouse gas emissions.
- The IMO has also introduced the Energy Efficiency Design Index (EEDI), mandatory for new ships and the Ship Energy Efficiency Management Plan (SEEMP).
- In addition, the London Protocol addresses carbon capture and sequestration in subsea geological formations and marine geoengineering, such as ocean fertilisation, which have great potential for climate change mitigation.
- From 1 January 2020, the IMO will enforce a new 0.5% global sulphur cap on marine fuel, which is lower than the present limit of 3.5%.

The timescale for transitioning the sector to a low carbon operation equates to little more than a single ship's lifecycle before major cuts in emissions will become a reality. By 2025, all new ships will be 30% more energy efficient than those built in 2014.[11] Building the cheapest ships is already giving way to building the greenest ships as a source of competitive advantage. The need to meet stringent emission reduction targets will matter to shipbuilders and shipowners not just because of the changing regulatory culture, but also because it matters to financiers and charterers.

Crucially, an important element in the required step-change in ship design will be the growing use of data driven by autonomous and connected vehicle technology. This will not only serve to improve efficiency and, thereby, enable the industry to improve its efforts to reduce its carbon footprint. For example, as of 2016, the IMO adopted mandatory requirements for ships of 5,000 gross tonnage and above (which account for approximately 85% of CO2 emissions from international shipping) to collect consumption data for each type of fuel oil they use. The data collected will provide a firm basis for making future decisions on additional measures over and above those already adopted by the IMO. This could include exploring measures such as speed optimisation and speed reduction.

Improved maintenance, safety and reduced cost of insurance claims

As with other modes of transport, autonomous vehicle technology can help to gather additional data on how the engine is performing. For example, being able to check via the internet that an engine is running hot improves the shipowner and operator's ability to identify engine parts that may be in need of repair and replacement before they fail. This helps to improve maintenance and reduce the amount of time ships spend in dry docks. Ensuring that vessels are better maintained will also help improve performance and safety levels.

In reducing the need for human judgement, the potential for human error also decreases. The equipment, and the software, shoulders more responsibility for ensuring that the vessel remains seaworthy under these new autonomous vehicle systems. Insurers are already in discussions with the OEMs and the electronics suppliers who will create the software and the sensors. Key questions include:

- Being able to determine who is at fault when accidents do occur.
- Whether the system is secure and is maintained in accordance with regulations.
- As with other transport sectors the degree of free flow of data between OEMs, software developers, shipowners, charterers and insurers.

Who owns the data?

When accidents happen, being able to access the data will have a major bearing in determining liability. But who owns the data? Is it the vessel owner who's purchased the vessel, including the equipment, or is it the company who manufactured the original equipment? Where does the data go and where is it stored? A consensus is emerging on the need for a network of parties who collaborate and share all the data via a common digital platform.

> It's early days, but shipping is an old, conservative industry. The objective in shipping is about safety and quality, because at the end of the day it's a dangerous thing. It's all about making sure the service is safer, lives are protected and property is maintained. When parties understand that, they're more likely to look at the bigger picture rather than looking at the competitive advantage that can be maintained by keeping exclusivity of data.

Impact on employment within the sector

Autonomous vehicle technology could help to address the ageing workforce within the shipping sector. With highly skilled engineers reaching retirement age and a shortfall of young recruits in some economies, there is a potential skills gap at hand in industry.[13] Incorporating autonomous technology in ship construction can help to reduce the potential for skills shortages in future. With labour constituting one of the major costs within the industry, the ability of technology to replace labour could provide major cost savings.

The technology may be ready to support a reduced crew in the next 5 to 10 years. However, there will need to be a regulatory rebalance before this can be operationalised. The International Labour Organisation and classification societies currently regulate crew levels required for operation on each ship and qualifications of crew members for 'safe manning', and accordingly dictate rules to flag states. What is considered enough personnel for 'safe manning' at present may be very different to a decade's time.

Practical considerations

As with road vehicles, the use of autonomous vehicle technology presents different challenges in different conditions. For example, bad weather conditions not only can reduce the speed of the vessel and intensify the difficulty of manoeuvrability, but also potentially endanger the crew. While smart routing through weather tracking, ship characteristics and cargo requirements, safe passage of the vehicle may require manual control and human expertise, rather than using an automated system. Likewise, navigating a vessel into port is a particularly precise operation, and will likely require manual supervision.

Another challenge rests with ensuring high-speed broadband to both send and receive data, particularly when the ship is at sea, where maintaining access to the internet can be expensive. Voices within the industry believe that while the shift towards partial autonomous vehicle technology is already taking place, the lead-in times for full automation will still take decades, rather than years.

A further practical consideration is the cost associated with retrofitting current vessels. This can form a major investment as well as potentially taking a lot of time. Shipowners need to be convinced of the business case of making this investment, taking the ship off hire and putting it in the yard for an unspecified period. The technology is also still new and innovating incrementally, and so much of it hasn't yet been tested in real-world scenarios. For example, the sensors currently in use in other industries for autonomous tracking are not sufficiently robust for maritime conditions. This includes when dealing with the weather conditions on board and the heat of the engine room. Here there are clearly two key issues: firstly, there is a question of calibration of the data and transmitting this back to shore, and secondly, whether this gleaned data is going to be reliable, given the nature of the environmental conditions on the ship. The focus in the short term, however, must be the quality of data and maintaining quality of the sensors throughout the vessel.

> A number of practical considerations still stand in the way of a wider roll out of autonomous vehicle technology - not all within the direct control of OEMs.

Recommendations

As the technology for autonomous vehicles matures, industry and public bodies alike must adapt their models, processes and positioning to keep apace in this brave new world.

For vehicle manufacturers, operators and insurers, the task of transforming business models will take years of careful planning and investment. The need to develop a deep understanding of the emerging risks associated with new technologies, as well as the emerging legal frameworks, will be a vital component of any investment decision.

End-users will be a critical factor in the adoption of new technology, how it evolves and the speed with which it can be adopted. High-profile fatalities involving the new technology has the potential to shift public perception and, by extension, the political and regulatory landscapes. Should this occur, the adoption of such innovation could be delayed for years and potentially decades. Ensuring public confidence throughout this process of innovation and taking every step to raise public awareness around the benefits will be essential in building greater trust and allaying public concerns.

Global automotive original equipment manufacturers' (OEMs) product ranges will need to accommodate both the highly customised personally-owned autonomous vehicles (more likely to feature in countries like Australia, Singapore, the UK and US) as well as the shared autonomous model (potentially a bigger feature in urban centres like Hong Kong and Singapore). Manufacturers will need to determine if they should redesign their business model to accommodate different ownership models or whether to focus on one market.

This cannot be done in isolation. Collaboration between OEMs is crucial in ensuring we avoid a fragmented approach in operating systems between different jurisdictions. This must be avoided at all costs.

For OEMs rolling out the next generation of autonomous vehicles, driver awareness and training will be an important factor to consider. All motorists purchasing an automated vehicle of Level 3 or beyond will need to be issued with documents setting out the key features of vehicle behaviour and communications with point-of-sale training or orientation offered to motorists covering the automated vehicle safety and driver assist features.

Data protection and data privacy

The other key consideration concerns data protection and data management. How data is stored, managed and controlled is becoming a major risk and compliance issue for all companies. The Chief Technology Officer, a role that would not have existed a decade ago, now plays a vital role in many companies and typically reports directly to the CEO. When we consider the press coverage on companies being hit with multi-million fines if they are found to be in breach of data privacy laws, including the GDPR, that companies are taking the issue so seriously is no surprise.

Setting out clear policies on what data is being collected and how this is used is critical to build consumer trust. With regards to data management, there are clear benefits in the creation of a central industry-wide data-hub shared by manufacturers, insurers and government agencies alike.

Technology firms are in a highly advantaged position to capture data-based value. Tech firms are driving much of the innovation currently being taken with vehicle sensors and how these interact with personal devices, such as smartphones and the Internet of Things. This generates greater amounts of data and insights to create opportunities for dynamic-pricing, single-payment, and consumption-based models to become much more prevalent. This not only impacts on how people access transport, but also how they insure the risks associated with transportation.

Commercial fleet operators stand to benefit through the introduction of driverless or remote operation delivery systems. This not only provides major efficiencies for operators, it also addresses human constraints such as driver fatigue, which places limits on hours driven. Removing human error can also help to reduce the number of accidents and improve public safety. Driverless technology also addresses the skilled labour shortages, an issue affecting haulage firms in Australia, Singapore, the UK and US.

Insurers are faced with strategic challenges in continuing to support the classic insurance model (where accidents are often the result of human error) towards new risk models in which the liability moves towards product manufacturers. Insurers must do so at a time when consumer appetite for insurance products is likely to shift away from annual renewals (with ongoing long-term customer relationships) towards on-the-go insurance, which develops more transactional relationships where less is understood about the risk profiles of individual drivers.

Connected and autonomous vehicles will create a massive increase in data, which may help to improve risk pricing and ultimately reduce premiums, but only if such data is not siloed. Insurers, technology firms and OEMs should, therefore, focus on developing collaborative approaches to data sharing and risk modelling. Only in this way can insurers better understand the impact on premium levels and pricing models. With flows of data required between OEMs, insurers and technology firms, there must be a robust framework and agreement in place between all parties to ensure a transparent view of vehicle behaviour, whilst also accommodating data privacy of users and commercially sensitive information.

From a product development perspective there will be a need to explore developing new types of policies reflecting changing consumer ownership patterns. Insurers need to better understand the changing nature of relationships between consumers, motor manufacturers and insurers and what this means for how people will buy insurance in the future.

Public bodies are faced with additional challenges in the shape of urbanisation and population growth, both of which place greater strain on public transport, congestion, air quality and public health. Autonomous vehicles present opportunities to unlock new capacity in urban transport systems by improving efficiency within the existing infrastructure, potentially reducing the need to invest billions into new metro or rail systems. In order for this opportunity to be maximised, there is a clear need for governments to ensure real-world 'test beds' are available to manufacturers to effectively pilot new technology and ensure a sufficient enough body of evidence to support wider roll-out.

> A cross-industry and state-led collaborative effort will be required to create the infrastructure and environment for autonomous vehicle technology to be developed.

Governments will increasingly have to work in collaboration to develop common standards to ensure that new technologies are developed consistently between different transport manufacturers and between different jurisdictions.

It is clear that a cross-industry and state-led collaborative effort will be required to create the infrastructure and environment for autonomous vehicle technology to be developed, to accommodate public perception and to put public safety front and centre. A comprehensive road map must be developed to adopt change and overcome public barriers, with strong communications with citizens a crucial element of this. As we have seen, there is a strong relationship between public understanding of the technology and subsequent levels of support. With much misunderstanding around road safety and data sharing, building greater awareness and public support will be essential in ensuring that the technology is quickly adopted.

> Insurers need to better understand the changing nature of relationships between consumers, motor manufacturers and insurers.

On the issue of security and hacking specifically, greater control and clarification are essential. The ability to build a "back door" into autonomous vehicle software for use by law enforcement agencies has obvious appeal. Take Australia for example. There, fatalities during police chases have been a major issue for a number of years. Law enforcement agencies being able to assume control of a rogue vehicle and bring it to a safe stop, as opposed to commencing a potentially dangerous chase, has clear benefits. So too the idea of air traffic control being able to assume control of a hijacked or unresponsive aircraft. However, building in such access then also creates weaknesses. What then the consequences should these "back doors" be hacked?

> Where there is commercial value there is the potential for manufacturers to sell data or provide insights to third parties.

Furthermore, there is a privacy issue. Connected autonomous vehicles will receive and supply a massive amount of information/data from and to the 'driver' and/or other transportation agencies. Not only would law enforcement agencies potentially have access to people's movements, but there would also be significant commercial value in detailed real-time data of every journey of every autonomous vehicle on the road, rail, air or sea. Where there is commercial value there is the potential for manufacturers to sell data or provide insights to retailers, service providers, councils, lobby groups etc.

These are deep questions that public bodies should be trying to answer. For public trust to be ensured and maintained, it is essential that this process be as transparent as possible.

Conclusion

The disruptive power of autonomous vehicle technology will come to re-shape the transport sector and wider society as a whole. Research by GlobalData estimates that the autonomous vehicle sector will grow at a compound annual growth rate (CAGR) of 76% by 2033 - making it the fastest growing sector in the automotive sector.[14] Clearly the technology is not going to go away.

Our survey demonstrates there is a public acknowledgement of the fundamental changes taking place. But public acceptance of that technology, particularly in its most advanced form with driverless "pods", is far from guaranteed. The psychological barrier to introducing 'ghost' vehicles on our roads, railway and airports has not yet been adequately addressed. There is a pressing need for greater public information and education.

We must also acknowledge that alongside the many benefits – efficiency and lower emissions, public safety and greater social inclusion – there are a range of emerging risks for businesses and end-users. In an environment where vehicles are increasingly driven by data and technology, rather than by people, there needs to be a clear call-to-action on governments to create modern legal frameworks providing appropriate protocols on the behaviours of vehicle technology, as well as the storage, usage and sharing of the masses of data which will be collected by the next generation of autonomous vehicles. This will require a collaborative approach across government, vehicle manufacturers, software developers, insurers, law enforcement agencies and consumer groups.

References

1 Please refer to the acknowledgements section for more information about Cicero

2 Reference to Hong Kong means the Hong Kong Special Administrative Region of the People's Republic of China. As a special administrative region, Hong Kong currently maintains systems/laws that are different from those of mainland China. Given these differences as well as our presence in the city, we have included an analysis of the position in Hong Kong alongside the analysis involving mainland China. References to 'China' throughout shall therefore mean mainland China.

3 Please refer to Diagram 5 for further details

4 McKinsey, How China will help fuel the revolution in autonomous vehicles, January 2019 https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-china-will-help-fuel-the-revolution-in-autonomous-vehicles

5 SAE, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, revised June 2018

6 Refer to Diagram 8

7 Refer to appendix 2

8 Please refer to the introduction for further details

9 Refer to Diagram 7 for a description

10 A study based on the US National Motor Vehicle Crash Causation Survey (conducted 2005-07) found that the critical reason of the crash causation was assigned to drivers in 94% of crashes at a national level – US Department of Transportation, National Highway Traffic Safety Administration, "Traffic Safety Facts: Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey", February 2015

11 IMO website, Reducing GHG emissions from ships, as of 17 June 2019

12 Law Commission of England and Wales, Scottish Law Commission, Automated Vehicles: Analysis of Responses to the Preliminary Consultation Paper, June 2019

13 Department for Transport, Maritime Growth Study: Keeping the UK competitive in a global market. September 2015

14 GlobalData Automotive Intelligence Center, June 2019

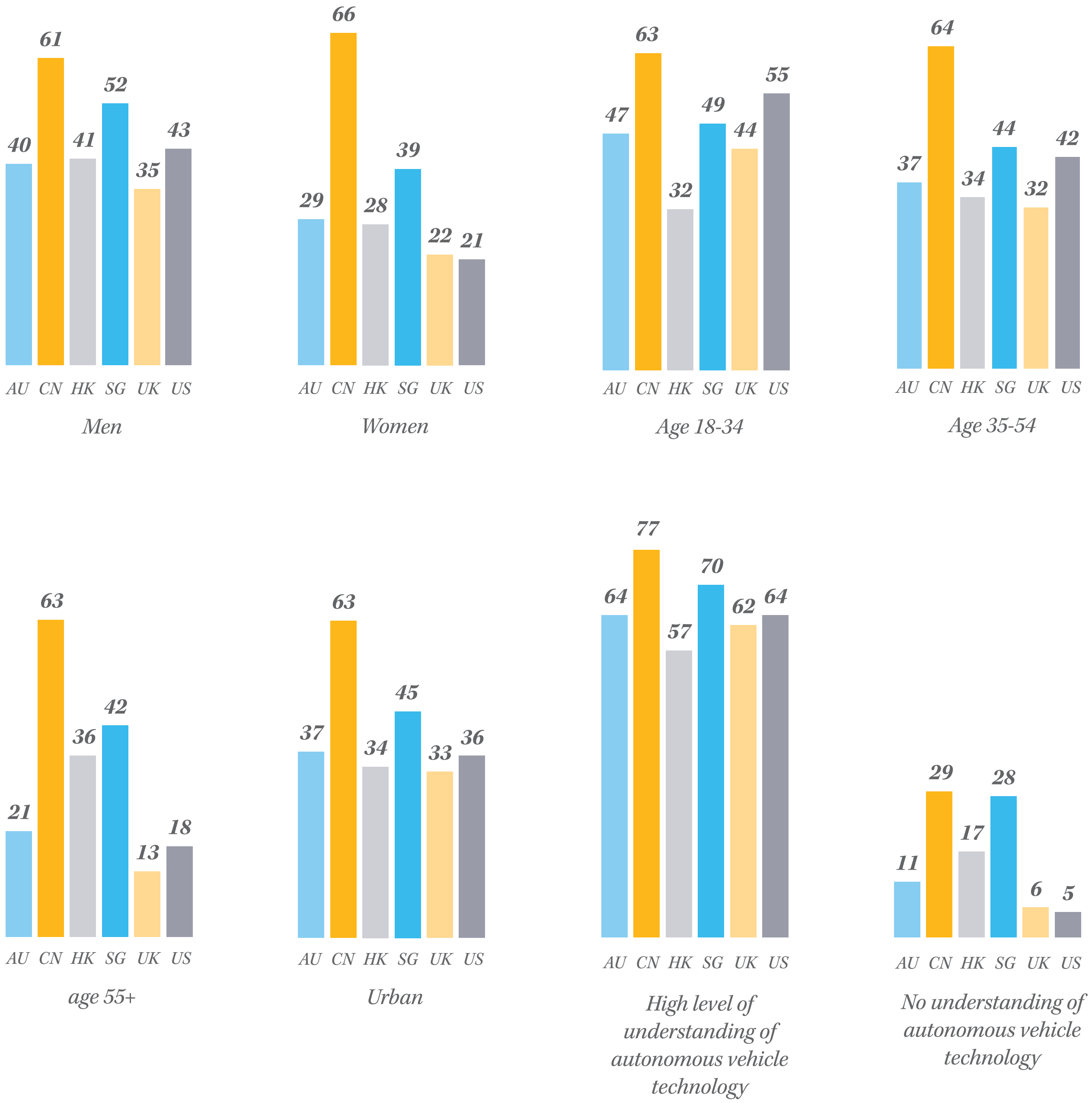
15 World Health Organization, Health and sustainable development: Transport – Climate Impacts

Appendix 1

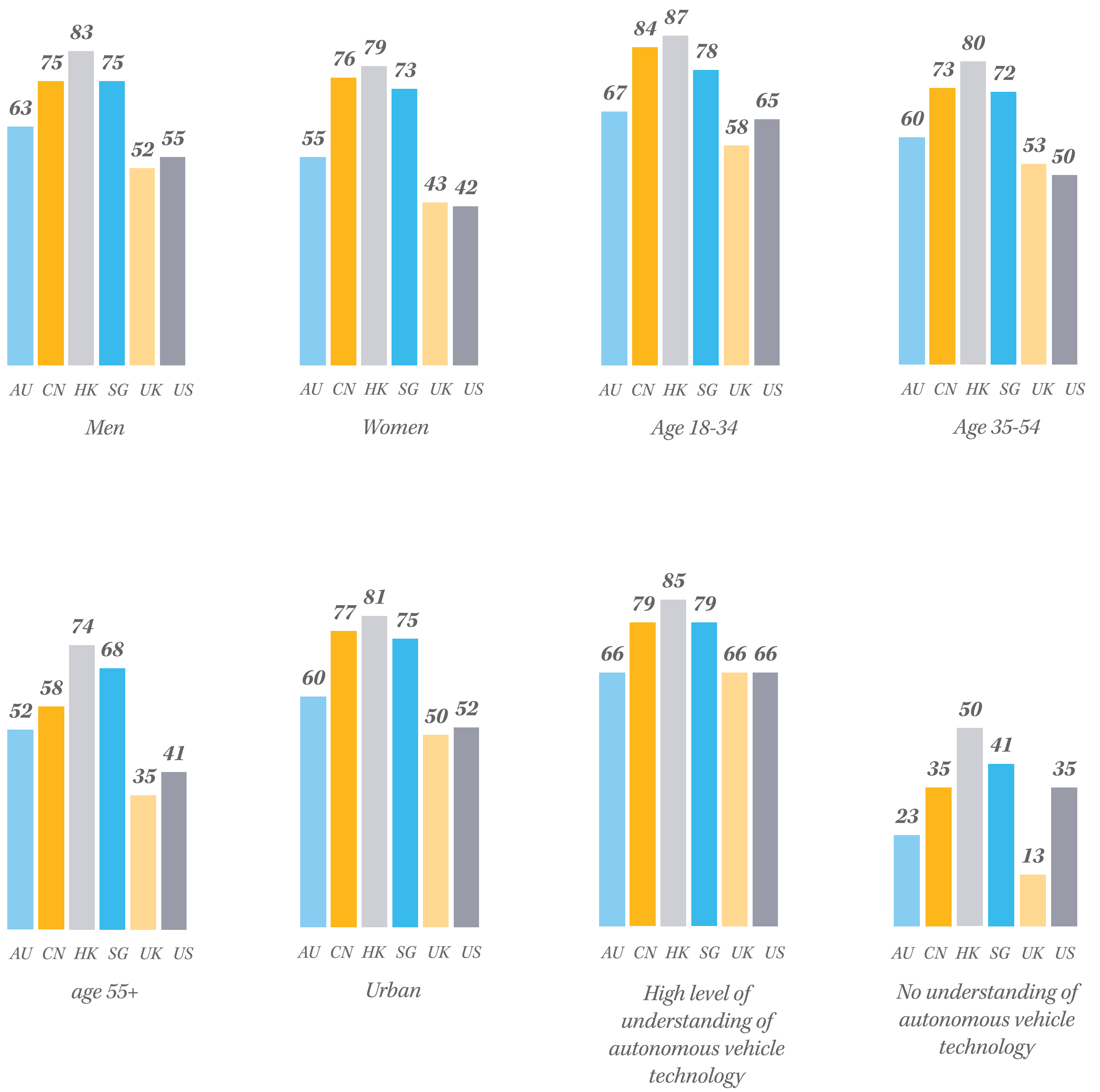
Levels of public support for driverless road vehicles across demographics groups (% supporting)

AU: *Australia*
CN: *China*
HK: *Hong Kong*
SG: *Singapore*
UK: *United Kingdom*
US: *United States*

Fully autonomous



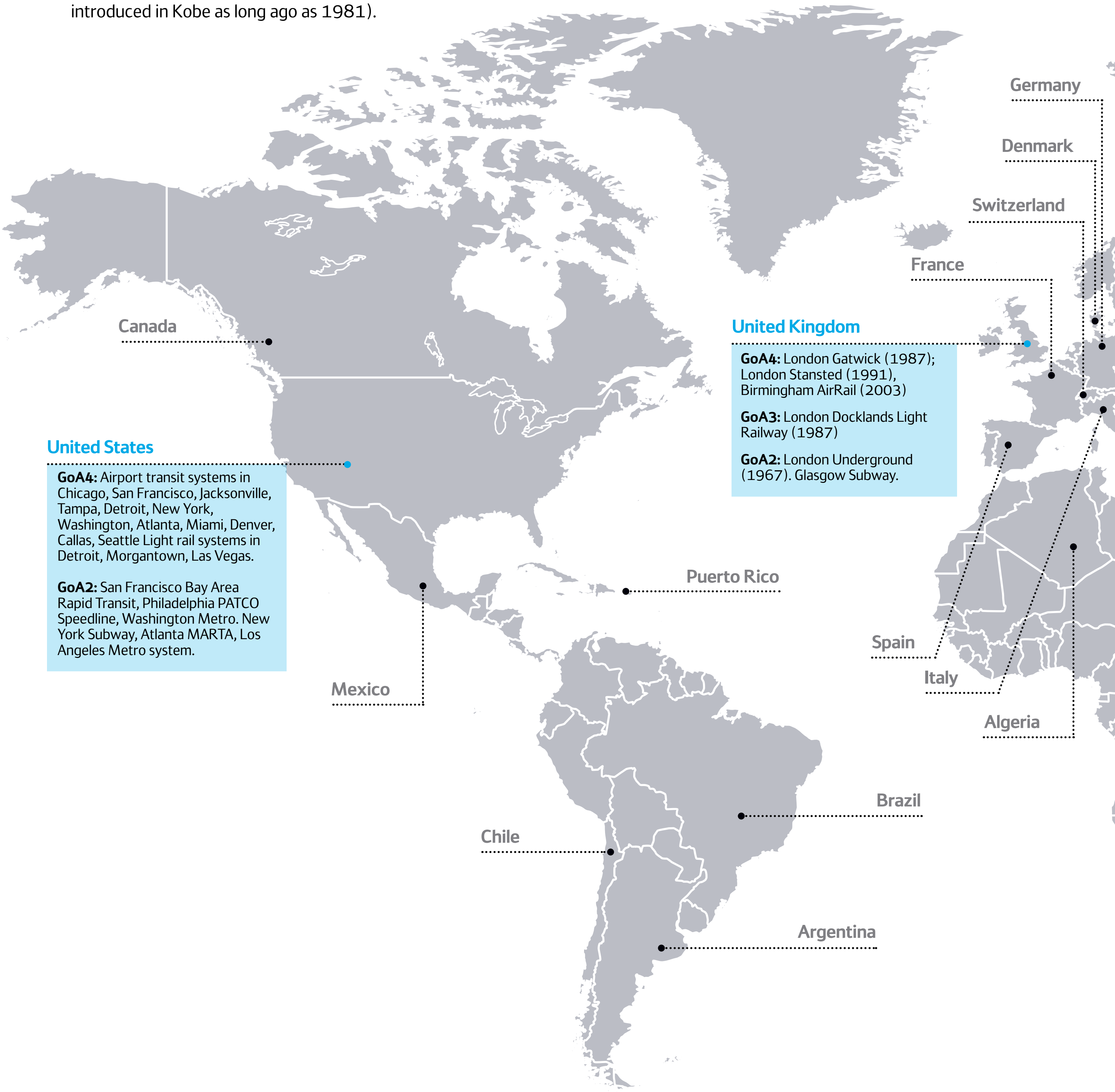
Partially autonomous



Appendix 2

Autonomous rail systems around the world

Rail transport systems around the world have already progressed as far as fully driverless technology (Grade of Automation Level 4 or GoA4). As the map shows, the technology is used in many countries – with the most extensive use coming in Asia including China, South Korea and Japan (where the first fully driverless train system was introduced in Kobe as long ago as 1981).

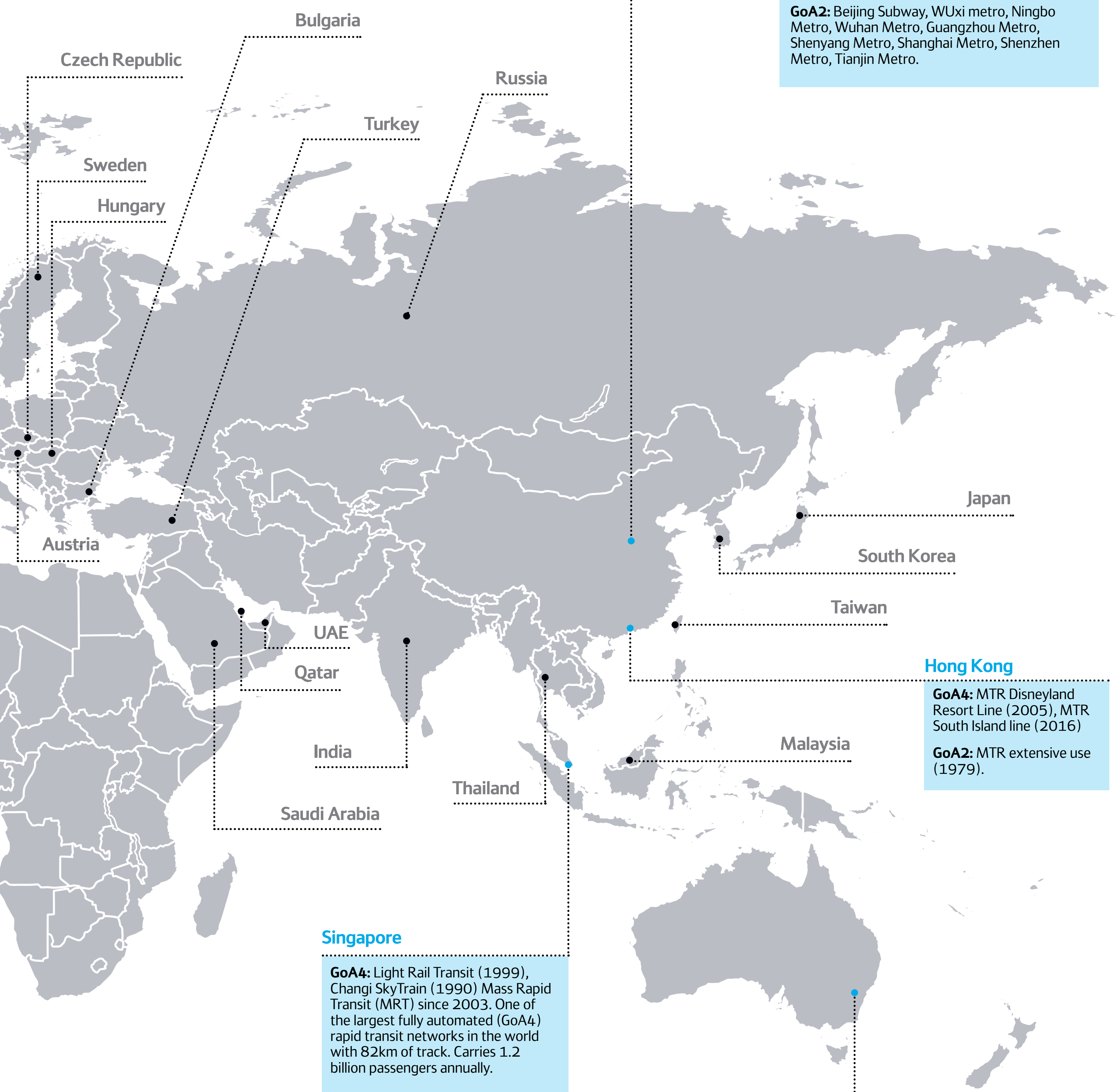


China

GOA4: Chengdu Line 9 (2019), Autonomous Rail Rapid Transit system (2018), Shanghai Pujiang line (2018), Beijing Yanfang Line (2017), Shanghai Line 10 (2010)

GoA3: Wuhan Metro Yangluo line (2017), Beijing Airport Link (2008)

GoA2: Beijing Subway, WUxi metro, Ningbo Metro, Wuhan Metro, Guangzhou Metro, Shenyang Metro, Shanghai Metro, Shenzhen Metro, Tianjin Metro.



Hong Kong

GoA4: MTR Disneyland Resort Line (2005), MTR South Island line (2016)

GoA2: MTR extensive use (1979).

Singapore

GoA4: Light Rail Transit (1999), Changi SkyTrain (1990) Mass Rapid Transit (MRT) since 2003. One of the largest fully automated (GoA4) rapid transit networks in the world with 82km of track. Carries 1.2 billion passengers annually.

GoA3: MRT North-South and East-West Lines (1987) Railway (1987)

Australia

GoA4: Sydney Metro North West Line since 2019. First completely driverless metro in Australia. Pilbara 'Autohaul' system used by Rio Tinto since late 2018.

Appendix 3

Driving to a greener future:

How autonomous vehicles can contribute to the low-carbon economy

It is impossible to discuss the future of transport without considering the green agenda. While consumers do not necessarily think about autonomous vehicle technology in these terms, there is no doubt that it has the potential to move beyond advantages for the individual and serve as part of a systemic shift towards a greener economy.

The 2015 Paris Agreement on climate change brings all nations into a common cause to reduce greenhouse gas emissions. The central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below two degrees Celsius above pre-industrial levels (and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius). The Agreement has led to substantial pressure on all industrial sectors to reduce their emissions to create a greener future.

The World Health Organisation has cited the transport sector as the fastest growing contributor to climate emissions, with land transport (i.e. cars and freight) being the main drivers of global transport energy growth.[15] There is arguably scope for autonomous vehicles to reduce the extent of this impact.

This is particularly the case for connected shared autonomous cars, with ride-sharing and a decrease in private ownership potentially reducing greenhouse gas emissions through increasing driving efficiency, smarter routing to avoid congestion and adoption of alternative fuels. Indeed, the power required for a fleet of electric vehicles would speed up installation of charging points, which if combined with increased usage of renewable power sources, could help reduce a country's overall carbon emissions.

It is not, however, guaranteed that autonomous vehicles will be the silver bullet in reducing countries' emissions. Indeed, if autonomous vehicle technology is not utilised to increase the amount of person-miles per vehicle-mile travelled (as would be the case with individual passengers in privately owned vehicles), little is being done to actively reduce the amount of power required to transport individuals. Should governments want to harness autonomous vehicles for their green potential, policies must seek to favour shared models and disincentivise individual vehicle usage and ownership.

Some governments are pledging their commitment to reach carbon neutrality by 2050, with the European Commission driving its members to support its long term climate strategy as one example. As part of the UK government's pledge to reach net carbon neutrality by 2050, it will introduce legislation requiring the installation of charging points for electric vehicles for all new housing in England. But pressure to go green is being pushed up as well as being dictated down by supranational organisations, with grassroots support for climate-centred initiatives making headlines worldwide. Sentiment among the population for a sustainable low-carbon transition is considerable. And with public buy-in essential for the introduction and roll-out of autonomous vehicles, promoting the environmental benefits could prove an important tool in governments' arsenals.

Glossary

Adaptive cruise control: Also called autonomous cruise control or traffic-aware cruise control – is an optional cruise control system for road vehicles that automatically adjusts the vehicle speed to maintain a safe distance from vehicles ahead.

Assisted parking: An autonomous car-manoeuvring system that moves a vehicle from a traffic lane into a parking spot to perform parallel, perpendicular or angle parking.

Automatic Train Operation or 'ATO': An operational safety enhancement device used to help automate operations of trains. Mainly, it is used on automated guideway transits and rapid transit systems which are easier to ensure safety of humans. Most systems elect to maintain a driver (train operator) to mitigate risks associated with failures or emergencies.

Autonomous car: Also known as a driverless car (or auto, self-driving and robotic car) is a vehicle that is capable of sensing its environment and navigating without human input. Autonomous cars use a variety of techniques to detect their surroundings, such as radar, laser light, GPS, odometry and computer vision.

Automated and Electric Vehicles Act 2018: A Parliamentary Act introduced in the UK in 2017. Part 1 of the Act makes the necessary legal reforms to the UK's liability framework to encourage the development and adoption of autonomous vehicle technology on the UK's roads.

Classification of autonomous vehicles: An internationally agreed system that measures the level of automation installed in a vehicle (i.e. the level of control an on-board computer has over the vehicle). Ranging from none (Level 0) through to fully-automated (Level 5).

Connected vehicle: A connected vehicle is a car that is equipped with internet access, and usually also with a wireless local area network. This allows the car to share internet access with other devices both inside as well as outside the vehicle to provide driver assistance to improve safety, vehicle and mobility management and in-vehicle entertainment. Part of the growing Internet of Things (IoT) (see opposite).

Driverless vehicle: These include any vehicle where no human intervention is required and any vehicle where advanced stages of autonomy have been implemented. In the case of the latter, specialist driving conditions (e.g. emergency breaking, traffic jams) may result in control being handed back to the human driver.

Driverless train operation or 'DTO': An autonomous system where starting and stopping are automated but a train attendant operates the doors and drives the train in case of emergencies.

Fully comprehensive motor insurance: The highest level of cover a person can have if they take out motor insurance in the UK. By taking out fully comprehensive cover, people are not only covered for third party claims after an incident, they are also covered for damage caused to their own vehicle.

Geofencing: The use of GPS or RFID (radio frequency identification) technology to create a virtual geographic boundary, enabling software to trigger a response when a mobile device enters or leaves a particular area.

Grade of Automation or 'GoA': According to the International Association of Public Transport (UITP), there are five grades of automation of trains ranging from manual train operation where a train driver controls starting and stopping, operation of doors and handling of emergencies or sudden diversions, through to unattended train operation or 'UTO'.

'Handover': The process by which control over a given vehicle is switched between a human driver and an on-board computer.

Internet of Things (IoT): The connection of devices (other than typical fare such as computers and smartphones) to the internet. Cars, kitchen appliances and even heart monitors can all be connected through the IoT.

Motor Insurance Directives: The body of EU law pertaining to single market (cross-border) aspects of road traffic, road safety and motor insurance ensuring that road traffic legislation within the EU supports the principles of free movement of people, goods and services.

Original equipment manufacturer (OEM): A company that produces a part or specific aspect of a product that is then used by another manufacturer in a separate product.

On-demand motor insurance: Also referred to as 'on-the-go' or temporary insurance policies. Rather than buying an annual policy these policies allow motorists to purchase short-term cover as and when they need it with policies providing cover from as little as one hour up to 30 days.
Platoons: Trucks are connected using direct Vehicle to Vehicle (V2V) communication. This allows the rear truck to react immediately to the actions of the front truck.

Pods: An enclosed electric driverless vehicle, designed to transport passengers short or medium distances on dedicated roadways. These are typically low-speed and designed for urban areas.

Safe manning: The number of crewmembers required on board a ship and/or the qualifications of each individual crewmember, as determined by the responsible authority.

Telematics: The area of technology that deals with sending digital information over long distances using wireless forms of communication. In vehicles, distance traveled can be used to monitor hours used and miles driven, each of which can be recorded real time.

Test bed: A dedicated site used for testing autonomous vehicles that replicates real-life conditions for product development and safety testing.

Third party insurance: The minimum level of motor insurance cover required by law in the UK. Third party policies cover the driver against costs that arise as a result of injuries or death of people, damage to other people's vehicles, damage caused to their vehicle by fire or the theft of their vehicle.

UK Road Traffic Acts: The body of traffic laws setting out the legal obligations on motorists with regards to ensuring road safety, ownership and insurance of road vehicles. This includes the creation of the Highway Code, speed limits, the requirement to register ownership of a vehicle, the introduction of statutory insurance and the penalties for committing driving offences.

Unattended train operation or 'UTO': An autonomous system where starting and stopping, operation of doors and handling of emergencies are fully automated without any on-train staff.

UN Conventions on Road Traffic: An international treaty designed to facilitate international road traffic and to increase safety by establishing standard traffic rules among the contracting parties. The first convention was agreed in Geneva in 1949, which has been accompanied by a number of additional road traffic conventions including the Vienna Convention agreed in 1968.

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About Cicero

Cicero Group is a full-service communications and market research agency. It designs and delivers award-winning corporate, brand, political and regulatory campaigns across all major business sectors from offices in London, Brussels and Dublin.

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