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The International Connected and Automated Mobility Landscape

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Acronyms

Abbreviation	Definition
CAM	Connected and Automated Mobility
ADAS	Advanced driver-assistance systems
ICV	Intelligent connected vehicles
CAV	Connected and automated vehicle
ADS	Automated driving systems
AI	Artificial intelligence
CCAV	Centre for Connected and Autonomous Vehicles
ODD	Operational Design Domain
CAVPASS	Connected and automated vehicles: process for assuring safety and security

Foreword / Paul Newman, UK's Automotive Council CAM Champion

Paul Newman brings his expertise and accomplishments to this report, having authored numerous papers and co-founded Oxa, cementing him as a reputable voice in the field.

In today's world, countries face diverse challenges, ranging from achieving Net Zero goals and recovering from the pandemic, to fostering business growth, creating jobs, and improving societies.

These challenges present opportunities for each country to thrive and showcase their strengths globally. Fostering collaboration, forging partnerships, and enabling disruptive innovation has become more critical than ever in effectively addressing these challenges.

An international perspective is essential to discover key localised solutions. I believe that the Connected and Automated Mobility (CAM) market offers solutions to these multifaceted challenges. That said, the CAM market is not one clearly defined market, but a complex and exciting mash-up of multiple markets, including testing, cybersecurity, safety, insurance, data, road infrastructure, energy, telecommunications, software, simulation, automotive, freight, and logistics. It impacts the daily lives of end-users, customers, and the general public.

The CAM market is accelerating like never before. Countries around the world are making their own way and I'm pleased to see that the UK is growing in its confidence and capabilities. This really is a global effort to radically transform the transport and mobility sector and it's through the collaboration happening around the world that we will see that transformation realised.

There is a huge global opportunity still on the horizon as countries and regions around the world are looking at the opportunity for safer, more efficient movement of people and goods, not just for the benefit of society, but also the potential economic opportunity it presents.

Zenzic's International CAM Landscape offers an insightful view of CAM perspectives in the USA, Canada, China, Japan, Germany, France, and Israel, through four key lenses: policy and regulation; innovation environment; testing capabilities; and deployments. This document complements Zenzic's other work, which includes the CAM Roadmap UK to 2035 and the UK CAM supply chain analysis, providing a global perspective on CAM trends and showcasing the UK's strengths in this multifaceted domain.

In forging a path as a true global leader, the UK must foster robust collaboration and understanding with our international partners. By gaining insights into their initiatives and aspirations, we unlock boundless possibilities to unite, collaborate, and create cutting-edge, customer-centric CAM technology.

'Fostering collaboration, forging partnerships, and enabling disruptive innovation has become more critical than ever.'

Paul Newman

Why the UK? /

The work underpinning this iteration of the International CAM Landscape uncovered several key themes, providing an insight into the direction of travel for countries around the world, and the opportunities available to the UK to strengthen it's position in the overall market.

To broaden your understanding of the UK's current position, we recommend reading the UK CAM Roadmap to 2035 and the Zenzic report into the UK CAM supply chain, accessible using the button links below.

Supply chain report | Roadmap report

1. The UK is well positioned in the International CAM Landscape to be at the forefront of realising global commercialisation.
2. By being clear on its strengths and staying focused the UK is in a strong position to reap the potential socioeconomic benefits of CAM.
3. The deployment of CAM is a global race, the UK is moving at pace and building on this momentum is key
4. Looking beyond our own borders, there are immediate opportunities for international collaboration.
5. The evolution of CAM brings a disruptive industry of industries approach that is prompting exciting commercial partnerships.
6. Culture plays a large role in defining countries' development and deployment of CAM.
7. Countries are moving quickly to invest in opportunities closest to market, informed by their societal needs.

1.0 / Introduction

The UK is part of a global effort to radically transform the transport and mobility sector through connected and automated technologies. Countries and regions around the world are looking at the opportunity for safer, more efficient movement of people and goods, for the benefit of society, but also the potential economic opportunity it presents.

There are many estimates from around the world, forecasting the potential market size of Connected and Automated Mobility (CAM). This has driven huge investment from all corners of industry into unlocking the promise of connected and self-driving vehicles.

However, the question remains – 'What role will the UK play in this new and emerging sector'?

The UK is well positioned within the global CAM sector. However, to have a strong and competitive UK CAM sector, it must invest wisely, focus more tightly, and collaborate more openly in areas that can deliver the most value to the UK and global economies.

This report provides a high-level view of a detailed analysis and insight of the CAM markets selected.

The work focuses by evaluating seven key CAM markets – **USA**, **Canada**, **China**, **Japan**, **Germany**, **France**, **Israel**, and the **UK** in the following critical capability areas – **Policy and Regulation**, **the Innovation Environment**, **Testing Capabilities** and **Trials and Deployments**. The countries as shown in Figure 1 subject to this study were selected based on several criterial including economic strength, visibility of CAM activities and global positioning.

> *To have a strong and competitive UK CAM sector, it must invest wisely, focus more tightly, and collaborate more openly.*

1.1 Markets in scope

The summary below shows the rationale for why these countries were selected as part of this study.

USA

Offers a different approach to CAM regulation and development. Making strong advancements in the sector with Europe seen as a natural next step for many USA-based companies. This work focusses US states for CAM development, testing and deployment of Arizona, California, Florida, Michigan and Texas.

Germany

A traditional automotive powerhouse with significant capabilities. Germany has also been on the forefront of CAM regulation and policy. As with France, it is important to gain a deeper understanding to determine closer collaboration opportunities and understand key European competitors.

Canada

Canada has been steadily active in the CAM space with areas such as cybersecurity being a priority for the Canadian government. Canada is also of interest due to the existing Commonwealth ties and opportunities this may present to UK based organisations.

China

China is not only rapidly becoming a powerhouse in CAM but is also expanding globally by establishing subsidiaries in Europe and other markets. It is valuable to understand key sector players as well as to establish relationships with several partners in the market and define UK as a potential European destination for investment and trade and vice versa.

France

Whilst not necessarily regarded as a country with high CAM investment opportunities, France is a key player in the European market. It is important to gain a deeper understanding to determine closer collaboration opportunities, consider any government and industry approaches that may work for the UK and understand key European competitors and partners.

Japan

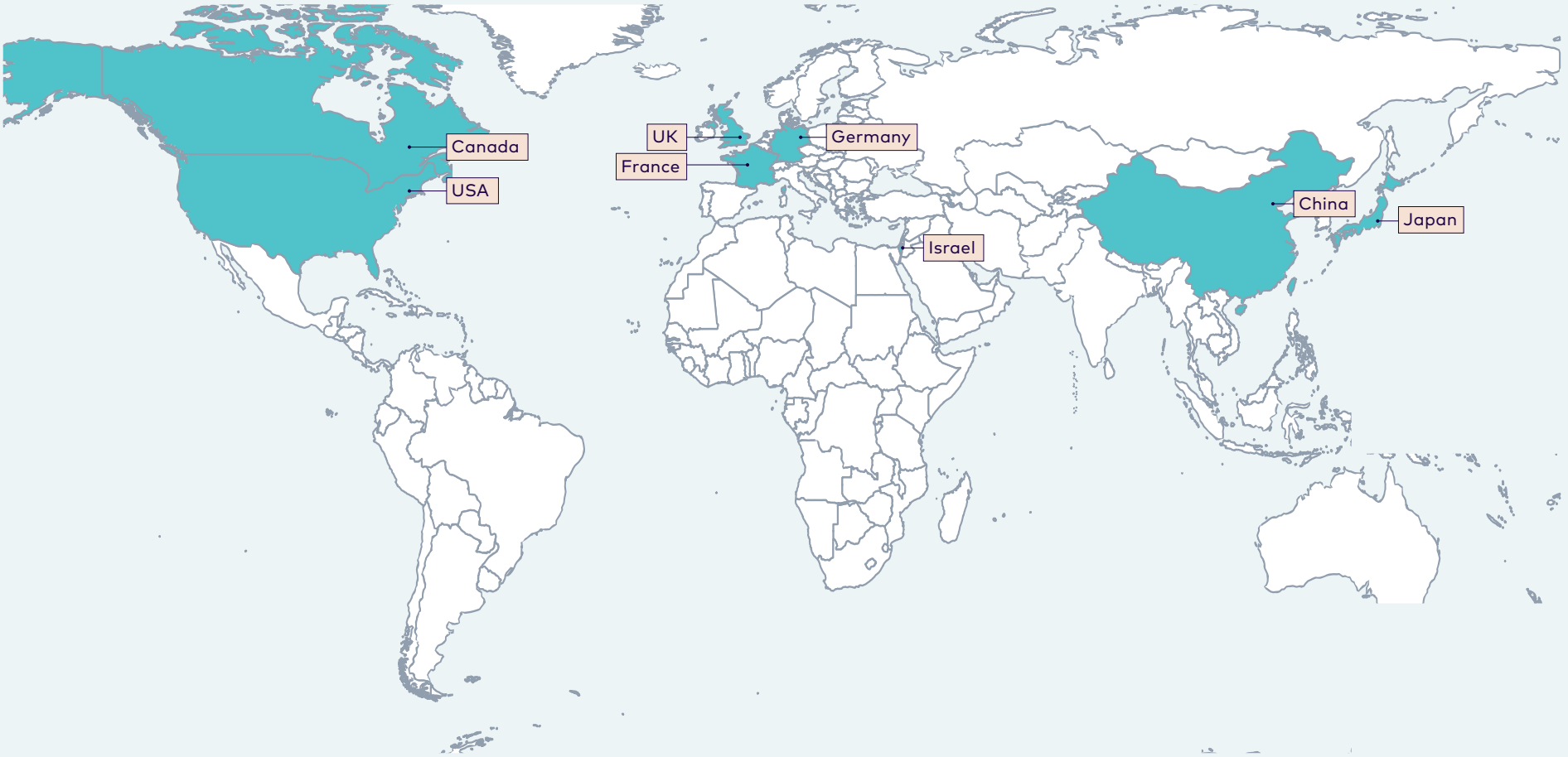
With a strong automotive sector and ties between the UK and Japan due to key automotive suppliers' presence in the UK. It is important to gain a clearer understanding of Japan's current position on CAM to continue developing existing relationships and identify new avenues for collaboration.

Israel

With a clear and ambitious focus on innovation, Israel offers a valuable perspective of how it transformed itself into a formidable player in CAM industry despite low traditional automotive capabilities.

Whilst smaller in CAM market size, Israel presents an opportunity to learn from its approach towards CAM sector development.

Figure 1: Countries in scope of the study



1.2 Approach

Four key areas were assessed in each market:

Policy and Regulation:

This includes the current regulatory environment and government position on CAM testing and commercial deployments.

Testing capabilities and trials:

Includes CAM testing infrastructure such as controlled and public environments, digital and CAM ecosystem support. In addition a look into public tests and trials – with and without a safety driver.

Innovation Environment

A look into the automotive and start-up ecosystems, public and private funding and key CAM R&D developments.

Deployment:

This includes a look into aspects required for the commercial rollout of CAM such as 5G coverage, technology infrastructure readiness, cybersecurity, consumer acceptance as well as commercial deployments taking place.

This report provides a high-level view of detailed analysis and insight of the CAM markets. The work that informed this piece combined desk research (which relied on government resources, industry publications, consultancy, and multilateral organisation reports), Zenzic in house intelligence, and data and information provided by its partner organisations. To ensure the validity of research findings, the team also conducted over 40 interviews with private and public sector organisations operating in CAM around the world. The research team also engaged the project Advisory Group which advised the team on methodology, the scope and validation of the findings.

This report provides a high-level view of detailed analysis and insight of the CAM markets.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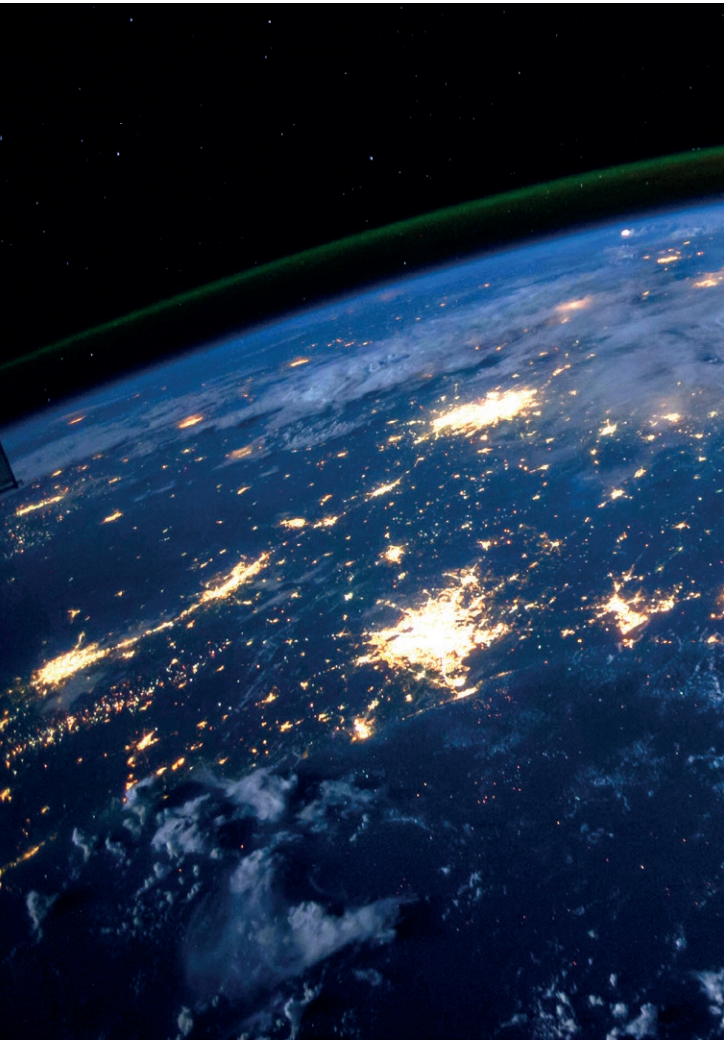


2.0 / Global findings

The market research behind this work has revealed trends which are indicative of the current 'headwinds' of global CAM development and deployment. Research into each country, having been evaluated and their challenges and approaches reviewed, has led to these six key findings for the global CAM sector.

2.1 Re-evaluation of CAM approach

Around and up to 2018, the global CAM sector experienced an intensive level of activity. Many well established and new businesses projected speedy self-driving technology uptake and both private and public investment poured in exemplified by CAM technologies peaking in the Gartner Hype cycle in 2015 [1] and predictions such as the then UK Chancellor's announcement in 2017 that self-driving vehicles will be on the UK roads by 2021 [2]. The global sector was galvanised by high levels of corporate and start-up development activity, and collaborative industry projects examples from the UK include £93m in R&D investment, £102m investment in CAM Testbed UK and £200m into 5G testbed and trials by the UK Government in 2017 alone [3]. The enthusiasm was equally supported by the governments around the world establishing testing infrastructure, passing CAM-enabling legislation and providing generous funding streams to kickstart CAM activity in their markets.

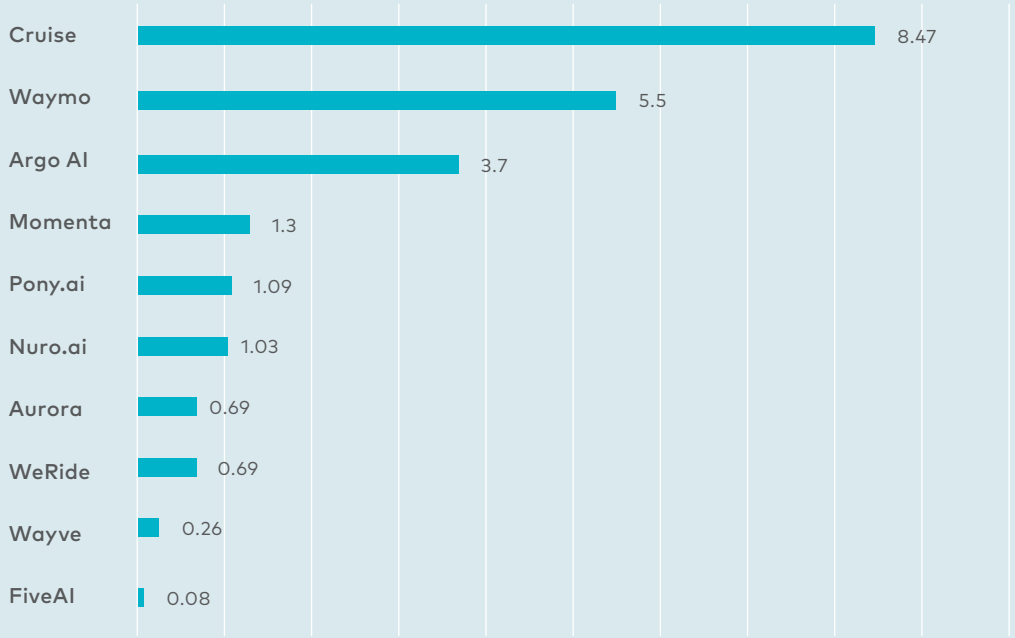
More recently (in 2022/23), while the world recovered from the effects of the pandemic, the sector seems to have taken a pause to re-evaluate its approach. This coincides with governments across the world engaging with the industry and setting out testing and deployment enabling regulations. There remains a clear need to continue with the creation and adoption of regulation and standards to give certainty and direction to the market. After billions being invested globally – see Figure 2.1 for a USA example – and return on investment not yet achieved in some areas; businesses, investors and governments are rethinking their approach.

The evidence from country's policy priorities as well as the interviews show that the pressure of environmental commitments and individual country challenges, governments are re-focussing their automotive and transport efforts towards EV roll out acceleration and alternative powertrains to meet net zero targets. Considering tightening budgets, the ambition for CAM is readjusted.

Overall country focus on specific CAM areas varies greatly and depends on the overall culture, demographic situation and governments' chosen strategic direction. It appears that some of the key factors being considered for public funding cases appear to include **environmental benefits**, **societal benefits** and a **path to commercialisation**.

More recently (in 2022/23), while the world recovered from the effects of the pandemic, the sector seems to have taken a pause to re-evaluate its approach.

Figure 2.1: Funding to key start-ups in the automotive vehicle space worldwide by 2022. (US$billion) [4]



2.2 CAM sector consolidation

Due to very high development costs, the industry is undergoing a structural change. Automotive OEMs, suppliers and new leading CAM companies are solidifying their positions through sector collaborations, acquisitions, and investments into start-ups. There exist strong industry newcomers such Waymo, Oxa, Wayve, Einride, Baidu and many others. In addition the CAM industry is seeing an emergence of frontrunners from the traditional automotive sector such as GM's Cruise, Ford, Daimler and Mercedes-Benz, Volkswagen, Toyota, Bosch, ZF, Magna and others. For the UK alone, the numerous key international investment milestones is shown in the breakout box.

Strategic industry partnerships for CAM capability development are being established; Bosch and Mercedes-Benz [5] , Magna and LG [6], Continental and Ambarella [7], and many others are uniting their efforts. Considering the close down of some disruptors and partnerships, such as shutdown of Argo AI [8], it remains to be seen how partnerships will develop against a backdrop of tightening budgets and growing pressures for deployments and return on investment. In addition to industry partnerships, CAM leaders are also solidifying their positions either through acquisitions (Bosch acquiring Five [9]) or solid investments into emerging frontrunners (ZF's 5% investment into Oxa [10]).

Example

Key international Investment milestones for the UK [11]

2017

- **Nissan** bases its European self-driving innovation programme from the UK at the NTCE (Nissan Technical Centre Europe).
- **Ford** of Europe opened Ford's Smart Mobility Innovation Office in London focusing near-term development of smart mobility technologies for European cities.

2018

- **Toyota** announced a new startup, Toyota Connected Europe (TCEU), to bring advanced mobility services to the European market.

2019

- Google's self-driving vehicle company, **Waymo**, chooses the UK for the location of its first European engineering hub when it acquires the Oxford University spinout **Latent Logic**.

2020

- UK CAM start-up **Five** raises £31 million at Series B from globally active investors, taking its successful funding rounds to £60 million in total.

2021

- UK CAM start-up **Oxbotica** raises £36 million at Series B. One of the world's largest Tier 1 automotive suppliers, **ZF**, takes a 5% stake to jointly develop automated driving systems, joining other investors including Ocado and bp ventures.

2022

- **Wavye**, a London-based self-driving vehicle start-up, completes a successful US$200 million Series B financing round, led by US Venture Capital company Eclipse.
- Israeli mobility intelligence company **Otonomo** acquires Sheffield company **The Floow**, a leader in connected insurance technology, for £52 million. Vehicle and mobile data from the two companies will be used to develop insurance models based on software-as-a-service that are more predictive and preventative.
- **Bosch** acquires **Five** – one of Europe's leading CAM start-ups and leader of the part government funded Streetwise project.

2.3 The impact of culture

The innovation environment and an overall entrepreneurial culture of each country plays an important role in the pace of CAM development and a country's global positioning. For example, the USA and China boast robust and well evidenced innovation ecosystems and benefit from strong tech, automotive, academia and high growth aimed at start-up culture. Israel, on the other hand, has no automotive manufacturing presence but capitalises on existing tech, defence and cyber capabilities, entrepreneurial mindset and strong stance on anchoring the IP in the country – as shown in Section 4.

Germany and France have strong traditional automotive sectors and are less driven by tech and start-up activity. France and Japan have taken a more societal approach to CAM technologies – with Japan focusing on their aging population and climate resilience issues and France focusing on accessibility.

Collaboration remains an important factor for the UK with the likes of CAM Testbed UK and collaborative R&D lead by CCAV.

2.4 Public environment testing underway

Although all countries reviewed have controlled and public testing capabilities the standard and scale vary greatly. CAM Testbed UK's range of testbeds, capabilities, coordinated approach and a close working relationship with the UK government and CAM industry presents a very competitive international proposition. Nevertheless, it is evident that most of the countries in scope are shifting towards public environment testing. China, Germany and especially the US have a growing number of public testing projects and deployments in urban environments and on highways (see examples opposite).

All countries are running a range of trials with a safety driver in the vehicle. In particular, self-driving shuttle testing is taking place or due to take place in all countries in scope examples include Easy Shuttle (Germany), CAM Deployment UK (UK), Michigan State University Autonomous Bus (USA),Baidu Robobus (China) RoAD to the L4 (Japan), ENA project (France) and VW's ID Buzz minivans (Israel).

Examples

Smart Mobility Living Lab and Midlands Future Mobility in UK working with transport authorities to facilitate public road testing since 2020 [45]

Arizona (USA) has allowed on-road testing since 2015 [40]

In 2019, Curiosity Lab at Peachtree Corners announced that Local Motors deployed its Olli electric AV shuttle in its smart living lab [41]

20+ public testing locations in China with public testing possible since 2018 [42]

Notable trailing activity by the likes of Baidu, Poni.ai & weRide.ai in China (2020-2023) [43]

Easy Shuttle in Frankfurt – a passenger service trial in the running until Oct 2023 [44]


7:00 - 10:00
16:00 - 19:00

2.5. Deployments require more than enabling regulation

Despite the presence of commercial deployment enabling regulations in a number of countries, currently only self-driving shuttle and bus operations are underway or about to go live in all markets in scope.

Although private capital is available, CAM development is proving to be capital-intensive and investors are increasingly favouring close-to-market-ready businesses. This brings specific CAM segments, such as automated freight and logistics, off-road and geofenced area operation, to the forefront of early use cases which can act as a gateway for wider CAM adoption.

Overall commercial deployment regulations have not yet translated into live, wide-ranging deployments. Evidenced in the interviews conducted, factors including **safety and cybersecurity, nationwide regulation harmonisation, infrastructure readiness, consumer acceptance** and others must be considered.

Further technology and safety regulation compliance (especially in the EU), building consumer acceptance and developing business models are key enablers for CAM deployment in the near future.

2.6 Insurance not ready for mass rollout

In each of the countries, insurance is an area requiring a collaborative approach from the governments, insurers, and businesses. Currently, existing insurance frameworks are being utilised to provide insurance products for testing and deployments. Although a range of discussions are taking place, clear CAM insurance products are not yet ready to be developed for mass rollout, presenting an opportunity for a country to take a leading role on a key stage.

CAM insurance products are not yet ready to be developed for mass rollout, presenting an opportunity for a country to take a leading role on a key stage.

3.0 / Research area trends

The following sections explore the key findings across the four research areas – Policy and Regulation, Innovation Environment, Testing Capabilities and Trials and Deployments – to highlight the key trends and differences between the countries within this study.

3.1 Policy and regulation

The UK's position

The UK is well positioned due to its coordinated approach to CAM development and a clear roadmap for the sector's development.

Having primary and secondary legislative and regulatory framework for commercial deployments would strengthen UK's international position and perception of the market, allowing the UK to maintain its strong positioning.

Regulatory safety compliance is one of the critical enablers for deployment and as countries still look to bring these into practice the UK has the opportunity to leverage its inherent testing, assurance and cybersecurity capabilities.

3.1.1 Policy

Most of the countries in scope place CAM as one of the long term-priorities either through government policy and/or funding. There has not been a clear statement from the US federal government, even though CAM technologies are being developed and deployed at pace. The UK [12], China [13] and Japan [14] have adopted robust CAM or AV roadmaps which are updated on a regular basis and provide a framework for Government and industry planning.

The UK, US, Canada, and Israel have clearly identified government agencies leading on CAM developments. Germany and China have multiple regional and national entities spearheading AV development and deployments. Japan has opted for a combination of ministries overseeing CAM on a national level.

3.1.2 Regulation

All countries in scope have well defined regulatory frameworks for AV pilots with a safety driver on public roads. Regulatory frameworks for the AV pilots without a safety driver on board for public roads either require a two-way communication with the control centre and/or need have a have a teleoperation function in place.

Countries are moving forward with CAM regulations at a slightly different pace hence different steps are anticipated for shaping local regulations further. Furthermore, UNECE and EU regulations exist for all recognising countries. Germany has made strong progress with setting up robust foundations for self-driving vehicle testing and deployments, but all EU member countries are also subject to EU regulations and subsequent regulatory developments are anticipated on a national level.

> *Countries are moving forward with CAM regulations at a slightly different pace hence different steps are anticipated for shaping local regulations further.*

Region/country	State of CAM regulation
UK	• The first legislation to cover automated driving was The Automated and Electrics Vehicles Act (AEVA) 2018. This provides clarity regarding the insurance of CAVs and supports quick access to compensation in the event of collision involving these types of vehicles. The Act also includes the legal definition of an AV • CCAV published a Code of Practice: automated vehicle trialling in 2015 (last updated in January 2022) • CAVPASS launched in 2019. This focuses on the processes and systems that are required for safety assurance of CAVs • The UK remains an active member of the UNECE working groups examining technical standards and use requirements for road vehicles – WP29 and WP1 respectively
France and Germany (Europe)	Key UNECE regulations and EU regulations as a foundation for individual country legislation: • UN Regulation for Uniform Provisions Concerning the Approval of Vehicles with Regards to Automated Lane Keeping Systems (UNECE 157), 2021 • UN Cybersecurity Regulation (UNECE 155), 2022 • UN Software Update and Software Update Management System Regulation (UNECE 156), 2022 • EU Regulation 2019/2144 for Vehicle General Safety, 2022 • EU Regulation 2022/1426 for the Type-Approval of the Automated Driving System (ADS) of Fully Automated Vehicles, 2022

USA, China, Germany, Israel, France and Japan have passed commercial AV deployment enabling regulations. In 2022, the Law Commission of England and Wales and the Scottish Law Commission [15] published its four-year review including its recommendations to the UK Government outlining a new regulatory framework for self-driving vehicles. Through the Connected and Automated Vehicles: Process for Assuring Safety and Security (CAVPASS) programme [16], the UK Government is anticipated to pass the regulations by 2025. France has a decree that allows for the commercial use of passenger AV services [17], however, no clear steps for commercial deployment regulations have been identified for Canada.

Clear CAM specific-type approval regulations were identified for the US, Canada, Germany and Israel. EU Regulation 2022/1426 for the Type-Approval of the Automated Driving System (ADS) of Fully Automated Vehicles must be factored in as the foundation for future nation-wide regulations in Germany and France. Large-scale type approvals are not yet in place in any of the countries in scope.

Region/country	State of CAM regulation
USA	US states – examples include, Arizona, California, Forida, Michigan and Texas – have passed required regulation or executive orders to enable CAM testing and deployment, however nationwide and/or regional harmonisation remains a key challenge for rollout US wide
Canada	There are some Canadian provinces – such as Ontario and Manitoba – which have a regulatory framework to support the testing of CAM, other provinces are only just beginning to enforce regulations for self-driving vehicles, which could delay deployment at scale in the future
China	Despite the lack of national legislation, specific provinces and cities in China – such as Beijing, Shanghai and Chongqing- are permitting self-driving testing on public roads. There are efforts to harmonise regulatory frameworks on a national scale as nationwide legislation on commercialisation of AVs for public transport and road safety commercialization is being put through.
Japan	Japan has shaped a coherent approach to advancing AV technologies through its 'regulatory sandbox' approach and spearheading major R&D projects on the ground, allowing the country to develop testing guidelines, AV road standards and commercialization framework.
Israel	Israel is adopting a 'regulatory sandbox' approach, enabling the country to rapidly adjust to technology developments and industry needs in testing and deploying CAM on public roads.

3.1.3 Data

All countries, apart from the US, have clearly defined data collection and data use parameters during public trials. However, more clarity is required on data regulations for commercial deployments. For example, the UK Government commissioned a report to propose how responsible innovation can be embedded in the future regulatory framework for self-driving vehicles and this document outlines expected requirements many aspects including for data privacy, and data sharing, explainability and road safety [17].

While cybersecurity is one of the fundamental elements for safe AV deployments, only the UK, USA, China and Israel have clearly defined national cybersecurity requirements for testing on public roads. Even though clear cybersecurity regulations have not been identified in Germany and France, it is anticipated that this has been or will be clearly addressed to comply with the EU and UN regulations. A similar case is expected for the rest of the countries recognising UNECE regulations including UN cybersecurity regulation UNECE 155 passed in 2022.

> *Only the UK, USA, China and Israel have clearly defined national cybersecurity requirements for testing on public roads.*

3.2 Innovation environment

The UK's position

The UK has strength in its overall innovation environment, with a strong start-up and SME ecosystem, and would benefit from a clearer defined a CAM identity based on its strengths and international perceptions within the global market. Based on the UK's strong public investment to date and the overall and CAM specific funding landscape, there may be opportunity to review how funding and investment can be best leveraged. Coordinated and strategically directed international collaboration with the public and private sector is an area of further opportunity.

Region/country	CAM Application focus
UK	The UK is taking a balanced approach and aiming to place its focus on a range of use cases: logistics, hub to hub operation, passenger shuttles and busses.
USA	Personal mobility solutions, such as AV taxis, and shuttles are taking the centre stage in the US. Strong progress is also being made in all segments of automated freight and logistics.
Canada	Passenger shuttles and public services are an area of focus and investment for Canada as the government drive to improve future mobility. Freight and logistics, specifically middle-mile and off-road operations e.g., mining, are also areas where there is activity.
China	Due to China's focus on the luxury markets, its OEMs are placing their efforts on developing premium CAVs. The country is also making headway through rolling out CAV taxis via ride hailing services and automated public transport solutions via shuttles and buses.

3.2.1 CAM identity

Overall country focus on specific CAM areas varies greatly and depends on the overall culture, demographic situation and the specific governments' chosen strategic direction. collaboration with the public and private sector is an area of further opportunity.

Countries have varying degrees of specific international research partnerships and development activity taking place. In 2017, the first cross-border demonstration between the USA and Canada took place between Ontario and Detroit. Magna and Continental, in collaboration with the Michigan Department of Transportation and the Ontario Ministry of Transportation tested two fully automated vehicles in a variety of settings as part of an international border demonstration [18]. Transport Canada's Vehicle Cyber Security Guidance states that Canada will continue to align efforts with the US DOT given the integrated nature of the North American automotive marketplace [19]. In 2018, Germany and China signed a Joint Declaration of Intent on the Cooperation in the Area of Automated and Connected Driving [20] and in 2020, the Sino-German Intelligent and Connected Vehicle Promotion and Application Centre was founded [21]. While many other factors are at play, Germany has been witnessing a significant

increase in a number of subsidiaries established by Chinese automotive companies. No other European country demonstrated such a strong pull for Chinese automotive investment.

There is also a growing number of German and other international start-ups eyeing the UAE and the Middle East, which are very proactive in attracting global innovators to assist with meeting regional sustainability targets. This trend is expected to grow as more companies are starting to look for alternatives to China.

France and Japan have also been working on a deeper bilateral cooperation in CAM. While the ties between Nissan and Renault are very strong and their effects on both markets are evident, there are signs of emerging CAM collaboration avenues such as multiple Navya shuttle deployments in Japan [22]. Moreover, France and Germany operate in a dynamic cross-border collaboration environment due to well established EU innovation programmes and structures.

Even though cybersecurity is a critical element to successful and safe AV deployments, the evidence of countries' efforts on developing these capabilities is limited. The scale and competencies vary due to countries' inherent expertise and the emphasis placed by the governments with the UK, China and Israel demonstrating strong competencies in this priority area.

Region/country	CAM Application focus
France	France is placing a strong focus on inclusive transport solutions via shuttles, especially, in rural areas. CAM services and products are explored as complimentary solutions to existing transport modes.
Germany	Germany's development activity is quite balanced across public transport solutions via shuttles and buses and personal mobility via CAVs and automated taxis. While freight and logistics is of great importance, the number of projects in this segment is still low.
Israel	Israel, due to limited geography and mounting congestion pressures, is moving towards automated public transport services via buses. While the overall focus is on the reduction of congestion and pollution, a number of leading companies are developing and trialling personal mobility vehicles in Israel. Automated fright and logistics is the next area of focus for the country.
Japan	Japan, due to an aging population and societal focus on inclusivity, is targeting mobility solutions for aging and rural populations via shuttles and buses. There is also an emergence of personal mobility and first mile solutions.

France and Germany operate in a dynamic cross-border collaboration environment due to well established EU innovation programmes and structures.

USA and China, are boasting high levels of start-up activity, driven by the industry, with the presence of major tech giants.

3.2.2 Public funding

Israel is the only country to have a clear focus on loan-funding for high risk/high potential projects where the private sector was unlikely to participate [23]. While most of the countries allocate CAM innovation funding through a range of programmes, it is difficult to define accurate cumulative amounts dedicated to the sector.

It is worth noting that French and German companies are eligible for a range of EU funding programmes which were out of scope for this report. Interestingly, Israel and Japan are active, successful, participants in Horizon Europe, the European Union's scientific research initiative, of which [24], the UK is still associated.

Only the UK [25], Canada [26], Israel (23) and Japan [27] are taking proactive steps in accelerating the start-up ecosystem via specific accelerator or incubator activity. Japan is starting to complement its strong support for the well-established automotive players with support towards the start-ups to energise the innovation culture in the country.

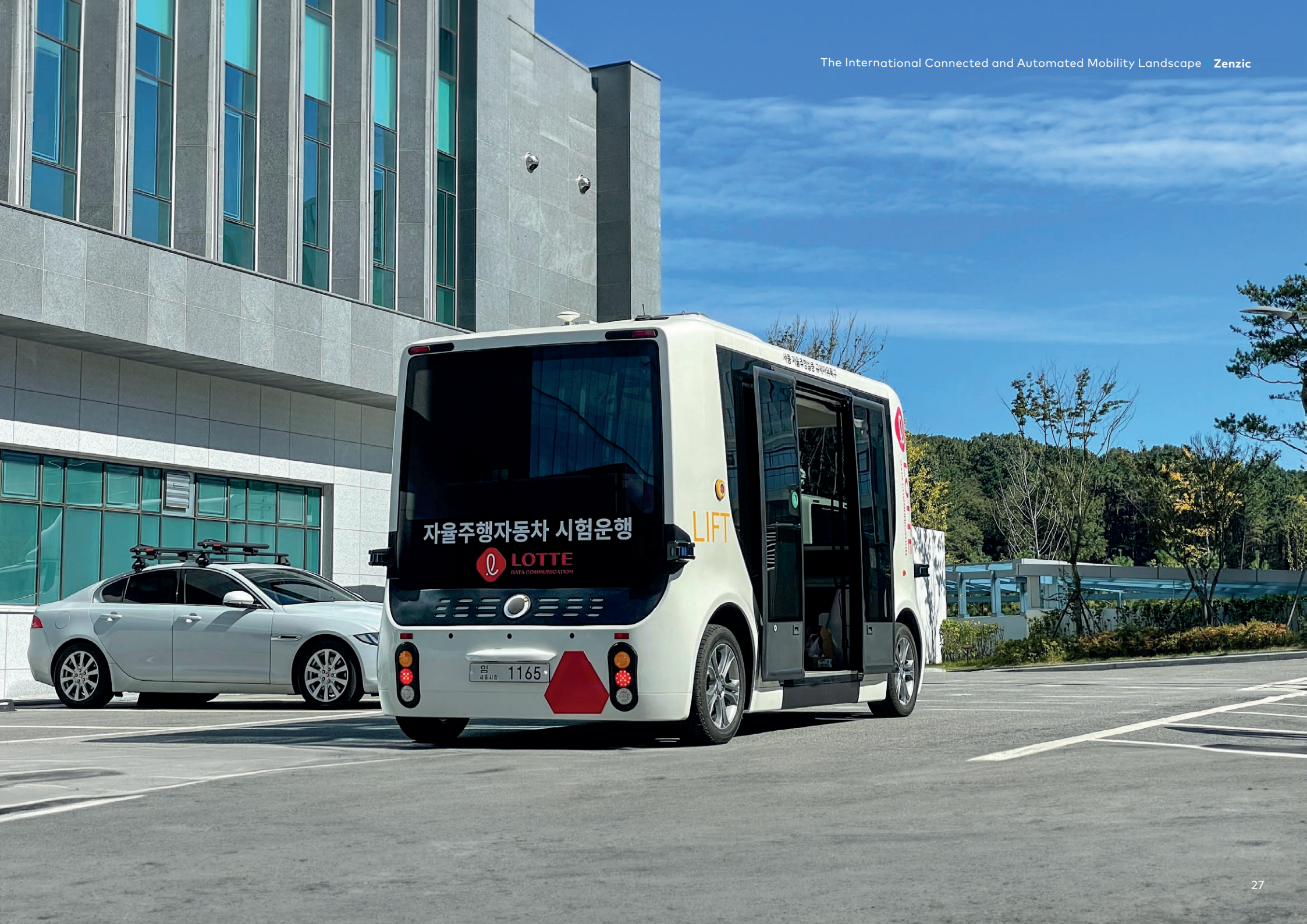
US and China, are boasting high levels of start-up activity, driven by the industry, with the presence of major tech giants, automotive companies, the size of the market and an overall entrepreneurial culture.

Interestingly, Germany has not been intentional in facilitating start-up activity, through publicly funded programmes. This gap is partially filled by the incubator programmes run by the OEMs and Tier 1 suppliers.

3.2.3 Private investment

The UK, US, China, Israel and Japan demonstrated healthy VC activities. Although VC ecosystem and overall culture was especially strong in the US and Israel, there has been a clear pause in investments in 2022. 2021 was an exceptional year for the global technology sector and benefited Israel and the US companies with an unprecedented $27bn and $113bn respectively invested in tech companies. In 2022, investment volumes nearly halved to $15.5bn and $67bn in Israel and the US respectively [28]. This is likely to be correlated with a post-pandemic effect, concerns regarding a global recession, socio-political factors and, most importantly, investors' drive for return on investment and the need to reassess asset allocation in CAM. Hence, there has been a clear emerging focus on specific closest-to-market use cases such as automated freight and logistics, offroad and geofenced area operations as EV technologies taking the centre stage short term.

All countries, despite the size of local automotive sectors, have witnessed strong industry investment into CAM capability development. Israel is notable for receiving high level of private investments into CAM research and development capabilities despite the lack manufacturing capabilities in the country. Frontrunners are emerging and strategic industry partnerships for CAM capability development are being formed. Leading automotive OEMs and suppliers, and newly emerging leaders in CAM are also solidifying their positions either through acquisitions (e.g. Bosch acquiring Five) or solid investments into emerging frontrunners (e.g. ZF's investment into Oxa).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3.3 Testing capabilities and trials

The UK's position

UK has a very strong proposition for public and controlled physical testing, validation, assurance and digital testing capabilities. Its public testing environment testbeds are world class, and many of the countries in scope are increasing their public testing capabilities and enabling overall access to testing on public roads. There is an opportunity for the UK to take the lead in self-driving testing in public environments, as projected deployment timescales crystalise.

3.3.1 Testing capabilities

The UK presents a well-coordinated and resourced controlled testing environment in CAM Testbed UK [29]. Its testing environment testbeds are world class. Most of the countries in scope are increasing their public testing capabilities and enabling overall access to testing on public roads. The US, China, and Germany are providing testing access to the streets of their major cities including; San Francisco, Beijing, Shanghai, Munich, Berlin.

While a number of the US states offer controlled testing capabilities, testing activity is strongly shifting towards public spaces which may not necessarily take place in public environment testbeds.

Canada presents a well-balanced testing environment which is proportionate to the size and the needs of the market.

China boasts many various types of testbeds and enables real life testing on public roads in some of its major cities.

Germany has been building its public testing capabilities since 2015 and offers a range of controlled and public testing options in urban, interurban, and rural settings. Germany also offers a specific port operations testbed. The country is home to many private controlled environments owned by the leading OEMs and Tier 1 suppliers. Key German automotive players are also active users of public testing environments which as a result is potentially restricting access for start-ups and SMEs.

Although France, Israel and Japan host controlled and public testing environments, the scale, and capabilities, specifically in Israel, are limited.

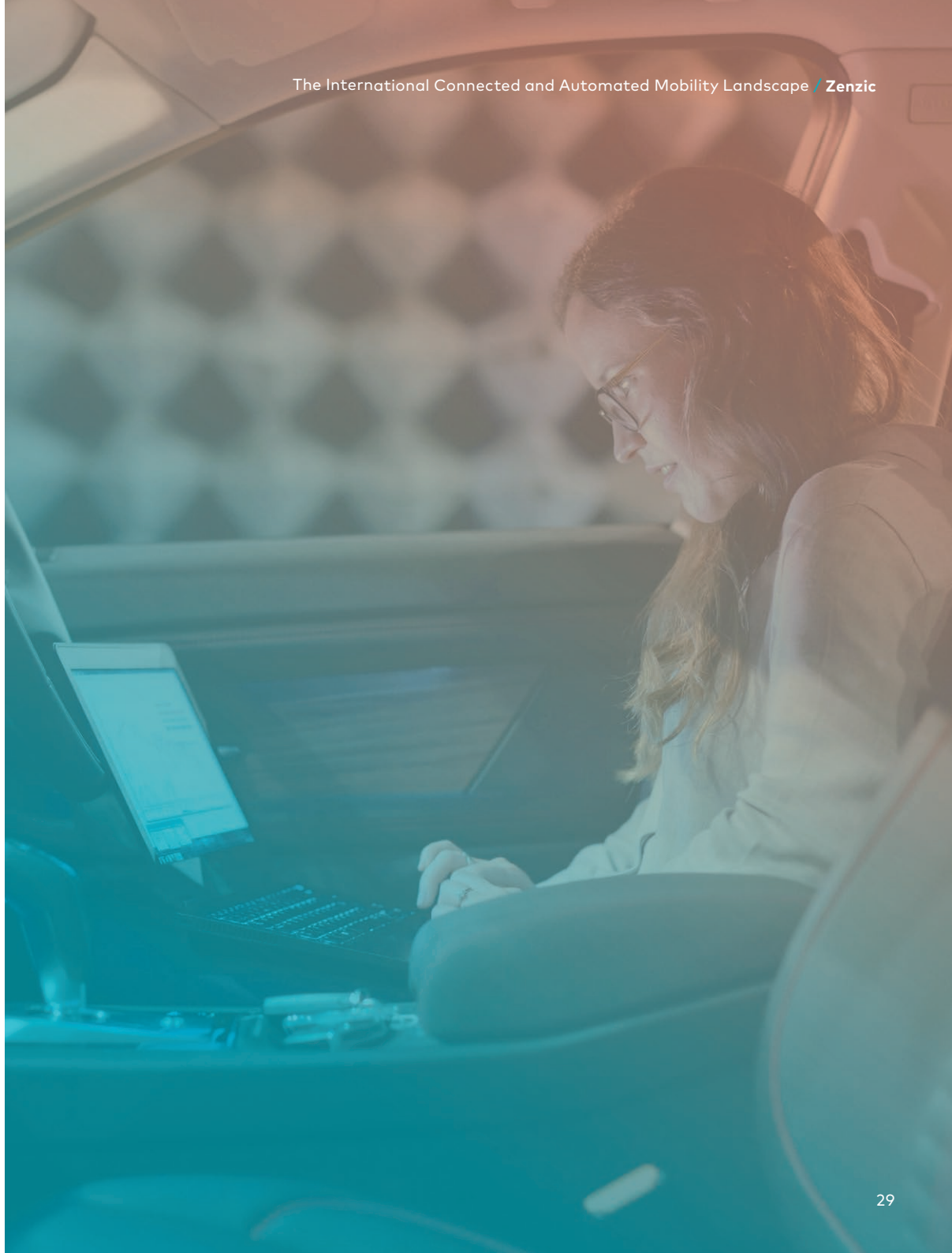
Digital twin capabilities are available in the UK, Canada, Germany, Israel and Japan.

Virtual validation is widely available across the testing ecosystem in all countries except Israel. Data exchange is facilitated in most of the countries except the US. In Germany, data exchange platforms are being rolled out.

Testbed interoperability and national coordination is strongly represented in the UK, and in place in Canada and Israel. This may be correlated with the size of the market and the governments' overall strategy for CAM development. Germany opted for partial regional coordination while China and France did not prioritise this type of approach. There is no compelling evidence indicating a coordinated testing facilities approach in the US and Japan.

UK and Israel are among the leading countries for cybersecurity testing. Israel was the first country in the world to open a specialised AV cybersecurity testing facility in 2021 [30]. Canada [19] and China [31] are evidently prioritising investing in their cybersecurity testing capabilities, France is following suit while a position on the overall cybersecurity testing in the US and Germany was unclear.

Digital twin capabilities are available in the UK, Canada, Germany, Israel and Japan. Texas A&M University was awarded $1.2m in June 2022 for a US digital-twin enabled testbed [32]. While China has very strong digital capabilities there was no clear indication of digital twins. No capabilities were identified in France.



3.3.2 Public road tests and trials with a safety driver

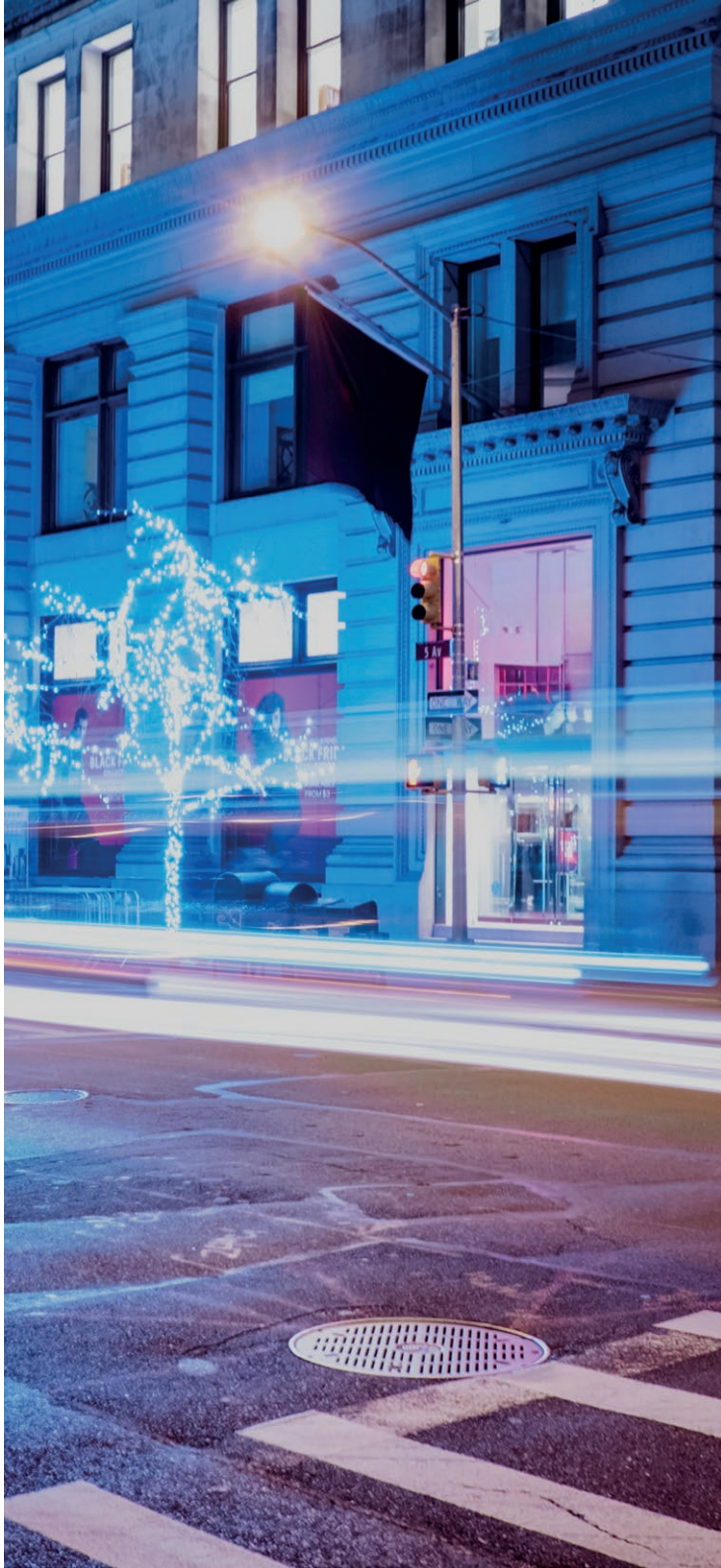
While all countries represented a well-balanced mix of trials with a safety driver, the emphasis on specific trials depended on several factors such as cultural preferences, demographics and a country's view on what CAM can deliver for its society.

All countries host a range of shuttle and bus trials. The US, Germany, Israel, and especially France and Japan, have a clear preference towards automated public transportation to ease road congestion and aim to serve more vulnerable members of a society.

Although automated freight and logistics is a priority area for all countries in scope and a range of trials in first, middle and last mile logistics are taking place, the scale and number of projects across all markets is still low given a growing consensus that this segment holds the highest potential for ROI and is a gateway for wider CAM adoption long term. A similar case has been observed with offroad trials which were evidenced in the UK, USA, Canada, and China while the picture was unclear in the rest of the countries.

All countries except the UK and Canada hosted public road personal AV and AV taxi trials with a safety driver in the vehicle. Their scale and deployment potential contrast greatly with the USA and China, however, who are taking the lead in this area.

> *The emphasis on specific trials depended on several factors such as cultural preferences, demographics and a country's view on what CAM can deliver for its society.*



3.3.3 Public road tests and trials without a safety driver

Regulatory frameworks for the AV pilots without a safety driver on board for public roads either require a two-way communication with the control centre and/or need have a have a teleoperation function in place.

Only the US is moving forward at pace in public self-driving testing areas, except for off-road where gathered information was inconclusive. In public testing with the driver, shuttles and busses are the leading categories where most of the countries are already running trials or about to start them, specifically, in Germany, Israel and UK.

Despite a strong interest in last mile logistics, only the USA and Canada are running self-driving trials. As the UK, France and Japan are running last mile trials with a driver in place, it is anticipated that self-driving trials will follow soon. Israel has also confirmed that their next focus area is automated freight and logistics, but it is unknown how soon self-driving trials will begin.

A similar pattern can be observed in the offroad segment. As the UK, USA, Canada, and China are running trials with the driver in place, and therefore a clear assumption is that these trials will enter the driverless testing stage within due course.

When it comes to self-driving testing of personal AVs and AV taxis, US and China are clear frontrunners. At this stage it is still unclear when self-driving public trials will take place in Germany and Israel despite the enabling regulation in place. There are indications that safety regulations in Europe are one of the main obstacles to overcome before necessary permits are granted. In Israel, applications for permits are yet to be submitted by the key developers in the market.

The presence of self-driving regulation is not the only prerequisite for enabling self-driving AV deployments in the market. Innovation and CAM environment, culture, demographics, infrastructure readiness, consumer acceptance and overall governments' position on CAM are vital areas which need to be enabled.

3.4 Deployments

The UK's position

Passenger shuttles is the leading area for all countries in scope. The US and China have the widest range of deployments (US: freight and logistics, personal AVs and AV taxis; China: freight and logistics, and AV taxis) and companies in the rest of the countries are just gearing up for this stage.

As deployments around the globe are picking up slowly, there is time for the UK to maintain its strong position by focussing on regulations and other deployment enabling factors such as consumer acceptance, road digitalisation and cybersecurity.

Given how tightly consumer acceptance is tied to safety, the current re-evaluation in CAM sector is an opportunity for the UK to implement the highest safety standards and ensure a successful roll out of CAM technologies long term.

Most of the countries are still some time away from wide scale deployments with the exception for buses and shuttles.

3.4.1 Deployments

As evidenced via the global testing activity overview, a deployment pipeline is being filled with a wide range of trials across markets.

The USA and China appear to be setting the pace not only for self-driving trials but also for commercial deployments; especially passenger shuttles, personal AVs and AV taxis, and middle and last mile logistics.

At the beginning of 2023, the UK announced seven commercial, automated passenger and freight deployment projects which should not only enable UK companies to test the technology with customers but also develop much needed business models [33]. The ongoing CAVPASS programme in the UK is expected to generate the required regulatory changes for these seven consortia to operate fully commercially from 2025 [16]. Focussing not only on the legislative changes required, but the processes and skills needed to assure and approve self-driving vehicles.

An emerging theme from the global deployment overview is that, despite current regulations, most of the countries are still some time away from wide scale deployments with the exception for buses and shuttles.

3.4.2 Communications, data, infrastructure and security

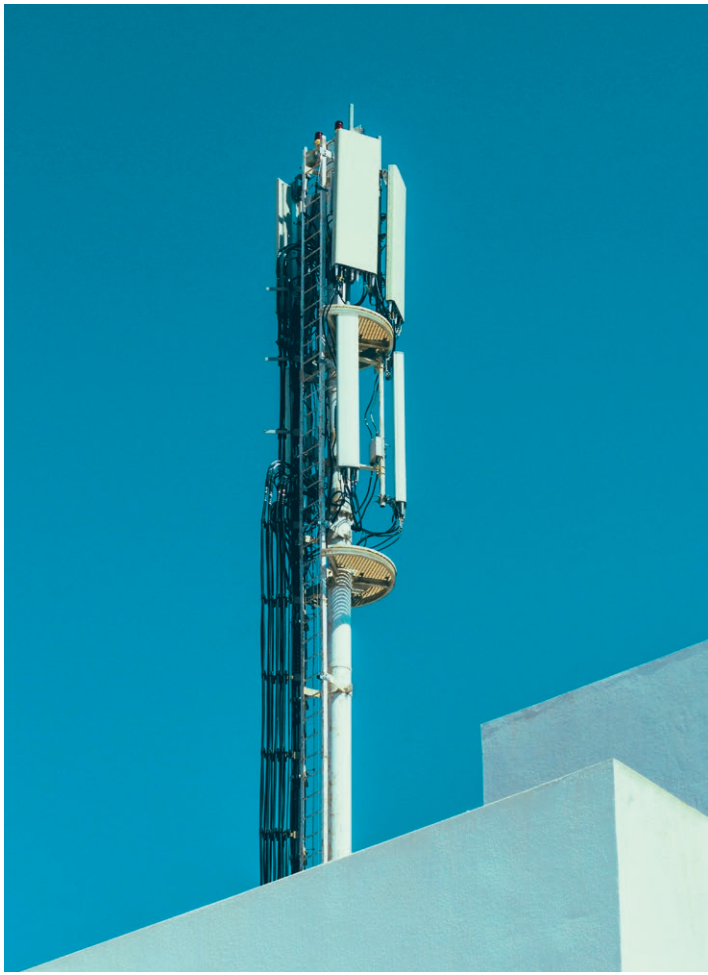
Infrastructure, especially 5G coverage, cybersecurity and digitalisation of the roads need to be factored into how effective CAM deployments are delivered. While connectivity – via 5G coverage – is one of the priorities for all countries in scope, comprehensive coverage across all geographies in all markets is still a few years away.

As shown in Section 3.3.1, when it comes to testing and trialling the UK and Israel are among the leading countries for cybersecurity with Canada, China and France evidently prioritising investing in their cybersecurity testing capabilities. Although cybersecurity has been and is becoming an area of definite priority, it is difficult to verify countries' approach to commercial deployment cybersecurity measures. This could be because CAM technology is still being tested and precise infrastructure cybersecurity requirements are still being developed before wide scale commercial deployments take place. Approaches to cybersecurity for testing and trials is outlined in Section 3.3.1

Road digitalisation information varies but it is evident that Japan [34] and China [35] are particularly strong in HD mapping capabilities. In Germany, to get a clearer view of digital road infrastructure readiness levels it is worth considering the vast range of fully equipped testbeds and the 13,191km of motorway (out of a total length of 625,000km) approved for conditionally automated driving [36].

Major infrastructure projects in the US may offer CAM enabling capabilities, which contrasts to Israel, who have deployed less CAM specific road infrastructure. Interestingly, because of the fragmented nature of the available infrastructure across states, US companies are developing AV technology that does not necessarily rely on infrastructure support and rely on their own perception capabilities. Organisations such as Cavnue in Michigan [37], however, are designing the physical, digital, coordination and operational infrastructure to realise the full potential of AVs.

The Ontario Goods Road Association in Canada have mapped a test corridor that identified the roads preferred for testing AVs, providing critical road-data to support CAVs in Ontario. In March 2023, the UK DfT published their Transport Data Strategy [38] where many CAM related aspects were mentioned such as the future desire to capture and publish sensor data as well as the importance of prioritising security of such data.



3.4.3 Consumer acceptance

An important consideration for the CAM sector is that of consumer acceptance. Although consumer acceptance data across all markets in scope is not available, data coming from the US and Germany illustrates consumer acceptance levels for Western countries which is just above 30% as shown in Figure 3.1. Interestingly, this number is just at 25% in Japan while China is above 50% [39]. In 2019 the UK Government commissioned a study into public acceptability of connected and self-driving vehicles. The study concluded that their outlook towards CAM technology is positive but many questions and concerns remain [39].

Such a wide acceptance variation may be related to consumers having varied levels of opportunity to experience AVs, different cultural approaches across countries and, very importantly, different demographics for each survey. More than a half of Gen Y/Z (18-41 years) are the keenest early adopters of self-driving technologies in a study that look at respondents from USA, China, Germany, Japan and Brazil, see Figure 3.2 [39].

Despite low consumer acceptance numbers, no evidence of clear consumer engagement strategies were found from most countries within scope. Partners for Automated Vehicle Education Canada (PAVE Canada), through funding from Transport Canada, are leading on a public education campaign on AVs to raise public understanding of CAM. Europe has PAVE Europe, which the UK is a member of and is leading its own programme of engagement. As various markets are ramp up for wider self-driving CAM testing and deployment, more data on consumer perceptions should become available. Public and private sector access to this type of data is crucial for a successful CAM roll out long term.

> *As various markets are ramp up for wider self-driving CAM testing and deployment, more data on consumer perceptions should become available.*

Figure 3.1:
Consumer consideration of CAM by country [39]

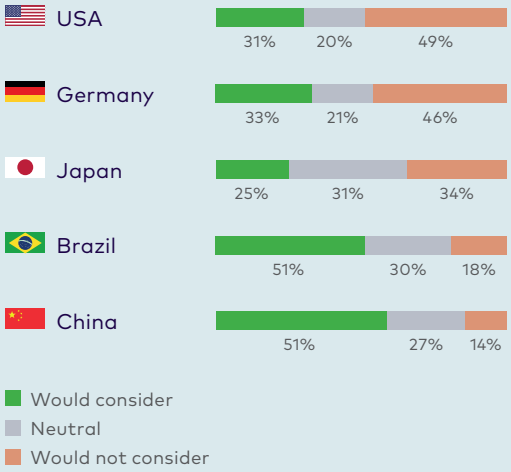
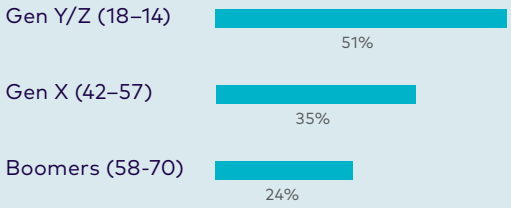


Figure 3.2:
Consumer consideration of CAM by generational group [39]

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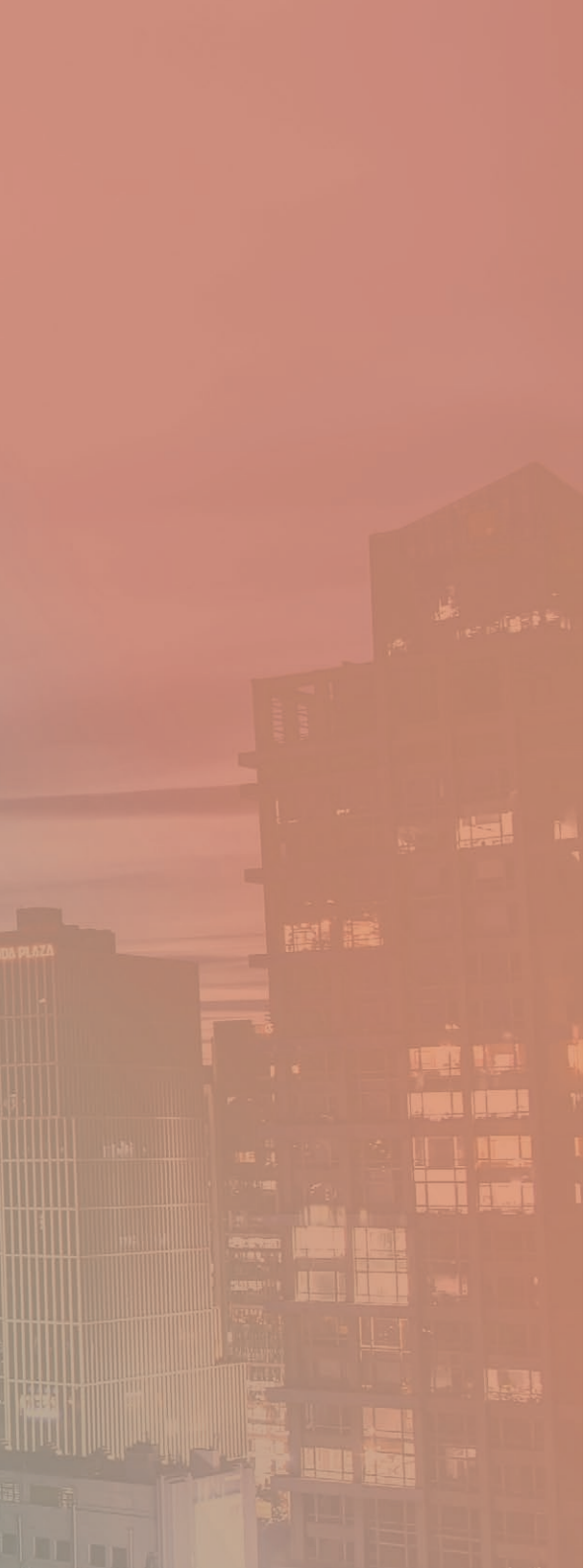

4.0 / Country overviews

Policy and Regulation

What local regulations exist?

Innovation environment

What innovation support is available?

Testing and trials

What are the key capabilities and trials?

Commercial deployment

What are the emerging services?

Country Dashboard

UK

UK is strong in innovation and testing. Collaboration is at the heart of the UK CAM sector with a great example in the coordinated CAM Testbed UK. The UK has specific CAM roadmap to 2035. In 2023, 7 commercial deployment consortia were announced with the focus on passenger and freight services.

Timeline

2018	The Automated and Electrics Vehicles Act (AEVA). Act defines what is considered self-driving
2019	First UK CAM Roadmap published by Zenzic
2019	The Government launched a programme of work called Connected and Automated Vehicles: Process for Assuring Safety and Security (CAVPASS)
2022	Publication of a Law Commissions report containing 75 recommendations to Government
2025	AV approval scheme and self-driving vehicle framework expected to be in place (CAVPASS).

Policy and Regulation

What local regulations exist?

UK is well positioned due to its coordinated approach to CAM development and a clear roadmap for the sector development.

Priorities

- CR&D
- Passenger vehicle and freight and logistics solutions
- Regulatory development

Strategy direction

- UK CAM ROADMAP to 2035 in place (2023)

Regulations enable

- Self-driving pilots with a safety driver
- Liability and cybersecurity requirements

Innovation environment

What innovation support is available?

UK has a strong innovation environment, focusing on collaboration. Recent attention has focused on commercialisation.

Public funding

- CCAV has channelled £440m of public and private investment in the CAM sector
- £476m and 1,465 new jobs have been generated in the UK CAM sector between 2018 and 2022

Private investment

- 2023 – Oxa £115m of Series C
- 2022 – Wayve – US$200m Series B funding

Testing and trials

What are the key capabilities and trials?

Worldclass, coordinated testing facilities. Real world testbeds and trials (with a safety driver).

Testing capabilities

- Interoperable CAM Testbed UK.
- Controlled environments
- Public environments
- Simulation and virtual validation
- Cyber security

▲ Five core testing facilities

● Seven commercial self-driving passenger and freight deployments

Commercial deployment

What are the emerging services?

Seven deployment consortia announced in 2023 with a focus in passenger and freight services. The UK has strong supporting digital infrastructure and cybersecurity strengths.

Additional

Supporting factors

- 96% 4G mobile coverage on UK roads
- 2nd Ranked in the International Telecommunication Union's Global Cyber Security
- £8.9bn UK Cybersecurity sector value (2021)

Country Dashboard

China

Robust capabilities in all areas are great enabler for Chinese providers to advance in foreign markets. Cultural familiarity with integrated high-tech services and high number of consumer first-hand experiences with CAM through the large number of ride-hailing AV fleets is laying strong foundation for uptake in CAM services once widely available.

Timeline

- Innovative Development Strategy – 2018
- National Road-Testing Guidelines (2018)
- Directive on the commercial use of AVs in public transport (2022)
- 'The Big Three Data Laws':
  - Cybersecurity Law, 2016
  - Data Security Law, 2021
  - Personal Information Protection Law, 2021.
- Road Traffic Safety Law (Draft Revision) (open until 2023)
- New set of AV standards (upcoming)

Policy and Regulation

What local regulations exist?

Regionally led regulation with some harmonization taking place. Very strong data and cybersecurity regulations that can be hard to navigate to newcomers in any technology market in China.

Priorities

- CAM aimed as a high-end luxury, personal mobility product
- Industry led initiative for the upbringing of the market and new technologies
- Ecosystem dominated by domestic ICT giants (Baidu, Alibaba and Tencent - BAT), automotive manufacturing leaders, and few unicorn start-ups

Strategy direction

- Intelligent Connected Vehicle (CAM) Technology Roadmap 2.0 to 2030 (2020)

Regulations enable

- Some regional frameworks enable comercial deployment
- Self-driving pilots with or without a safety driver
- Liability and cybersecurity requirements
- Some CAM specific type approvals

Innovation environment

What innovation support is available?

Innovation hubs are positioned strategically to facilitate and tap into its strong academic resources. That in combination with massive VC presence and BAT ecosystems allows for great innovation capabilities across all fields of tech.

Public funding

- 'Chinese Guidance funds' – set up and managed on a national and regional level aimed at earlier stage ventures
- £1.20bn each (and above for national level ones)
- Open to all areas of innovation

Private investment

- VC available to all areas of technology innovation for anything between early-stage to mature ventures
- $8.5bn into the AV taxis and automated trucks, LiDAR, and NEVs in 2021
- Technology investment focus in AI and ICT

Testing and trials

What are the key capabilities and trials?

Due to early public road testing legislation, Chinese CAM products have the maturity of technology to rapidly deploy with and without a safety driver.

Testing capabilities

- 17 national-level public testing and demonstration zones
- Testing standards and requirements provided on city and provincial administration level
- Leaders in public road test and trials with and without safety driver include: Baidu, Poni.ai, WeRide.ai, DiDi Group, Auto X and others

▲ CAM pilot zones for testing, demonstration and deployments

Commercial deployment

What are the emerging services?

Development of personal mobility vehicles is becoming an increasing priority (AV taxis) for both OEM and technology companies.

Additional

Supporting factors

- High acceptance rate, 51% would consider using CAM products vs 31% in the USA
- Internet of Vehicles (IoV) is emerging as a sub-sector due to the development of CAM services and strong push for seamless integration of technologies across sectors

Country Dashboard

France

High level of social orientation embedded in the study of possibilities CAM offers and which ones would be needed most from the public. The challenges of reduced rural demographic are met by government's implementation strategy. Innovation in CAM development is primarily coming from newcomers to the market as opposed to traditionally strong OEMs possibly due to lack of alignment in priority between government focus in tech and industry interest.

Timeline

2019	Mobility Orientation Law – Articles 31 and 32
2018	The French strategy for the development of automated road mobility – V1
2020	The French strategy for the development of automated road mobility – V2
2021	Decree n° 2021-873 on automated vehicles' conditions of use and automated road transport systems' commissioning
2021	UN Regulation for Automated Lane Keeping Systems (UNECE 157)
2022	EU Regulation 2022/1426 for the Type-Approval of the ADS for fully AVs
2022	UN Cybersecurity Regulation (UNECE 155)

Policy and Regulation

What local regulations exist?

The challenges of reduced rural demographic are met by government's implementation strategy for CAM. Unfavorable regulation to off-highway and freight and logistics is limiting activities in the use case scenarios.

Priorities

- CAM services and products focused on mass passenger mobility applications (especially in mixed mode and rural transportation scenarios/use-cases)
- Industry led forth by service operators such as Transdev and new platform providers (ex. Navya and EasyMile)

Strategy direction

- Whilst no formal roadmap exists, there exists the French strategy for the development of automated road mobility

Regulations enable

- Limited regulation for pilots without a safety driver; unclear view on future regulation
- Liability considerations in place

Innovation environment

What innovation support is available?

Innovation in CAM development is primarily coming from newcomers to the market opposed to traditionally strong OEMs – Prioritising the passenger mobility business case.

Public funding

- Investments for the Future Program (PIA) round 4 and 'France Relance Plan' France 2030
- Cumulative – E50bn
- Future of transport segment – E4bn
- The primary purpose of the programme is to fund innovative investments and optimise growth potential for the overall French industry

Testing and trials

What are the key capabilities and trials?

Limited number testbeds are complimented with early adoption of public road testing. Public road trials are primarily led by potential service operators as opposed to OEMs or software providers.

Testing capabilities

- 3 controlled testing fascilities – UTAC and Transpollistestbeds
- Public road test and trials with safety driver – focus on mass passenger mobility
- Trials without safety driver – very limited

▲ Testing/advanced trialling locations

Commercial deployment

What are the emerging services?

Low level of deployments due to enabling regulation being recent (2021) and limited to passenger applications. Freight and logistics development and operation is where strong industry interest needs to be evidenced as a key driving factor for potential future emergence of services.

Additional

Supporting factors

- As of 2022 only a single deployment has been confirmed
- Heavy focus and investment in connectivity development (5G Open roads & EU Horizon projects)
- 5G coverage: 87% of population by leading Free Mobile operator

Country Dashboard

Germany

No single agency leading on CAM but there is a strong coordination among multiple ministries on AV R&D, testing and deployment. Despite of testing and commercial deployments regulations in place, only a few shuttle operations are currently deployed. There is a rapidly growing number of public road-testing environments that provide only a limited access to these capabilities for the SMEs and start-ups.

Timeline

2017	Germany Autonomous Driving Law
2020	Intelligent Transport Systems Act
2012	Data Strategy; 'Mobility' Space Data
2021	The Law on Autonomous Driving enabling L4 vehicle testing and deployment defined public environments
2021	UN Regulation for Automated Lane Keeping Systems (UNECE 157)
2022	AV Regulations supplementing The Law on Autonomous Driving (AFGBV)
2022	EU Regulation 2022/1426 for the Type-Approval of the ADS for fully AVs
2022	UN Cybersecurity Regulation (UNECE 155)

Policy and Regulation

What local regulations exist?

No single agency leading on CAM but there is a strong coordination among multiple ministries. Regulation in place for testing and commercial deployments without a safety driver. Regulatory framework complimented by international legislation with Germany an active EU and UN participant.

Priorities

- Transforming the domestic automotive sector to be leader in CAM and smart mobility.
- Focus in R&D, testing and deployment

Strategy direction

- 'Research for Autonomous Driving' action plan (2019)
- Part of Digital Strategy (2022) (covers up to 2025)

Regulations enable

- Regulation for pilots without a safety driver and limited future regulation.
- Liability considerations in place
- Strong position on data and cybersecurity
- Small scale CAM type approvals in place

Innovation environment

What innovation support is available?

High levels of public funding, plus, access to the EU funding streams. Despite a strong automotive OEM and Tier 1 presence, the country's start-up and VC activity is low.

Public funding

- 'Investments in the future in the vehicle industry' (2021-2024) – €1.5bn
- Future Fund for the Automotive – €1bn
- The start-up innovation activity focuses on less complex capabilities such as hardware and connectivity, rather than deep tech and AI

Private investment

- Unclear but is indicated to be rather low.
- Overall public accelerator/incubator support is not readily available to German start-ups. In addition, the number of VCs focusing on automated driving is indicated to be low

Testing and trials

What are the key capabilities and trials?

High numbers and a strong mix of controlled and public testing capabilities, including a range of privately (OEMs and Tier1s) owned testbeds. Interstate coordination on testing capabilities but access for SMEs difficult.

Testing capabilities

- 26 testbeds and 142 projects identified
- Some regional level coordination of testbeds
- Focus on developing digital test beds for CAM applications in real-time regional, urban and highway scenarios

▲ Testing/advanced trialling locations

Commercial deployment

What are the emerging services?

Despite commercial deployment regulations in place, only a few shuttle operations are currently deployed. Digitalization of the roads and cybersecurity measures are yet to be enforced.

Additional

Supporting factors

- 13,191km of motorway (out of 625,000km) approved for conditionally automated driving
- Just 30% of consumers willing to consider fully AVs
- 99% – Expected 5G coverage of Germany population by 2025

Country Dashboard

Japan

Driven by societal needs and climate resilience, high priority is given to liaising academia and industry paving the way to creating and maintaining highly skilled working population for the sector. The government is leading the direction of the sector through a practical approach to CAM that shows very heavy long-term outlook. To understand and create the needed regulation the government is running its own trials to shape their legislative approach. Incidents during trials seem to have set back key OEMs' CAM ambitions and are shifting the focus to implementation of services in enclosed areas such as airports and smart cities.

Timeline

2018	Regulatory sandbox approach
2016	'Guidelines for Public Road Testing of Automated Driving Services'
2020	'Criteria for Granting Permission for Road Use in Demonstration Tests of Automated Driving on Public Roads'
2022	Revision of the Road Transport Vehicle Law and Road Traffic Act (2019-2022) – commercial SAE level 4

Policy and Regulation

What local regulations exist?

The government is leading the direction of the sector through a practical approach to CAM that shows very heavy long-term outlook and dedication to learning from past events.

Priorities

- Strong focus on developing digital capabilities in the field of 3D mapping and V2X technology.
- Heavy emphasis on infrastructure connectivity testing and development (V2I and V2X)

Strategy direction

- Public-Private Intelligent Transport Systems (ITS) Initiative/Roadmaps – regularly updated, last version from 2020

Regulations enable

- Regulation for pilots with and without a safety driver and commercial deployments
- Liability considerations in place
- Cybersecurity consideration bounded by cultural approach

Innovation environment

What innovation support is available?

High priority is given to liaising academia and industry. Japan is looking to boost its startup ecosystem and become perceived as one of the hubs for innovation vs traditional automotive manufacturing.

Public funding

- No CAM specific funding identified – public funding streams identified target collaboration with academia and skills development not R&D

Private investment

- £2bn VC investment in 2021
- Japanese leading OEMs aim to outsource innovative and digital technology products through investment and acquisition of promising ventures domestically and abroad

Testing and trials

What are the key capabilities and trials?

Limited controlled environment testing capabilities are countered through early adoption of public road testing. To create educated legislation for both industry and the public Japanese trials are incorporating a lot of public acceptance and business models aspects in their studies.

Testing capabilities

- Only two controlled environment testbeds – the Japanese Automobile Research Institute sites – Shirosato and J-town
- Public road test and trials with safety driver – Mass passenger and MaaS implementation focus
- Trials without safety driver predominantely taking place through shuttle services in geofenced areas

▲ Testing/advanced trialling locations

Commercial deployment

What are the emerging services?

Strong focus on developing digital capabilities in the field of 3D mapping and V2X technology. Culturally different approach to cybersecurity with lack of deployments happening in the area but evaluated as a requirement for CAM technology. Deployment of CAM is happening simultaneously through smart city initiatives.

Additional

Supporting factors

- Even though high level consumer acceptance levels are indicated to be rather low -25%, detailed breakdowns across age brackets, rural vs. urban population and use case acceptance indicate high levels of uniformity.
- 40% of the population has access to 5G services (2021)

Country Dashboard

Israel

Despite the lack of traditional automotive industry, the country has a very vibrant innovation environment and is home to hundreds of mobility start-ups attracting high levels of private funding. Israel's inherent capabilities in defence, cyber and tech provided a solid foundation for the sector development. Multiple global OEMs and Tier 1s have presence in Israel. Many Israeli companies choose to test in the US or Germany due to the lack of required testing infrastructure. Although the recent legislation enables commercial deployments, formal applications and deployments are yet to happen.

Timeline

2017	National Plan for Smart Mobility
2022	Traffic Ordinance Ammendment Bill
2022	Procedure Instruction No.AV- 02-2022; Procedural Order – Cyber Security for AV – outlines the requirements to deploy AVs on public roads without a safety driver

Policy and Regulation

What local regulations exist?

The Ministry for Transport leads on CAM development and deployment in the country. Despite the lack of a country CAM Roadmap, the National Plan for Smart Mobility serves as a base for the sector.

Priorities

- Strong cyber security capabilities due to defence culture
- The government focuses on agile innovation and focused on high risk and high potential projects.

Strategy direction

- No national roadmap

Regulations enable

- Regulation for pilots with and without a safety driver and commercial deployments
- Liability considerations in place
- Strong position on data and cybersecurity requirements
- Enabling innovation environment

Innovation environment

What innovation support is available?

A very vibrant innovation environment and home to hundreds of mobility start-ups attracting high levels of private funding. Israel's inherent capabilities in defence, cyber and tech provided a solid foundation for the sector development. Multiple global OEMs and Tier 1s have presence in Israel.

Public funding

- Offered by The Israeli Innovation Authority (IIA)
- Overall, the Government of Israel invests approximately 40million USD into smart mobility projects per year; access to Horizon Europe.
- The IAA is taking a 'bottom up' approach by backing early-stage innovation and providing wider support to hundreds of projects annually via a range of its programmes.

Private investment

- 2007-2021 more than $25bn invested in smart mobility
- 2022 – $400 million in smart mobility deals
- Cyber security, AV systems, connectivity and mobility services
- Mobility Services – Shared Mobility, Traffic Management, Road Safety

Testing and trials

What are the key capabilities and trials?

The first AV Cybersecurity testing facility, however, relatively limited CAM testing capabilities with the focus on smaller sites and utilising existing infrastructure. Many Israeli companies choose to test in the USA or Germany due to the lack of required testing infrastructure.

Testing capabilities

- Israel Smart Transportation Centre
- Automotive Cyber Test Centre
- The Drone Test Site via the National Drone Initiative supporting urban and mobility areas
- Also utilises various areas that are readily available (parking lots, warehouses, public roads) and existing military testing facilities
- Public road test and trials with and without a safety driver focused on MaaS and public-transit solutions

▲ Testing locations

Commercial deployment

What are the emerging services?

Indicated low deployment infrastructure readiness level (connectivity and the roads). Although the recent legislation enables tests and commercial deployments these are yet to happen. A two-year multi partner autonomous bus testing and deployment project was announced in 2022. It is part of the regulatory sandbox framework with freight and logistics projects anticipated to come next.

Additional

Supporting factors

- Israel is ranked 32nd in the world with a median broadband bit rate of 90.42 MB per second, according to Ookla (2022)
- As of December 2022, approximately 70 AVs were operated by various companies under the previously issued permits requiring a safety driver in the vehicle

Country Dashboard

Canada

There is great public investment into the research and development of AV technology in Canada. There is clear harmonisation, collaboration and coordination between government, industry, and academia to drive innovation and in established innovation hubs and clusters. Responsible agencies are extremely dedicated to ensuring vehicle system safety and uses an 'in-house' driving simulator to study driver interactions with AV technology in a safe and controlled environment. There is a significant amount of support in provinces such as Ontario for the development of CAVs, however, only one commersial deployment has been identified in the freight and logistics field.

Timeline

2018	Motor Vehicle Safety Act (MVSA)
2018	Strengthening Motor Vehicles Safety for Canadians Act
2021	Guidelines for Testing Automated Driving Systems in Canada Version 2.0

Policy and Regulation

What local regulations exist?

Co-ordinated approach across levels of government. Safety conscious and limited operation without a safety driver.

Priorities

- Cybersecurity and resilience
- R&D is a focus for Canada, shaping of the entire country to be a technology/innovation hub
- Enhancing talent and supporting the labour force is a top priority for the Canadian government to further economic growth

Strategy direction

- No national roadmap however there is a Talent and Strategy Roadmap for Ontario

Regulations enable

- Regulation for pilots with a safety driver only; unclear view on future regulation
- Liability considerations and small scale CAM specific type approvals in place
- Strong position on safety, data and cybersecurity requirements

Innovation environment

What innovation support is available?

Strong overall R&D focus. Innovation hubs are primarily supported by global investments rather than domestic businesses and there is a focus on talent and skills.

Public funding

- Strategic Innovation Fund (SF): Program to Advance Connectivity and Automation for transportation-Can$2.9m (2017-2021); ENCQOR 5G – Can$200m; Can$40m in Blackberry QNX safety project
- Ontario Vehicle Innovation Network (OVIN) – Can$141m to date for regional automotive innovation R&D
- Federal Economic Development Agency for Southern Ontario – Can$5m regional auto innovation finding
- Natural Sciences and Engineering Research Council (NSERC) – Can$40.2m for university-based AV research
- Research focus on security, privacy, road infrastructure cybersecurity and talent development for road authorities

Private investment

- No flagged VC investment into sector

Testing and trials

What are the key capabilities and trials?

Good testing capabilities, the MVSA does allow for international organisations to import their vehicles to Canada for testing purposes.

Testing capabilities

- Eight research and testing facilities in Canada;
- Public road test and trials with safety driver focused on off-road, passenger and personal mobility, middle and last mile freight
- Single commercial automated vehicle service without a safety driver in freight and logistics

▲ Testing/advanced trialling locations

Commercial deployment

What are the emerging services?

Single commercial fully automated vehicle service delivering goods. Loblaw, Canada's food and pharmacy retailer, and Gatik announced Canada's first fully automated self-driving commercial deployment in October 2022. Gatik is a market leader in autonomous middle mile logistics and now operates Loblaw's PC Express service with a fleet of multi-temperature autonomous trucks. Before then, Loblaw and Gatik have transported automated deliveries with a safety driver with a 100% safety record.

Additional

Supporting factors

- A study by Deloitte (2018) cited that research estimated that two-thirds of vehicles in Canada have connectivity

Country Dashboard

USA

A unique vibrant ecosystem of automakers, suppliers, technology developers, start-ups and innovation institutions that all have a vested interest in driving CAM. The wide diversity of interest in use cases for testing is supported by robust testing facilities. The roles and responsibilities of regulating AVs vary between agencies both on a national and state level, with future fragmentation potentially impacting scalability. Country observations are based on leading US states for CAM development – Arizona, California, Florida, Michigan and Texas.

Timeline

Arizona	House Bill 2813 (2021)
California	Senate Bill 570 (2022)
Florida	House Bill 311 (2019) and House Bill 1289 (2021)
Michigan	Senate Bill 995 (2016)
Texas	Senate Bill 969 (2019) and Senate Bill 2205 (2021)

Policy and Regulation

What local regulations exist?

Individual US states (including Arizona, California, Florida, Michigan and Texas) have led the way in passeing regulation or executive orders to enable CAM testing and deployment – however nationwide and/or regional harmonisation remains a key challenge for rollout across all of the USA.

Priorities

- United States Department of Transportation (DOT) is leading the work in the federal regulation and has used its rulemaking authority
- Commercial deployment with a diversity of use cases
- Strong and vibrant innovation environment

Strategy direction

- No national road map – state-by-state led policy

Regulations enable

- Some state-led frameworks enable comercial deployment
- Self-driving pilots with or without a safety driver in states with approved legislation

Innovation environment

What innovation support is available?

Funding is primarily led by the private sector. Unique vibrant ecosystem of automakers, suppliers, technology developers, start-ups and innovation institutions that all have a vested interest in CAM.

Public funding

- Strengthening Mobility and Revolutionising Transportation (SMART) Grants Programme – $100m annually for fiscal years 2022–2026
- The Intelligent Transportation Systems Programme – grant of $250m

Private investment

- As of 2022, examples of key investments figures in start-ups in the AV space include:
  - Cruise – $8.5bn
  - Waymo – $5.5
  - Nuro.ai – $1bn
  - May Mobility – $194m

Testing and trials

What are the key capabilities and trials?

Strong testing capabilities and diversity of use cases for trials; Shuttles, cars, trucks on public roads, highways, private environments, supported by robust testing facilities.

Testing capabilities

- Very comprehensive spectrum of CAM testing capabilities. Facilities include American Center for Mobility, Mcity, Wisconsin AV Proving Grounds and SunTrax
- Public road test and trials with and without safety driver – Across a diverse set of use cases – Shuttles, cars, trucks on public roads, highways, private environments, supported by robust testing facilitie.

▲ Testing/advanced trialling locations

Real-world deployments

Commercial deployment

What are the emerging services?

There is a small number of commercial deployments spread across all major use cases but concentrated in 'sunshine states'. Infrastructure to support AVs presents itself as a challenge in the US. A focus is being placed on public engagement to build trust with the end user. Infrastructure to support AVs presents itself as a challenge in the US.

Additional

Supporting factors

- 48% of public said they would never get in a taxi or ride-sharing vehicle that was self-driving (2022)
- Focus is indicated to be placed on automation and not connectivity aspect of CAM technology

5.0 / What's next

The International CAM Landscape is ever evolving. As countries press on with their strategies to realise the opportunities presented by CAM technology, it is important to look beyond the UK borders, learn from our neighbours, and seize opportunities for productive international collaboration.

It's clear that all markets are pushing ahead with trials and working toward deploying operational services at scale. Governments around the globe are committing to deliver new regulation and the UK is well positioned to be influential. Building on its strengths in testing, assurance, software and services, the UK will become a key player in the global CAM supply chain.

Zenzic continues to build on the UK's understanding of its position within the overall CAM Landscape. If you'd like to contribute your thoughts to future iterations of this work, or if you'd like to talk to us more about the content, you can submit any comments or questions to the team through the survey below.

Click for survey

Why the UK? /

The work underpinning this iteration of the International CAM Landscape uncovered several key themes, providing an insight into the direction of travel for countries around the world, and the opportunities available to the UK to strengthen it's position in the overall market.

To broaden your understanding of the UK's current position, we recommend reading the UK CAM Roadmap to 2035 and the Zenzic report into the UK CAM supply chain, accessible using the button links below.

Supply chain report | Roadmap report

1. The UK is well positioned in the International CAM Landscape to be at the forefront of realising global commercialisation.
2. By being clear on its strengths and staying focused the UK is in a strong position to reap the potential socioeconomic benefits of CAM.
3. The deployment of CAM is a global race, the UK is moving at pace and building on this momentum is key
4. Looking beyond our own borders, there are immediate opportunities for international collaboration.
5. The evolution of CAM brings a disruptive industry of industries approach that is prompting exciting commercial partnerships.
6. Culture plays a large role in defining countries' development and deployment of CAM.
7. Countries are moving quickly to invest in opportunities closest to market, informed by their societal needs.

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