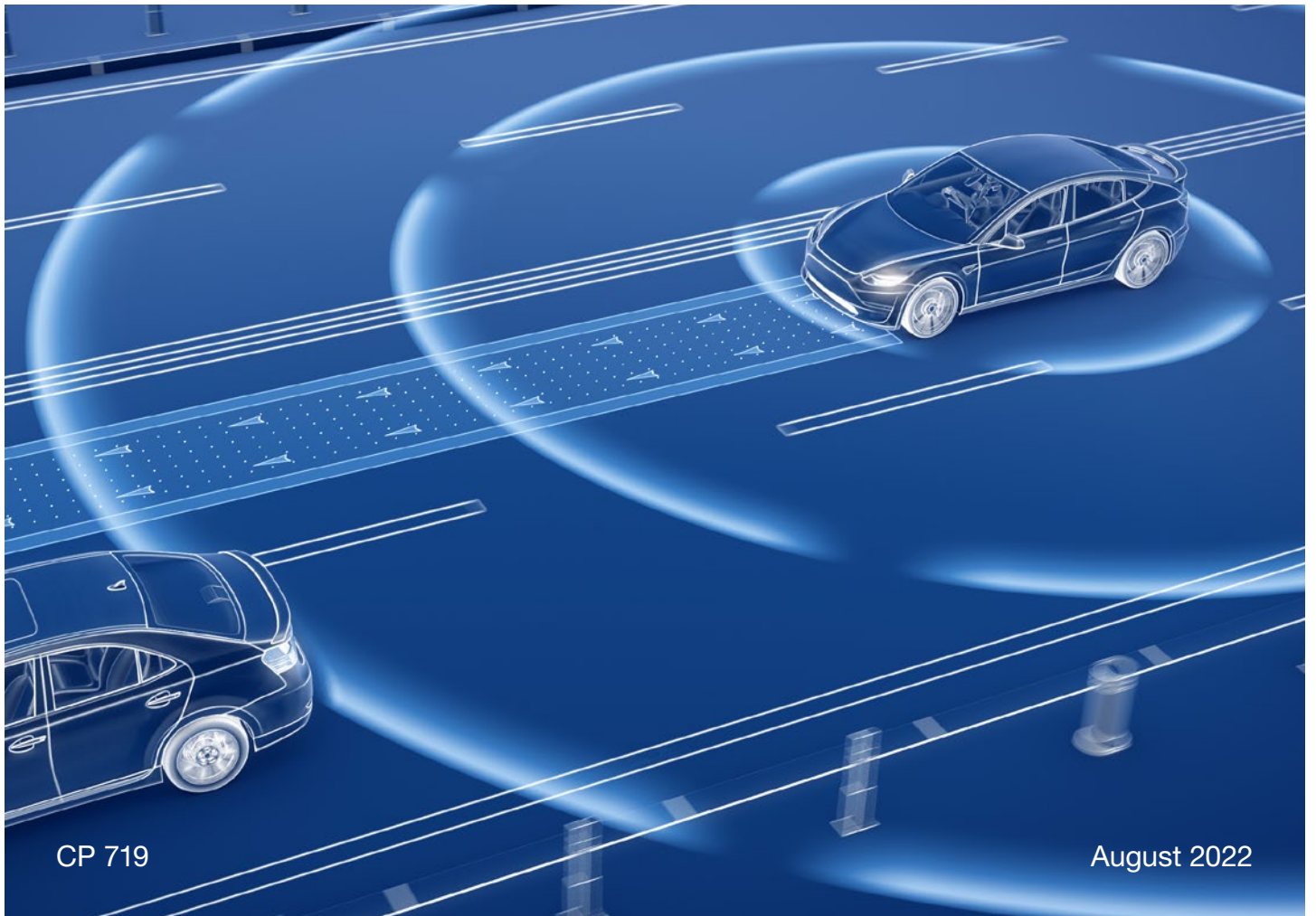




HM Government

# Connected & Automated Mobility 2025: Realising the benefits of self-driving vehicles in the UK







# **Connected & Automated Mobility 2025**

Presented to Parliament  
by the Secretary of State for Transport  
and the Secretary of State for Business,  
Energy and Industrial Strategy  
by Command of Her Majesty

August 2022



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# Foreword

Self-driving vehicles are fast approaching commercialisation in markets across the world. By 2035, 40% of new cars in the UK could have self-driving capabilities.<sup>1</sup> Grocery deliveries and passenger services look likely to be operating in self-driving vehicles within a similar timeframe.

This will be the future of road travel, but we are at the beginning of this journey, and human drivers will share the roads with self-driving vehicles for many years to come. It is therefore vital for us to manage the changes that connected and self-driving technologies will bring by introducing the right rules, training and support at the right time.

The potential benefits of connected and self-driving technologies are considerable: from better integrating rural communities and reducing isolation for people with disabilities or older people, to helping deliver essential goods and improving access to education, work and leisure. Intelligent vehicles will communicate not just with each other, but also with road infrastructure such as traffic lights, helping minimise congestion. These technologies could also make our roads safer, reducing

the number of collisions involving human error – which is currently a factor in over 80% of collisions that result in personal injury. Self-driving vehicles won't get tired or distracted. They won't worry about the children in the back seat, stress about their next meeting or be anxious to get home for dinner. They are likely to react more quickly than a human, remaining consistently able to assess how to drive safely in a fraction of a second.

New ways of making vehicles safe and testing their safety will ensure the benefits of self-driving technologies become a reality, which is a major focus for this document. This need to embed safety is, in itself, driving innovation: scenario generation techniques have been specifically developed to help us understand how a self-driving vehicle will behave in millions of situations; new sensor technologies, data processing and computational approaches mean vehicles will be capable of perceiving their environments in ways that human drivers will never be able to; and emerging thinking is happening within the field of AI to enable those self-driving systems that use machine learning to explain their driving behaviour.

Our current legal framework was not designed with self-driving technologies in mind. That is why, in 2018, government asked the Law Commission of England and Wales and the Scottish Law Commission to conduct a world-leading multi-year review of the law relating to self-driving vehicles.



**Grant Shapps MP**

Secretary of State  
for Transport



**Kwasi Kwarteng MP**

Secretary of State for  
Business, Energy and  
Industrial Strategy

This document sets out government's response to the Law Commissions' recommendations and commits to a new legislative framework for safe self-driving road vehicles, based on these recommendations. This new framework will enable innovation whilst also ensuring safety.

In addition to the substantial gains in getting from A to B safely, these technologies could deliver huge economic benefits, attracting international investment and reinforcing the UK's place as a global science superpower. The UK market alone could be worth as much as £42 billion by 2035, creating as many as 38,000 jobs in the sector. The UK is in an excellent position to secure the benefits of these new technologies, and they can be part of our approach to Build Back Better from the COVID-19 pandemic.

The UK is home to some of the most exciting self-driving mobility companies in the world, who are safely and responsibly setting the standard for global innovation in this space. The UK's Centre for Connected and Autonomous Vehicles has helped secure over £400 million in joint industry-government funding to date, supporting over 90 projects involving 200 organisations. Last year, government held a call for evidence about the future of the UK Connected and Automated Mobility sector. This has informed our thinking about government's priorities, and this document contains the government's response.

We are pleased to provide details of £100 million of new R&D funding (£66m in the Department for Business, Energy and Industrial Strategy (BEIS), and £34m in the Department for Transport (DfT)) to support commercial deployment of connected and self-driving technologies and the creation of a safety assurance framework. This funding will support further development of the technologies as this industry moves towards commercialisation.

This document builds on previous work by government and sets out how connected and self-driving technologies can help create a more prosperous, safer, and greener future – and how we will put in place the building blocks for this future in the coming years. As part of this, we are also seeking your views on our proposed safety ambition for self-driving vehicles, which will form the foundation of a new safety framework.

We have an extraordinary opportunity here to drive forward this unfolding mobility revolution, showing global leadership as only the UK can.



# Introduction



## Connected and automated mobility (CAM) is no longer a tantalising prospect from science fiction: connected and self-driving road vehicles are here today.

These technologies could play an important role in how government improves and levels up access to transport across the nation, helping us to build back better and make everyday journeys greener, safer, easier, and more reliable. In the coming years, connected and self-driving vehicle technologies could also bring vast economic benefits to the UK, creating an industry worth billions of pounds and generating thousands of well-paid, skilled jobs across the country.

Government established the Centre for Connected and Autonomous Vehicles (CCAV) in 2015 to bring together CAM technology developers, vehicle manufacturers and suppliers, academia, insurers, local and regional government, and transport bodies, among many others,

to test and develop policy and to build UK capabilities and supply chains. Through this collaboration, the UK is moving towards a new era of mobility that safely embraces innovation and technology. Reflecting this, the UK is noted as a top 10 market in KPMG's Autonomous Vehicles Readiness Index 2020, leading particularly on policy, legislation, and cyber security.

Government's role going forward is to help realise the transport, economic and wider societal benefits that CAM could unlock. To maximise these benefits, government is committed to working with industry, local government, safety organisations and others as we move towards the safe roll out of these technologies.

This work sits within the wider context of emerging transport technologies and business models and the Future of Transport programme was created to respond to these radical changes. The programme aims to stimulate innovation, prepare the UK for new technologies, support the transition to zero emission, and create a world-leading future transport system that is safe, secure, and accessible

to all. Government has already set out nine principles that help define our vision for future transport and guide how we can harness the opportunities and mitigate the unintended consequences of profound changes in the way we travel (see below). The government's approach to CAM, set out in this paper, has been developed with these principles in mind and we provide further detail on this in Chapter 4.

## **Nine key principles from the Future of Mobility: Urban Strategy<sup>2</sup>**

**In facilitating innovation in urban mobility for freight, passengers and services, the Government's approach will be underpinned as far as possible by the following Principles:**

1. New modes of transport and new mobility services must be safe and secure by design.
2. The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.
3. Walking, cycling and active travel must remain the best options for short urban journeys.
4. Mass transit must remain fundamental to an efficient transport system.
5. New mobility services must lead the transition to zero emissions.
6. Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.
7. The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.
8. New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.
9. Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system.

## 1.1 Government's vision for CAM

The UK is reaching a transition point in the emergence of the CAM sector and application of the technologies to solve transport problems. Early uses are approaching commercialisation, while more will follow in the longer term. We have a clear understanding of the future regulatory framework; and the public are starting to have opportunities to interact with these transport innovations through trials and our public engagement programme. The UK's decision to leave the European Union provides us the flexibility to set our own bold ambitions for CAM, ensuring that we can consolidate and advance our reputation as one of the best places in the world to develop and deploy the technologies. It is therefore the right time to review what we want to achieve and refresh plans for securing the real-world economic, environmental, and societal benefits of CAM.

### Government's 2025 Vision for CAM

“By 2025, the UK will begin to see deployments of self-driving vehicles, improving ways in which people and goods are moved around the nation and creating an early commercial market for the technologies. This market will be enabled by a comprehensive regulatory, legislative and safety framework, served by a strong British supply chain and skills base, and used confidently by businesses and the public alike.”

To realise our 2025 vision, we will build on the successes achieved since 2015 by both government and industry, setting out an approach to secure the UK's long-term position as a leading market to develop and deploy the technologies.

The approach will be delivered in collaboration with industry, academia, and alongside central, regional, and local government partners. It is built on four core considerations:

- Advanced CAM technologies and services are starting to transition from R&D demonstrations to commercial deployments in global markets. Government views passenger transport, logistics and freight, and private land use as areas of particular interest for early self-driving vehicle services in the UK.
- The UK is acting from a position of strength and opportunity, but this cannot be taken for granted given intense global competition.
- To accelerate the societal and economic benefits of CAM we must help the sector progress rapidly from R&D towards the safe commercial deployment of early technologies and services.
- Self-driving vehicle technologies and services will not be successful in the UK without a robust regulatory framework that provides certainty for innovators and investors, as well as confidence for the public that the technologies are safe, secure and work in the interests of society.

Our work will be driven via three pillars of activity, which are set out in more detail in the following chapters:

- **Ensuring the safety and security** of CAM to establish certainty for industry and ensure public confidence
- **Securing the industrial and economic benefits of CAM** that will deliver new jobs and investment, boost growth and productivity, and support the UK's traditional automotive sector and homegrown emerging technology markets
- **Delivering the societal benefits of CAM** so that it improves the quality of transport provision across the country and supports the UK's levelling up and decarbonisation goals

This document sets out how government intends to work towards realising the benefits of CAM technologies over the next 3 years, summarised in Figure 1 (Theory of Change) and Figure 2 (Timeline of activity to 2025). It also invites comment on government's proposed overarching safety ambition for self-driving road vehicles:

**Question 1: What are your views on government's proposed safety ambition that self-driving vehicles would be expected to achieve an equivalent level of safety to that of a competent and careful human driver?**

Details on how to respond are on page 23, and further information on what we are asking is on pages 37–40.

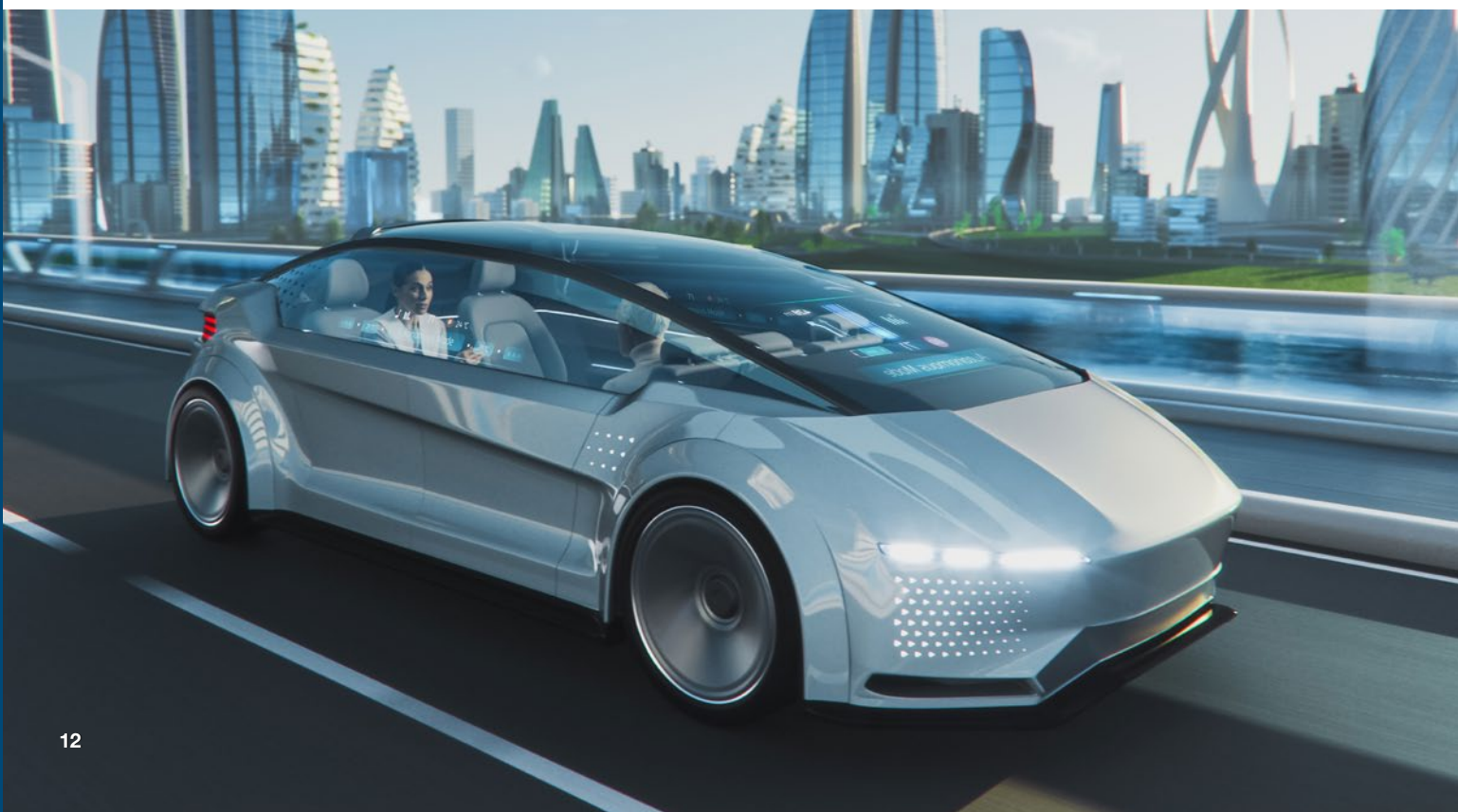
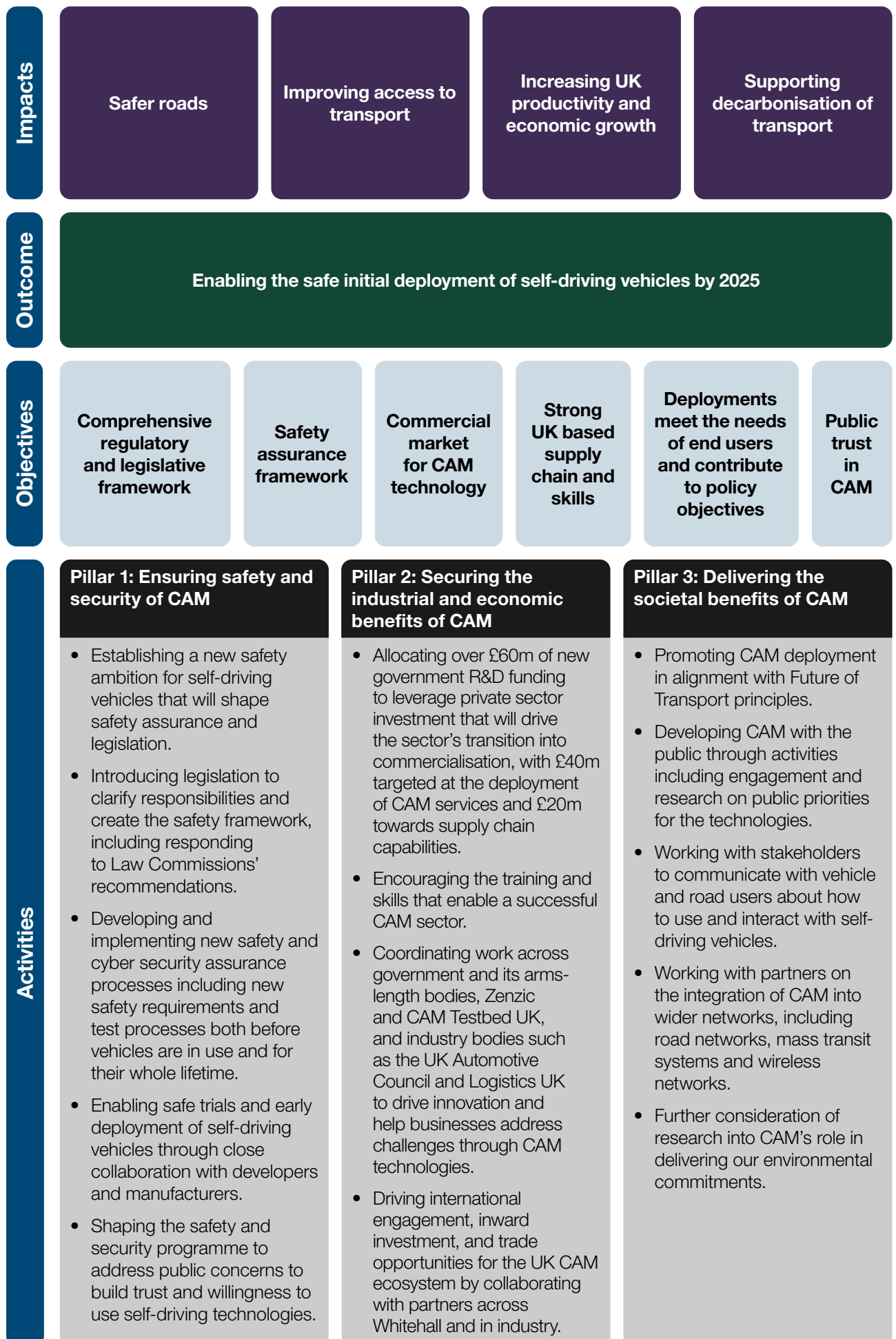


Figure 1. Theory of Change





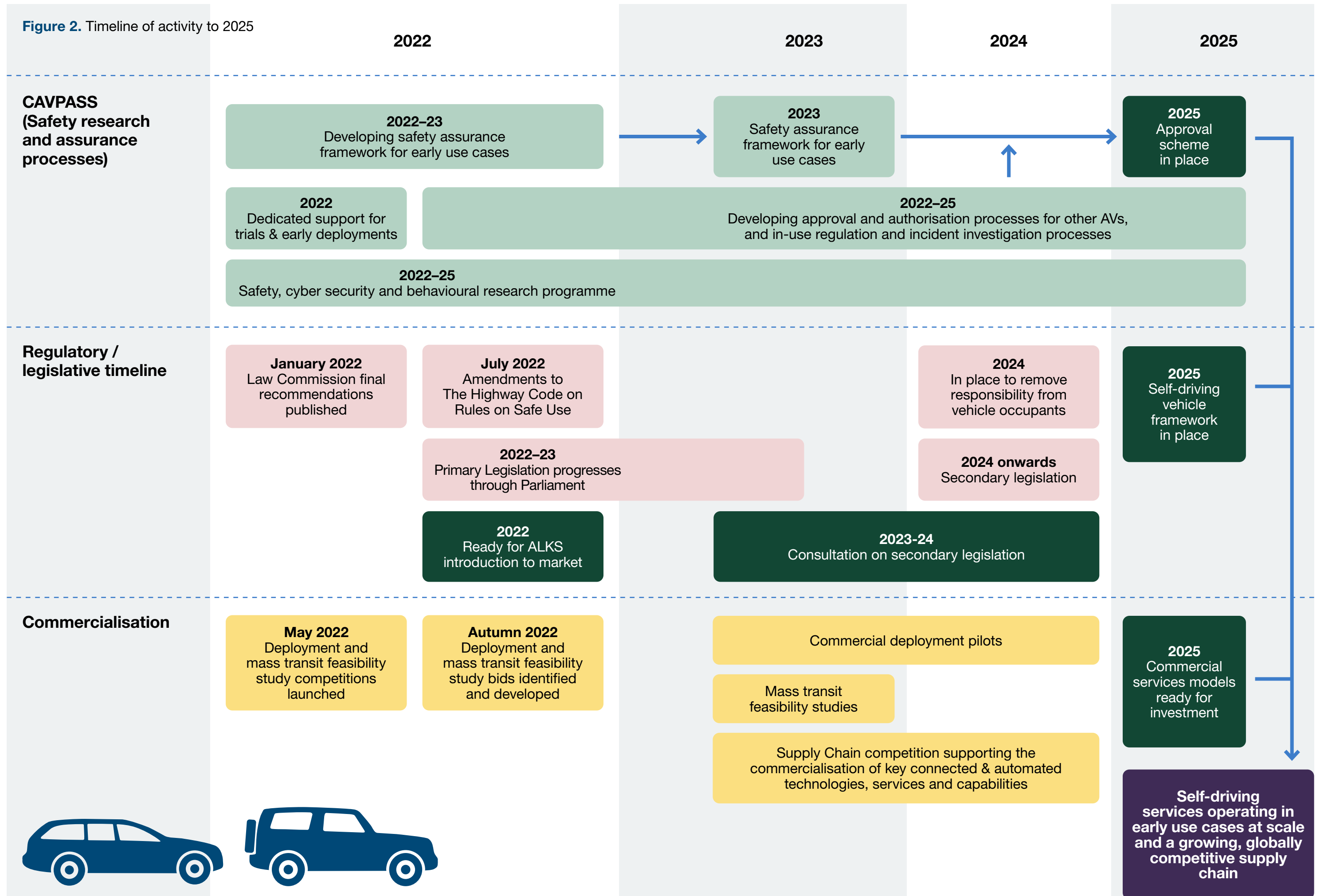
This plan complements other areas of government strategy and policy, including but not limited to those in the box below. CCAV works with the teams delivering these policies, and an outline of the relevant

Departments and Agencies can be found at Annex A. We would like to thank all those – both within and external to government – who have contributed to the development of this document.

- The Department for Transport ‘Transport Decarbonisation Plan’
- The Department for Transport ‘Transitioning to Zero Emission Cars and Vans: 2035 delivery plan’
- The Department for Transport ‘Future of Mobility: Urban Strategy’
- The Department for Transport ‘Future of Freight Strategy’
- The Department for Transport ‘Road Safety Strategy’
- The Department for Business, Energy & Industrial Strategy ‘Automotive roadmap: driving us forward’
- The Department for Business, Energy & Industrial Strategy ‘UK Innovation Strategy: leading the future by creating it’
- The Department for Business, Energy & Industrial Strategy ‘UK Research and Development Roadmap’
- The Department for Digital, Culture, Media and Sport 5G Testbeds and Trials Programme
- The Department for Digital, Culture, Media and Sport ‘Wireless Infrastructure Strategy’
- The Department for International Trade ‘Export Strategy’
- ‘Levelling up the United Kingdom’ White Paper
- The National Cyber Strategy
- The UK National AI Strategy
- The Department for Transport ‘Transport Employment and Skills Taskforce’
- Transport for Scotland ‘A CAV Roadmap for Scotland’



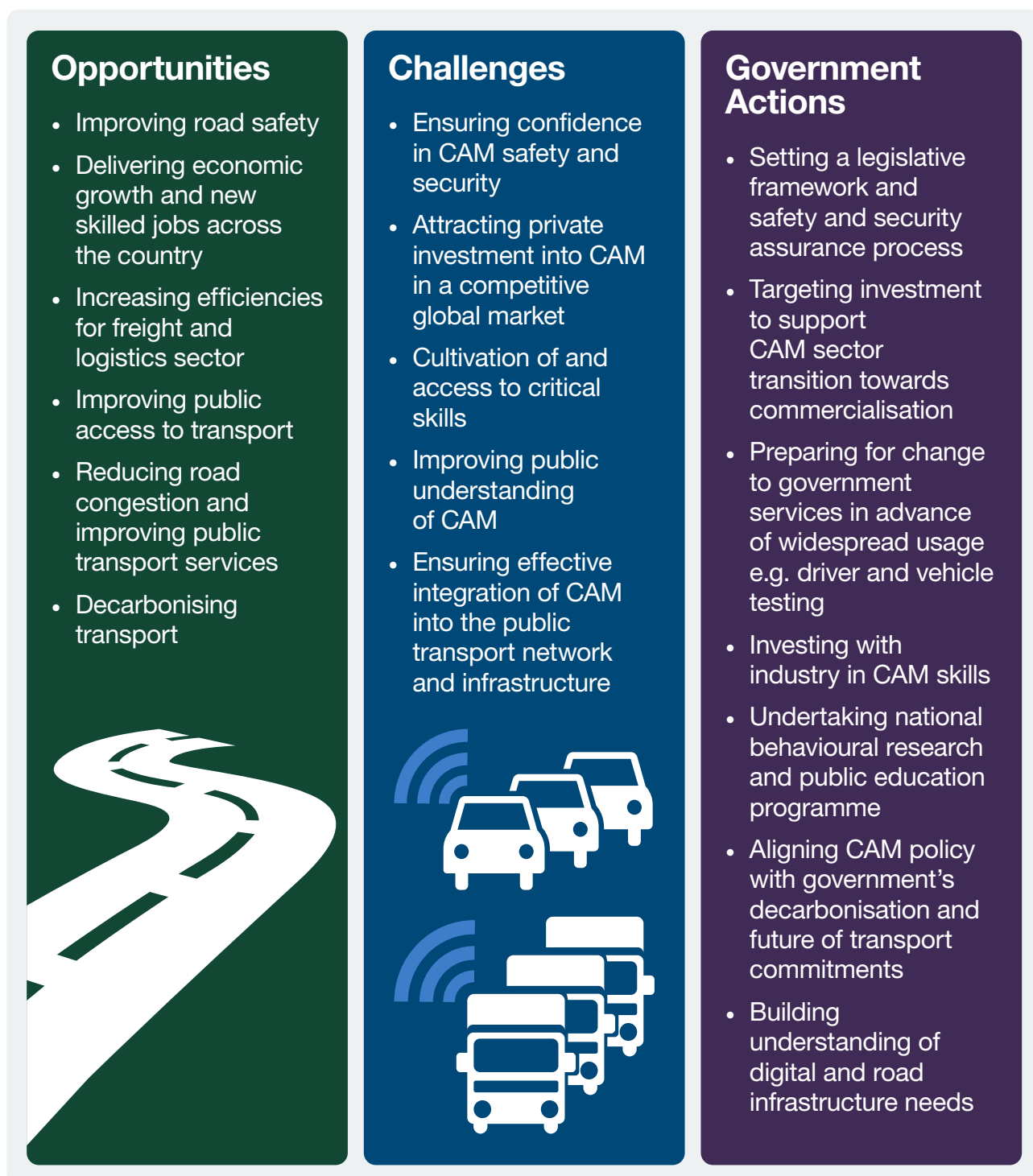
Figure 2. Timeline of activity to 2025





## 1.2 Why is CAM Important?

**Figure 3.** Key opportunities and challenges facing the UK CAM sector, and associated government actions



### 1.2.1 Global market context and the UK CAM sector

The global race to develop and deploy CAM technologies poses significant challenges, and the complexities are not limited to the development of technologies. Public trust, regulatory challenges, and how services are integrated into existing and future transport networks have all raised questions for companies and governments looking to bring self-driving vehicles to market. This has required industry and government in recent years to develop technology, policy, and regulation in lockstep, encouraging open analysis of the barriers facing the introduction of self-driving vehicles and reflected in Zenic's 'UK CAM Roadmap to 2030' (2019).<sup>3</sup>

The UK CAM sector is now gearing itself up for initial commercialisation, reflecting impressive advances of the technology and service capabilities in recent years. British CAM companies – many with support from government – have grown to become competitive on the global stage, establishing the UK as a leading destination for developing and deploying the technologies. Data compiled from publicly available sources shows that, of the ~200 companies who have received government grant funding to date, 35 have secured additional private investment totalling £790 million. The true level of investment across the sector is likely to be much higher, as this does not include investment in companies who have not received government funding, nor the deals that have not been made public.

Connected and self-driving vehicles could deliver huge economic benefits for the UK, attracting international investment and enhancing the UK's standing as a global science superpower. The market in the

UK alone could be worth as much as £42 billion by 2035, capturing around 6% of the £650 billion global market, and creating up to 38,000 new jobs<sup>4</sup> in the sector. Respondents to the government's 2021 call for evidence into the 'Future of connected and automated mobility in the UK' stated that the emerging CAM opportunity would not only contribute to future-proofing the UK's automotive, logistics and mobility sectors, but would also open new markets for other homegrown emerging technologies, such as artificial intelligence, machine learning, cyber security, Mobility as a Service (MaaS) and innovative insurance products. These outcomes could support wider government Levelling Up, Net Zero and Global Britain priorities set out in government's 2021 publication, 'Build Back Better: our plan for growth'<sup>5</sup>. These opportunities and challenges are explored further in Chapter 3.

Globally mobile investors are currently evaluating significant, long-term commitments in CAM technologies and services, and the UK faces intense competition for these investments. The UK's geography, including its varied road network and varied climate, provides a challenge for UK CAM developers but offers a good choice of location to develop technologies that can be exported to markets with similar or less challenging geographies. It is therefore essential for government and industry to work together to secure the economic growth, employment opportunities and domestic capabilities associated with a thriving homegrown market. The UK has worked hard to achieve its reputation as a world leader in CAM and government's renewed commitment aims to ensure that the UK becomes a technology 'maker' rather than a 'taker'.

## 1.2.2 A Transport Revolution

Across a range of transport modes, networks and infrastructures, technology is revolutionising how people and goods move around the country. CAM technologies are at the heart of this, with potential to make journeys and logistics safer, fairer, cleaner, and more efficient:

- Self-driving technologies in zero-emission cars, buses and delivery vehicles could smooth traffic flow and reduce emissions per mile, improving air quality and helping the UK to build back greener to meet its net zero carbon commitments.
- Research has shown that connected services, with traffic lights and vehicles speaking to each other, could help keep traffic flowing, improve safety, ease congestion, and reduce emissions.<sup>6</sup>
- CAM technologies could increase UK productivity by allowing drivers to benefit from optimised route planning and improved traffic flow and by giving them more productive time in their vehicles
- CAM services could improve access to transport for people with mobility issues – those who are losing access to independent mobility as they age and those who have never had access to independent mobility.
- CAM could reduce the cost and improve the reliability of transport services, helping to level-up access to transport in rural and historically disconnected areas.

- Crucially, even at relatively low levels of automation, the technologies could reduce road collisions. At higher levels, it could significantly improve safety on our roads by markedly reducing human error. These opportunities – and how government intends to take advantage of them – are explored further in Chapter 2 of the document.

The safety of CAM systems and technologies is central to all that we do; we provide details of our approach to this for self-driving road vehicles in Chapter 2. Successful design and delivery of these vehicles and services will be contingent on effective public engagement, giving confidence the technologies can safely meet people's transport needs. The public will need to be able to access the right training, accurate information and supporting products (e.g. insurance) to enable safe use.

The complexity of implementing CAM technologies also goes beyond safe and there are a range of challenges that must be addressed to realise the benefits we want to see and avoid unintended consequences. The shift to CAM technologies will not happen overnight. There will be a period of transition; conventional vehicles and systems will continue to operate alongside those with new CAM technologies. This is why government is actively considering how CAM technologies and business models will integrate into the UK's existing transport network in practice, and how we can mitigate potential risks such as increased congestion, energy consumption and barriers to active transport. These challenges have been considered in the government's 2019 Future of Mobility: Urban Strategy (see Chapter 4), which sets out 9 Principles to guide the successful deployment of new transport technologies.

To support this, the ways in which we design, plan, build, and maintain national, regional, and local transport infrastructure must be able to incorporate CAM so that it can be used in a way that promotes greener, safer and fairer travel. This will require government to build skills and understanding of CAM technologies at all levels, from local to central, such as the work being done by the Transport Technology Forum which brings road operators together with local and central government, among others, to encourage the uptake of innovative technologies and services to solve common transport challenges.

CAM technologies will need good digital and data infrastructure for elements of their functionality and the regulatory framework. For example: routing and efficiency services will require connectivity, while the core functions of self-driving systems are expected to function safely without it; data retention will be essential to ensure proper management of incidents involving self-driving vehicles. 4G coverage across major roads in the UK is currently at 66%, with urban coverage at 84% and rural coverage at 57%<sup>7</sup>. This will need to extend further to meet the needs of “vehicle to everything” (V2X) connectivity, and in Chapter 4, we explore connectivity needs for CAM. Systems must be in place to mitigate cyber and data security risks that arise from introducing a transport mode so reliant on technology and data, and this is explored in Chapter 2. We go into greater detail on the cyber security of connected places in section 4.3.4.

We must also consider how CAM technologies may shape the jobs and skills of the future, ensuring that the technologies benefit society by solving labour challenges, rather than adding to them.

## 4G coverage across major roads in the UK is currently at 66%, with urban coverage at 84% and rural coverage at 57%

The HGV driver shortage, for example, has brought the skills agenda in the sector into sharp focus, and transport and logistics businesses have noted challenges around the wider skills supply pipeline and staff retention. The government also recognises these challenges and has published the ‘Transport labour market and skills: call for views and ideas’. We are also establishing an industry-led Transport Employment and Skills Taskforce (TEST) to advise on addressing these challenges<sup>8</sup>. CAM offers one solution – although by no means a panacea – to improve the resilience of the supply chain and the reliability and cost efficiency of the freight and logistics sector, with potential to translate these benefits to adjacent sectors. CAM technologies are also expected to create tens of thousands of good employment opportunities across all skill levels to attract and grow talent. Government and industry must work together to consider what is necessary to prepare the workforce for increasingly digitised and automated industries, an area considered further in Chapter 3.

## 1.3 A Note on Language

There are many ways to refer to CAM technologies. Throughout this document we use CAM to refer to the sector and broad set of vehicle technologies that can be used in wheeled (non-rail), ground-based vehicles. We also refer to self-driving vehicles, or vehicles with self-driving features. Self-driving capability is a specific application of CAM technologies, and a substantial target for commercialisation and deployment within the sector. Our use of language is important because of the need to build public understanding of CAM technologies and ensure clarity of associated responsibilities. Although often used interchangeably, we are using the terms self-driving and automated in distinct ways.

A self-driving vehicle is one that has at least one self-driving feature, delivering sufficiently high levels of automation that it meets a legally defined threshold and is capable of safely driving itself with no human input. Such features could provide self-driving capability for all or part of a journey. Automated can refer to a wider range of automation, including technologies which are not capable of self-driving. While the term 'automated' vehicle will continue to be used by the sector and in legislation, 'self-driving' and 'self-driving feature' are better terms to support public understanding. To reflect this, it is intended that 'self-driving' becomes a protected term for the purposes of marketing products to the public.

Our public engagement programme will continue to research how understanding can be built (see Chapter 4). A list of terms and acronyms used throughout this document has been included in Annex B.

Many of the terms in this paper relating to the new legislative framework are derived from those used in the Law Commissions' published report, for example the planned new legal entities, and may be subject to change as they are turned into legislative proposals.

## 1.4 Territorial Extent

The sectoral policy and funding availability contained in this document is UK wide, while legislative proposals apply to Great Britain only. This mirrors the territorial application of the Automated and Electric Vehicles Act 2018.

Northern Ireland is subject to a different system of regulation. As a result, the Law Commissions were only able to make recommendations for regulatory reform in respect of England, Wales and Scotland. This does not exclude opportunities for Northern Ireland to deploy CAM commercially within its own jurisdiction.

We will work closely with the devolved administrations on the policy contained in this document, respecting areas of devolved competency, as we jointly work towards our shared goals of a robust regulatory framework and thriving industrial policy.

In December 2019, Scottish Government published 'A CAV Roadmap for Scotland' setting out their intention to be at the forefront of this exciting and innovative sector<sup>9</sup>. We recognise our partnership with the Scottish Government and share the same commitment to future plans.



## 1.5 Consultation – What We're Asking

We are seeking final stakeholder views on the appropriate level of safety ambition for self-driving vehicles. The government's position on this is set out on page 41 in section 2.2.2.

### How to Respond

The consultation period runs until the end of 14 October 2022. You can respond to this consultation in three ways:

1. Online through a survey, a link to which can be found on the gov.uk webpage.
2. By email, to [consultation@ccav.gov.uk](mailto:consultation@ccav.gov.uk)
3. By posting your response to:

Centre for Connected and  
Autonomous Vehicles  
Department for Transport  
Zone 1/33 Great Minster House  
33 Horseferry Road  
London  
SW1P 4DR

When responding, please state whether you are responding as an individual or representing the views of an organisation. If responding on behalf of a larger organisation, please make it clear who the organisation represents and, where applicable, how the views of members were assembled.

## 1.6 Consultation Principles

The consultation is being conducted in line with the government's key consultation principles. Further information is available at <https://www.gov.uk/government/publications/consultation-principles-guidance>.

If you have any comments about the consultation process, please contact:

Consultation Co-ordinator  
Department for Transport  
Zone 1/29  
Great Minster House  
33 Horseferry Road  
London  
SW1P 4DR

Email [consultation@dft.gov.uk](mailto:consultation@dft.gov.uk)



## 1.7 Freedom of Information

Information provided in response to this consultation, including personal information, may be subject to publication or disclosure in accordance with the Freedom of Information Act 2000 (FOIA) or the Environmental Information Regulations 2004.

If you want information that you provide to be treated as confidential, please be aware that, under the FOIA, there is a statutory Code of Practice with which public authorities must comply and which deals, amongst other things, with obligations of confidence.

In view of this it would be helpful if you could explain to us why you regard the information you have provided as confidential. If we receive a request for disclosure of the information, we will take full account of your explanation, but we cannot give an assurance that confidentiality can be maintained in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not, of itself, be regarded as binding on the Department.

The Department will process your personal data in accordance with the Data Protection Act (DPA) and in the majority of circumstances this will mean that your personal data will not be disclosed to third parties.

## 1.8 Privacy Notice

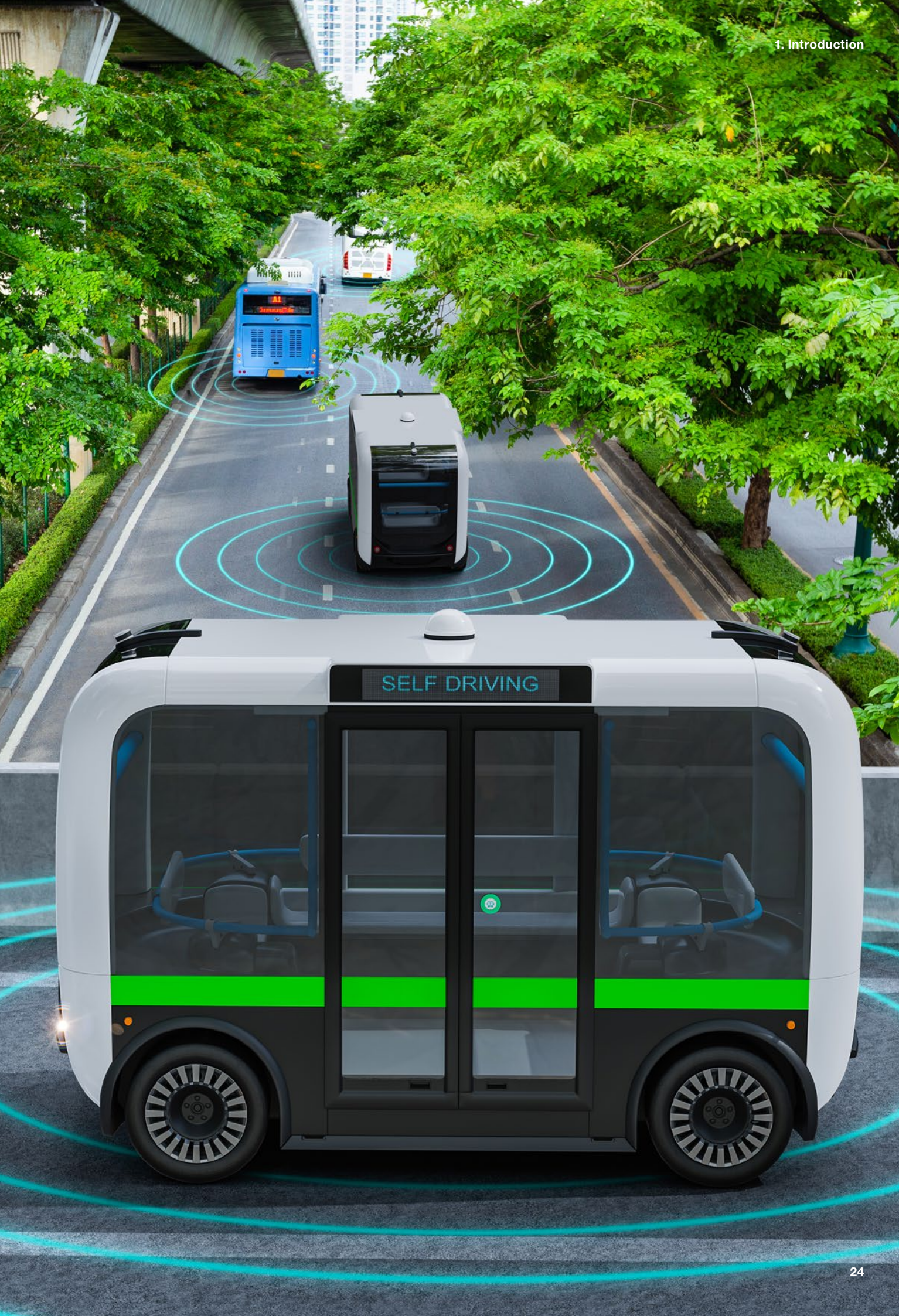
The Centre for Connected and Autonomous Vehicles (CCAV), a joint unit between the Department for Transport (DfT) and the Department for Business, Energy and Industrial Strategy (BEIS), is carrying out this consultation to seek your views on our proposed safety ambition for self-driving vehicles, which will form the foundation of a new safety framework. This consultation and the processing of personal data that it entails is necessary for the exercise of our functions as a government department. If your answers contain any information that allows you to be identified, DfT will, under data protection law, be the Controller for this information.

As part of this consultation, we're asking for your name, location, and email address. This is in case we need to ask you follow-up questions about any of your responses and to enable us to understand the context of your response. You do not have to give us this personal information. If you do provide it, we will use it only for the purpose of asking follow-up questions and for understanding the context of your response.

To receive this information by telephone or post, contact us on 0300 330 3000 or write to Data Protection Officer, Department for Transport, Ashdown House, Sedlescombe Road North, St Leonards-on-Sea, TN37 7GA.

Your information will be kept securely within DfT and destroyed within 12 months after the call for evidence has closed. More information about DfT's privacy policy can be found at: <https://www.gov.uk/government/organisations/department-for-transport>







A large, stylized number '2' in a dark purple color, positioned on the left side of the page. The '2' is composed of a thick, curved line that starts at the top left, curves down and right, then loops back up and left to form the top of the '2', and finally curves down and right to form the bottom of the '2'.

# Ensuring Safety and Security

Self-driving vehicles are a key element of wider CAM technologies. This chapter looks at government's role in ensuring the safety and security of self-driving road vehicles, their occupants and other road users.

The existing safety framework for roads and road vehicles is extensive – from vehicle standards and driver licensing, to rules of the road and motoring offences; but it has been developed with the human driver at its heart. New and innovative self-driving technologies are pushing the boundaries of existing legislation and safety assurance processes. Government is therefore undertaking a comprehensive programme of research into the safety of self-driving vehicles and is introducing legislation to create a new safety framework which will enable a new era of safe self-driving road vehicles. This is facilitated by the UK's departure from the European Union, which provides us with the platform to capitalise on our regulatory freedoms and make decisions that are right for Great Britain.

The new safety framework will deliver transformational change to existing safety assurance provisions. The framework must allow for the continued innovation that we expect to see as self-driving vehicle technologies develop. We anticipate two broad development routes: vehicles that can undertake part of a journey (requiring a driver some of the time) and are likely to look much like conventional vehicles; and vehicles that can undertake an entire journey (so do not require a driver), which may look novel in design and are likely to be offered as a service.

But these routes may change, so the safety framework must allow for this, as it must also permit for different technical solutions to ensure safe deployment.

This chapter sets out the government's intended structure for the new framework and the work that is being done to implement it through legislative and safety assurance processes. Primary legislation will be introduced with the intention of setting out the broad structure of the framework, with further detail to be developed and set out in secondary legislation. Both the research needed to support this development and implementation of the framework will continue to be undertaken through government's CAVPASS<sup>10</sup> programme.

The chapter is divided into themes set out in Table 1, which summarises the actions of government in response to the safety challenges posed by self-driving vehicles, based on the evidence obtained so far. Themes 1-6 are addressed in further detail within this chapter, with themes 7 and 8 picked up in Chapter 4. Taken together, these government actions will deliver a comprehensive safety framework fit for the future. This work will be funded using the £34m allocated to DfT for CAM safety and security in the government's Spending Review for the period 2022/23 to 2024/25.

2.1 Table 1: Safety themes and government action

Theme	<b>Road safety contribution:</b> Setting a safety ambition for self-driving vehicles to ensure they contribute to improvements in overall road safety.	<b>Clarity of responsibility:</b> A clear distinction is needed between self-driving features and driver assistance features. Developers, operators and users of self-driving vehicles need clarity on their responsibilities.	<b>Continuous learning:</b> The Law Commissions advocated the development of a “learning culture” rather than a blame culture to deal with any post-authorisation incidents and prevent their recurrence.	<b>Safety and enabling regulation:</b> Public attitudes research identified the need for ‘regulation and oversight’ as a core factor for self-driving vehicles to be considered “safe enough”. The Law Commissions’ report recommended a new “Automated Vehicle Act” to deal with the profound legal consequences of self-driving vehicles.	<b>In-use regulation:</b> Public attitudes research identified the need for ‘evidence of safety’ as a core factor for self-driving vehicles to be considered “safe enough”. Safety assurance is also a core tenet of the Law Commissions’ recommendations.	<b>Safe trials and early deployment:</b> Trials and deployment of self-driving vehicles ahead of implementation of the new safety framework must be safe.	<b>Safe use:</b> Drivers, passengers and road users should have a clear understanding of how to safely use and interact with self-driving vehicles.	<b>Public understanding:</b> Theory of Change work identified that this is essential in order for self-driving vehicles to realise their potential safety (and other) benefits.
Government Action	Government will establish a safety ambition for self-driving vehicles: proposed as equivalent to a competent and careful human driver. The ambition will be developed further in the National Safety Principles against which we intend to assess the overall safety of self-driving vehicles. The Principles will inform all elements of the new safety framework. The Principles and framework will be considered alongside broader road safety strategy, as part of the UK’s soon to be published Road Safety Strategic Framework (RSSF).	Government will legislate to introduce the Law Commissions’ recommendations on the ‘Authorisation’ process that will be used to determine which vehicles meet the self-driving threshold, and on the new legal entities necessary to ensure clarity of responsibility.	Government will ensure the new safety framework includes a feedback loop so that learnings from the operation of new technologies will lead to continued development of safety assurance processes. This will be achieved principally through the intended in-use regulatory scheme and incident investigation mechanisms.	Government is committed to bringing forward legislation on self-driving vehicles in the forthcoming Transport Bill. Annex C lists the Law Commissions’ recommendations and Annex D highlights particular recommendations, or issues, worthy of comment.	Government will legislate to take forward the Law Commissions’ proposals for both pre-deployment and in-use regulation. The CAVPASS programme is already delivering work in this area – see section 2.4 on a new safety framework (pages 44-49).	Government will continue to work with individual developers, wider industry and other stakeholders to support the safe trialling and deployment of self-driving vehicles ahead of implementation of the new safety framework (see infographic on page 45). We will consider the need for new/ updated guidance.	Government will review driver training, driver and vehicle licensing, and The Highway Code, and is working with industry and other stakeholders to ensure all road users have a clear understanding of how to use and interact with self-driving vehicles (see section 4.2.3 on education & public understanding). Legislation will also enable us to regulate how users are educated on the safe use of self-driving vehicles.	Government will continue to track public attitudes towards self-driving vehicles and engage the public on this area (see sections 2.1.4 and 4.2.1) and will take public understanding into consideration as the safety framework is developed and implemented.

## 2.1 Building the Evidence Base

### 2.1.1 Road safety and technology

While we have some of the safest roads in the world, even in 2020 – when travel was severely disrupted – more than 1,460 people were killed on our roads. This is equivalent to over four people a day, 28 people a week or 122 people a month losing their lives. These figures were higher in 2019, when there were 1,752 road traffic fatalities. This, and the 22,000 people who are seriously injured every year<sup>11</sup>, is unacceptable.

Driver assistance technologies in vehicles are already improving safety on our roads: EuroNCAP and ANCAP assessed that vehicles fitted with low-speed advanced emergency braking (AEB) had a 38% reduction in real-world rear-end crashes compared to a sample of equivalent vehicles with no AEB<sup>12</sup>. Because human error is a significant factor in many road collisions, self-driving technologies have the potential to further improve safety. The Institute for Engineering and Technology (IET) claim that for every 10,000 errors made by drivers, a self-driving vehicle will commit just one<sup>13</sup>. This is supported by evidence showing that in 2020, 88% of all recorded collisions on roads in Great Britain involved human error as a contributory factor<sup>14</sup>.

Vehicle technology has already delivered significant advances in road safety and is expected to continue to do so with the right legislative and safety frameworks in place. Technology is not infallible, and new technologies bring new risks and challenges which must be managed and met. Road safety is also not the result of vehicle technology alone, and can only be achieved by addressing and aligning the many factors that contribute towards it – adopting a ‘safe system’ approach.

As well as ensuring new technology is designed with safety at the forefront, users and operators must know how to use the vehicles safely, and other road users must understand the technology and how to interact with it.

### 2.1.2 The Law Commissions’ Review

In 2018, government asked the Law Commission of England and Wales and the Scottish Law Commission (the Law Commissions) to conduct a review of legislation to prepare for the safe introduction of self-driving vehicles on GB roads. This world-leading review concluded in January 2022 with the publication of a report with 75 recommendations to government which, taken together, set out a new regulatory framework for self-driving vehicles<sup>15</sup>. The review involved extensive consultation across the self-driving vehicle landscape, including manufacturers, insurers, academics, and civil society, generating a wealth of evidence. It has provided international thought leadership on the way in which self-driving vehicles should be regulated and the recommendations provide for the world’s first comprehensive regulatory framework for self-driving vehicles.

Government congratulates the Law Commissions on their work and welcomes their recommendations. This chapter sets out how government will bring about this transformational change and represents the UK government’s formal response to the Law Commissions’ recommendations, which are listed in full in Annex C. Annex D provides comments on specific recommendations or issues.

Based on these recommendations, we are developing proposals for legislation and intend to introduce them to Parliament

within the forthcoming Transport Bill. All elements of the framework which require legislation are therefore subject to Parliamentary scrutiny.

We are continuing to consider the government's response to recommendations that relate to policy outside the Department for Transport's remit, and so these areas are not included in the current legislative agenda.

### **2.1.3 Responsible innovation in self-driving vehicles – Centre for Data Ethics & Innovation**

Building on the Law Commissions' review, government commissioned a report by the Centre for Data Ethics and Innovation (CDEI) to propose how responsible innovation can be embedded in the future regulatory framework. The CDEI's report "Responsible Innovation for Self-Driving Vehicles" is published alongside this document.

Their recommendations cover the breadth of the regulatory framework proposed by the Law Commissions, highlighting tangible points at which government can assure the safe and ethical behaviour of self-driving vehicles, leading to fair and equitable outcomes. For example, they have made recommendations on governance and the handling of personal data by self-driving vehicles, the importance of understanding why a vehicle behaved as it did, and the centrality of public trust.

### **2.1.4 Public attitudes to self-driving safety**

Public trust and acceptance of any new technology is key to its success, and this is identified as a critical factor in our Theory of Change modelling (see Figure 1 in section 1.1). One particularly important factor in public acceptance is safety.

The Department for Transport's long-running "Transport and transport technology public attitudes tracker survey"<sup>16</sup> has shown that the public see self-driving vehicles as providing a number of safety benefits. However, levels of awareness and understanding of the technology are still low and replacing a human with technology raises concerns, particularly regarding safety. As a result, government commissioned further deliberative research to understand these concerns, the findings of which were published in August 2021<sup>17</sup>.

The deliberative research explored the factors that influenced perceptions of safety and the minimum safety requirements that would be required for participants to consider self-driving vehicles as 'safe enough'.

There were two commonly identified core factors:

- Evidence of safety: Examples that were given during the research included testing and expert testimony.
- Regulation and oversight: Examples that were given during the research included updating The Highway Code and driving tests.

These findings provide support for the safety assurance and legislative reforms that form the basis of government's new intended safety framework. The research also identified potential levers for accurately understanding perceptions of safety. These include educating and upskilling the public, particularly drivers in the first instance, and taking steps to ease initial tensions around trusting technology. These findings are influencing government's work on safety assurance.



## **Advancing Safely to Full Vehicle Automation**

In June 2021, government funded four projects, bringing together more than 20 organisations from across industry and academia, to support the development of safety assurance processes through practical application; advancing our understanding of the safe and secure removal of the safety driver from self-driving vehicles.

Sharing £2.3m in government R&D funding, the four projects were:

### **Assured Zero Occupancy with Remote Assistance (AZORA)**

Led by Oxbotica, the project focused on the required physical systems and software behaviours to enable the self-driving vehicle to safely respond to adverse situations, including systems failures and unexpected behaviours from other drivers. The project safely demonstrated minimal risk manoeuvres (bringing the vehicle to a safe stop in a safe location) in test conditions with and without a safety driver in the vehicle, laying the groundwork for the deployment of novel vehicles with no traditional driving controls.

### **Safe Pathway to Autonomous Control Externally Supervised (SPACES)**

Led by Aurigo, the project was dedicated to the safe operation of low speed automated driving systems using remote monitoring without an onboard safety supervisor. The project assessed the additional safety requirements that arise because of remote supervision, both in terms of implementation and engineering processes, and examined communication requirements that would ensure resilience from signal interference and cyber-attacks.

### **Safely Advancing Vehicle Automation On Roads (SAVOR)**

Led by Conigital, the project focussed on three elements: the feasibility of remote monitoring and teleoperation, including how to ensure the minimum communications requirements for safe operation; developing safety critical “fail-safe” minimal risk manoeuvre systems; and a human factors study that was undertaken in a controlled simulation environment to explore the usability and safety of the systems.

### **Ensuring cybersecure deployments of driverless teleoperated vehicles (ENCODE)**

Led by StreetDrone, the project developed a “multi-driver” system (in-vehicle and remote operator, and self-driving system) and the required safety and cyber security features to ensure safe operation in all modes. To demonstrate the project’s objectives, two “multi-driver” vehicles were operated simultaneously on public roads in London and Oxford.

The vehicle control systems allowed for switching of vehicle operation between in-vehicle, self-driving and remote operation. The remote operator demonstrated the ability to switch from one vehicle to another and individually teleoperate them, assisting the self-driving system when it identified that the environment was outside of its intended usage.

Completing in March 2022, all four projects demonstrated their technologies to government officials, industry stakeholders and local authorities, and the learnings from these projects will be considered in future government safety and security assurance work.



Streetdrone's Remote Driving Station



Oxbotica's Ford Ranger test vehicle



## 2.2 A new safety framework

### 2.2.1 A comprehensive framework

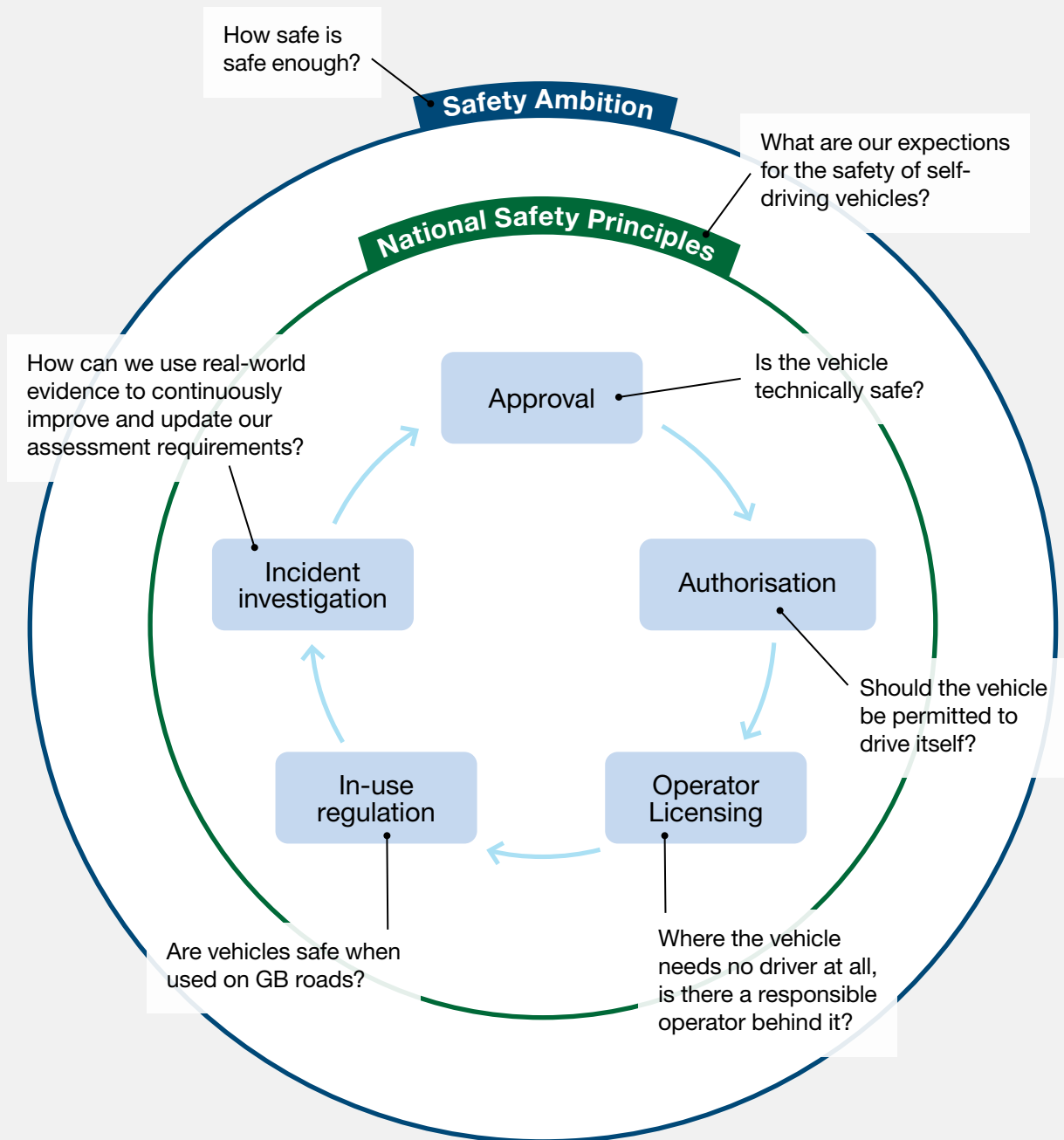
The evidence is clear that realising the potential of self-driving vehicles is only possible if we also transform the way we ensure safety. That is why government is developing a new self-driving safety framework to meet the needs of society and industry in ensuring the safety of self-driving vehicles when first deployed

onto our roads and throughout their deployment. Some of the most significant changes will be to how the safety of the self-driving system is assured, particularly when in use operating on public roads after authorisation. These elements of the new framework are summarised in Figure 4. A more detailed diagram is provided in Figure 5 in section 2.2.4. As we develop each element of the new framework, we will consult further and have due regard to the better regulation principles<sup>18</sup>.





**Figure 4.** The self-driving vehicle safety framework – overview



The new framework will be guided by a high-level safety ambition for self-driving vehicles, which will be expanded upon in the National Safety Principles. Driving systems will be assessed against safety requirements, most often through approval to either national or international technical standards. We intend to assess vehicles with these systems at authorisation to determine whether they should be permitted to drive themselves in at least some circumstances or situations. This will include identifying the organisation responsible for the vehicle when it is driving itself. Where the vehicle requires no driver at all, we intend to identify a responsible operator which must be licensed to oversee the vehicle's operation. We intend to monitor the ongoing safety of a self-driving vehicle through in-use regulation, and issue sanctions to the responsible organisation(s) if standards fall below those set out in the National Safety Principles or in wider regulation. If a specific incident of concern occurs, or a significant negative trend is identified, the proposed Road Safety Investigation Branch (RSIB) may also investigate and identify learnings, which will be fed back into the safety framework. The framework as a whole creates a safety feedback loop which provides for continuous learning throughout the life of a self-driving vehicle.

### **2.2.2 Road safety contribution – Setting a safety ambition for self-driving vehicles**

Safety is the first priority for the development and introduction of self-driving vehicles. Wider benefits will not be realised if the technologies are not safe. It is therefore essential that self-driving vehicles meet a publicly acceptable level of safety.

So, what is the appropriate level of safety? This is a question that has attracted significant debate and was addressed by the Law Commissions in their review. Having consulted on several options, they concluded that an acceptable level of safety is determined by the public's acceptance of risk and that it is essentially a political question, best taken by Ministers. The Law Commissions also concluded that there is no single or easy test for whether a vehicle is safe enough to be acceptable.

Similarly, in their Responsible Innovation for Self-Driving Vehicles report, the CDEI conclude that government should be cautious about trying to set numerical targets for the overall safety of self-driving vehicles, or an acceptable level of risk, given that they are not yet widespread. The report highlights that it is difficult to know whether targets set in advance will truly provide assurance of their safety, especially as not all self-driving vehicles will be alike nor operate in the same areas. Instead, the CDEI outline elements of a 'safety-by-design' framework, which locates self-driving vehicles within an emerging regime of standards, certification and inspection, aiming to improve safety over time. These processes will give confidence to government that vehicles are safe enough prior to deployment, and the means by which to assess their safety once on the roads as well as their effect on fairness and equity for road users.

Both the Law Commissions and the CDEI emphasise the importance of public understanding of, and confidence in, the safety of self-driving vehicles. Providing evidence of improved safety will be a key factor in supporting this.

This section sets out government’s proposal for a high-level safety ambition for self-driving vehicles and provides a final opportunity to comment on the high-level question of ‘how safe is safe enough?’. The ambition aims to provide a clear focus for government and industry as self-driving vehicles are developed and deployed, and to provide an understandable aim to support public acceptance. This section also highlights the importance of ensuring improved safety for all, as well as elements of the new safety framework that contribute to a ‘safe-by-design’ approach, putting safety at the heart of every stage of a self-driving vehicle’s life.

### How safe?

Government is keen to realise the safety benefits from self-driving vehicles as soon as possible in order to prevent needless injuries and deaths. To achieve this, the safety requirements must not be set at a level that stifles innovation or sacrifices near-term safety improvements. Equally, requirements should be high enough to avoid the safety benefits being very low or non-existent. Balancing safety, innovation and public expectations is challenging, and must be considered carefully in the context of technologies that are still under development, are moving towards being deployed at scale and about which public understanding is still being built.

Society has, over time, improved road safety through the rules it has set and the behaviours it expects. Road traffic law sets the expected standard of behaviour as that of a “competent and careful” driver. The Highway Code provides further guidance on what this means in practice. The result of these rules and behaviours are some of the safest roads in the world. This government believes that self-driving vehicles should be

held to the same standard of behaviour as that expected of human drivers; competent and careful. This standard is higher than that of the average human driver – which includes, for example, drivers who are fatigued, distracted or under the influence of drink or drugs. The standard of a competent and careful driver will therefore capitalise on the huge safety potential of self-driving vehicles, ensuring improved safety on our roads and thereby supporting public trust and acceptance.

Self-driving vehicles will be expected to comply with road traffic law and relevant rules in The Highway Code but this may not mean they should replicate the actions that a competent and careful human driver would take in every circumstance. Self-driving vehicles are likely to operate within defined parameters – for example at limited speeds, on specific routes, within defined geographic areas, etc. – meaning that direct comparisons with a human driver may not be appropriate. Work is already underway to develop a structure for describing The Highway Code rules to enable their integration in development and testing activities.

As mentioned above, government wants to realise the safety benefits of self-driving vehicles as soon as possible and believes that holding self-driving vehicles to a high safety standard should not preclude this. By setting out clear and appropriate assessment criteria at each step of the safety process, government will support industry to develop and deploy safe self-driving vehicles on our roads as soon as possible. The safety feedback loop that will be created by the new safety framework will provide industry and government with an excellent opportunity to ensure continued learning and improvement.

Government's ambition for self-driving vehicle safety will be further developed into a set of National Safety Principles for Self-Driving. It is government's intention that these National Safety Principles will take the form of Statutory Guidance and will be subject to public consultation and Parliamentary scrutiny. Government would be required to pay due regard to the Principles when making decisions on the safety of self-driving vehicles. The Principles will be kept under review to ensure they are sufficiently up-to-date and continue to secure the safety benefits offered by self-driving vehicles. It is government's intention that changes to the Principles will also be subject to Parliamentary scrutiny, much like The Highway Code today.

### **Safety improvement for all**

When determining the appropriate level of safety, we must also remember the question of fairness. Even an overall positive effect on safety may negatively affect some groups more than others. Under the Public Sector Equality Duty, the government must have due regard to eliminating discrimination and advancing equality of opportunity when creating new policies. We intend to require any organisation seeking authorisation of their vehicle as self-driving to submit an assessment of fair outcomes, including considerations of data bias, which must include how they avoid their vehicles unfairly discriminating against certain people as well as vulnerable road users, and their considerations of the importance of accessibility for people with different disabilities. This is recommended in the CDEI report. Under the planned safety framework, we are considering whether those organisations responsible for the behaviour of self-driving vehicles, known as Authorised Self-Driving Entities (ASDEs), should be under a duty to report

## **When determining the appropriate level of safety, we must also remember the question of fairness**

data relating to discriminatory behaviour by their vehicle(s) to the in-use regulatory scheme, which will also take evidence from third parties. The scheme could then consider whether the effect on specified groups is unacceptable and take action to resolve issues.

### **Safe by design**

There are many points in the lifecycle of a self-driving vehicle at which safety will be assessed by developers, manufacturers and government. Government intends for the safety assessment to be undertaken at various stages, as set out below, in order to provide confidence that self-driving vehicles are safe enough throughout their lifecycle. The detail of the requirements at each of these stages, including data requirements, is under development and will be subject to consultation.

### **Automated vehicle approval**

Detailed technical assessments of the safety of each self-driving feature will form part of automated vehicle approval, as well as any exemption approvals or post approval modifications. These technical assessments will form an important part of authorisation and further information on the development of these standards is provided in section 2.2.6 government safety assurance processes.

## Authorisation to self-drive

Authorisation will assess, among other things, whether a self-driving vehicle can safely and legally drive itself in at least some circumstances or situations. This will build on existing work to develop a ‘monitoring test’<sup>19</sup> which seeks to determine whether a vehicle can safely and legally drive itself without the need for monitoring by an individual. The monitoring test sets out 5 criteria:

A vehicle must:

- Comply with relevant road traffic rules
- Avoid collisions which a competent and careful driver could avoid
- Treat other road users with reasonable consideration
- Avoid putting itself in a position where it would be the cause of a collision
- Recognise when it is operating outside of its operational design domain

Authorisation will also consider whether a suitable ASDE can vouch for the safety and lawfulness of the vehicle. An ASDE is the organisation that will be held responsible for a vehicle when it is driving itself. An ASDE will need to be registered, considering whether they are suitable to take on responsibility for a vehicle, such as having sufficient financial standing and good repute.

We intend Authorisation to set a number of ‘in-use duties’ on ASDEs to ensure they continue to take responsibility for the vehicle and apply deployment conditions where necessary (see Annex D for a further discussion of conditions). We also intend to establish clear thresholds for when a vehicle must be re-authorised.

## In-use regulation

The process of in-use regulation will ensure that vehicles continue to meet these criteria for as long as they drive themselves on our roads. This will require data from ASDEs and operators of self-driving vehicles to be supplied to the in-use regulatory scheme.

It is likely that data will be needed to help assess:

- Whether the authorisation remains valid
- How frequently breaches are occurring, if at all
- Whether sanctions are appropriate against the ASDE for their vehicle operating below expectations (and/or the vehicle operator, where relevant)
- Whether there has been a failure to disclose, or a misleading disclosure of, safety-relevant information, which will be a criminal offence by officers of the ASDE and operator

Sanctions will scale from an informal warning through to a compliance order, and a civil penalty to suspension of authorisation, and will be issued as appropriate to reflect the severity of any traffic infraction or breach of authorisation or license.

The ability for a vehicle to ‘explain’ its actions is likely to be a fundamental component of in-use regulation, as highlighted by the CDEI report. Understanding what happened following an incident, and to what extent it was caused by a failure of due diligence by the ASDE or something that could not have been predicted, will make for a more intelligent regulatory framework.



This will enable the sector to learn from unforeseen issues and give clarity to government and industry when heavy regulatory sanctions may be necessary. Only through an effective approach to explainability can the sector move towards a culture of 'no blame', as advocated by the Law Commissions.

Work on future standards to explain self-driving vehicle behaviour is already underway, and early proposals suggest it may be possible to set requirements in future. However, this is a new area of research and more work is needed to understand the issues, particularly the implications it could have on development and deployment.

### **Overall safety of the vehicle fleet**

Data obtained through in-use regulation will contribute to assessment of the aggregate safety of self-driving, and comparisons with the safety of human driving. Government will publish a regular report detailing its analysis of self-driving compared to human driving. Over time this will help to establish the real-world effect of these new technologies. Appropriate comparisons will depend on the operational use cases for the vehicles with self-driving features, and comparative data is unlikely to be available for every circumstance. Some uncertainty of real-world impact is a feature of any emerging technology and does not undermine the safety potential of self-driving vehicles or the safety approach outlined in this chapter to ensure that potential is realised.

### **Consultation question**

#### **Consultation – stakeholder views on a safety ambition for self-driving vehicles**

This government believes that self-driving vehicles should be held to the equivalent standard of behaviour as that expected of human drivers; competent and careful. This ambition will capitalise on the huge safety potential of self-driving vehicles, ensuring improved safety on our roads and thereby supporting public trust and acceptance.

#### **Question 1: What are your views on government's proposed safety ambition that self-driving vehicles would be expected to achieve an equivalent level of safety to that of a competent and careful human driver?**

Following this consultation, government will outline a final safety ambition which will provide the basis for discussion and development of more detailed safety requirements, for example how the ambition will be translated into secondary legislation and guidance. Details on how to respond can be found at the end of Chapter 1 on page 23.

This ambition for self-driving vehicles aligns with the government's broader road safety strategy which will be based on the Safe System pillars, which cover:

- Safe vehicles
- Safe road user behaviours
- Safe speeds
- Post collision care, including victim support

Although the safe vehicles pillar may seem the obvious home for self-driving vehicles, it is important to also consider their impacts on other pillars. For example, ensuring self-driving vehicle users and other road users know how to safely interact with them will fall under the 'safe road user behaviours' pillar and will require education and communication. Ensuring the cyber security of any infrastructure and/or vehicle communications will fall under the 'safe roads and roadsides' pillar and will require national co-ordination. Government will consider alignment with the whole road safety strategy, including the soon to be published Road Safety Strategic Framework (RSSF) during the development of the self-driving vehicles safety framework.

### 2.2.3 Clarity of responsibility

#### The distinction between driver assistance and self-driving

Both driver assistance technologies and self-driving vehicle technologies have significant potential to improve road safety, and both are likely to play a key role in the years to come. However, it is vital that people in the driving seat understand the capabilities and limits of the vehicles they are operating so that they can use different types of technology accordingly and understand their responsibilities.

The distinction between driver assistance and self-driving was highlighted within the Law Commissions' review and is explained succinctly in the quote below:

“On one side of the line, technology to assist human drivers may be very advanced but still unable to deal with all situations. Instead, it relies on the human behind the wheel to monitor the vehicle and the driving environment, and to respond to events.

On the other side of the line, the vehicle is regarded as self-driving. The human in the driving seat (if any) may relax and divert their attention, knowing that they are not responsible for anything that happens while the automated driving system (ADS) is engaged. The ADS itself monitors the driving environment and responds to events.

Consultees expressed a strong desire for a clear bright line between systems which require attention and those that do not, to minimise the potential for confusion between the two.”

This need for clarity is supported by evidence from sources such as the responses to government's call for evidence on the safe use of Automated Lane Keeping System (ALKS). And research findings showed that while levels of awareness of assistance features are quite high (84%<sup>20</sup> of people reported having heard of an assistive feature), experience of using them and accuracy of understanding are much lower. For instance, only 49%<sup>21</sup> of people could accurately identify the capabilities of adaptive cruise control; and when assessing the capabilities of assistance features, drivers tend to over-estimate these capabilities by believing they take a more active role in the driving task or in preventing collisions.

A fundamental principle that underpins the new safety framework is therefore a clear distinction between driver assistance features and self-driving features. Driver assistance features, such as advanced emergency braking and lane-keep assist, are designed to undertake some elements of the dynamic driving task (DDT), such as braking or steering. They require a human driver to monitor the road environment at all times and the human driver remains responsible for the behaviour of the vehicle at all times. Self-driving features are designed to undertake all elements of the dynamic driving task and must be sufficiently capable that a human driver is not needed in order for the vehicle to behave safely and legally on the road when the feature is active under agreed conditions. If this bar is met, under our legislative proposals, the human driver would no longer be responsible for the vehicle's behaviour whilst it is driving itself.

It is government's intention that authorisation will be the key mechanism by which driver assistance and self-driving features are distinguished (see section 2.2.2 and Annex D for more details). We intend to support driver, user and public understanding of the distinction by making it an offence to market a vehicle as self-driving (or to use terminology that suggests self-driving) where that vehicle has not been authorised to drive itself. We will work with stakeholders to develop appropriate messaging to the public through our AV-DRiVE (Automated Vehicle Driver Responsibility in Vehicle Education) group – more detail on this can be found in Chapter 4.

### **Two categories of self-driving features**

We anticipate that there will be two broad categories of self-driving features. The first category includes features that can only drive the vehicle for part of a journey: vehicles with these features require a human driver in the driving seat to take control for the rest of the journey. For example, the vehicle may be able to drive itself on major roads and in limited weather conditions: if the vehicle is going to turn onto a minor road, or the weather deteriorates, it will issue a transition demand so that the human driver can take over. In such a vehicle, government intends for the human driver to become a User-in-Charge (UIC) when the vehicle is driving itself and therefore no longer responsible for the behaviour of the vehicle. They will remain responsible for other legal requirements however, such as vehicle insurance, loading and roadworthiness. It is our intention that responsibility for the vehicle's behaviour will pass to its ASDE.

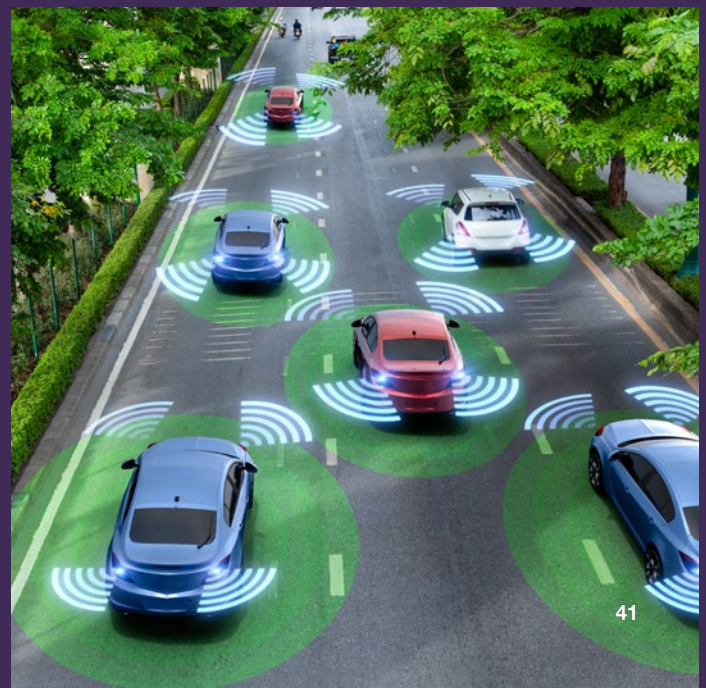


An ASDE is likely to be a vehicle manufacturer or software developer, or a partnership between the two. If a self-driving vehicle breaks a traffic law while it is driving itself, for example by driving in a bus lane, the human occupants will not be responsible, instead the ASDE will be responsible and could be subject to regulatory sanctions [see section 2.2.4].

The second category includes self-driving features that can drive for the entire journey. Any human in the vehicle would be merely a passenger. The feature would not require a User-in-Charge and is therefore referred to as a No User-in-Charge (NUiC) vehicle under the planned framework. Responsibility for the behaviour of these vehicles would remain with the ASDE. However, they would also need to have a licensed operator, a 'NUiC operator', which would be responsible for overseeing the wider operation of the vehicle and taking on the non-dynamic driving task responsibilities, such as ensuring the vehicle has appropriate insurance, that would otherwise remain with the User-in-Charge. This is similar to a bus operator who purchases buses from a manufacturer but is responsible for their operation. Vehicles run by a NUiC operator could be offered in a public capacity, but it would also be possible for these vehicles to be leased to individual owners, operated as part of a car club or operated by delivery companies as part of their vehicle fleet. We therefore believe the new framework could open up a whole new market with the potential for many different business models.

It is also possible that a vehicle could be fitted with both categories of feature, such as a motorway pilot that requires a User-in-Charge, but also an automated valet parking function that does not. In this example, the human in the driving seat would become a User-in-Charge when the vehicle was driving itself on a motorway, but that person would become a normal driver off the motorway. Whereas when the vehicle was parking itself, the driver could defer their responsibilities to the appropriate NUiC operator. The regulatory framework can accommodate vehicles with either UIC or NUiC features, or both.

We also recognise that the ASDE and NUiC Operator roles may be performed by the same entity, particularly for early deployments. We are exploring whether it would be useful to identify another entity – a Combined Authorised Self-Driving Operator (CASDO). This would accommodate a situation where two organisations, fulfilling the role of ASDE and NUiC Operator respectively, are working closely together. We believe this may help streamline regulatory approval for these partnerships.



#### 2.2.4 Continuous learning

Under the proposed legislative framework, before any self-driving vehicle is allowed to drive itself on our roads, it must go through two stages. It must first meet appropriate technical safety standards, for example UNECE Regulations or GB vehicle type approval standards for automated vehicle technologies. It must then be 'authorised' to drive itself by government.

Once authorised, a UiC vehicle would be able to lawfully drive itself on public roads in authorised circumstances. Any vehicle authorised with a NUiC feature could only have that feature engaged under the oversight of a licensed NUiC operator, and subject to conditions set at authorisation. For NUiC vehicles that will be used to provide a public service, an additional permit would be required to ensure public service requirements are met, similar to taxi or bus licensing.

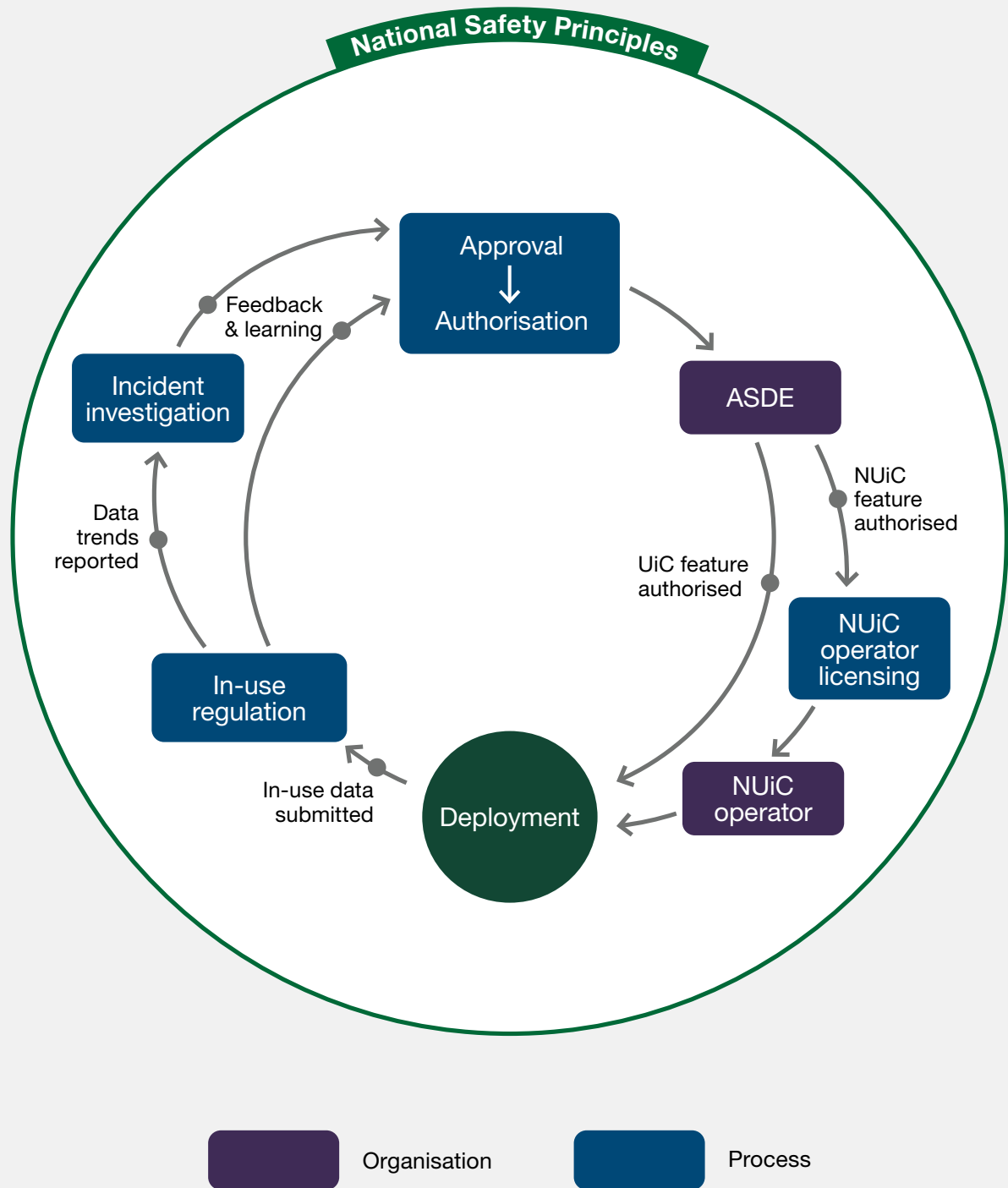
However, self-driving technologies are new and developing, and it is likely that deployment at scale will bring new understanding to help develop new ways to improve self-driving vehicle safety. The proposed new regulatory framework will deal with this – via a system of continuous learning.

Once deployed on the road, the behaviour of the self-driving vehicle would be subject to in-use regulation. ASDEs and NUiC operators would be required to provide safety data to the in-use regulatory scheme. Though one aim of in-use regulation is to take action against ASDEs and NUiC operators when things go wrong, it also provides a powerful opportunity to improve learning. Data and learning from the in-use regulatory scheme will be fed back into the authorisation scheme, as well as wider vehicle approvals, and, if appropriate, learnings might be shared with ASDEs or NUiC operators.

Data may also be provided to the government's proposed Road Safety Investigation Branch<sup>22</sup> in the event of a specific incident of concern or the emergence of a particular trend in the data. The RSIB would have discretion to investigate, and the outcome of any investigation would feed back into the authorisation and in-use regulation schemes.

Figure 5 shows the detail of the continuous safety feedback loop. It shows how the different organisations and processes interact, and demonstrates the difference in the requirements for the two categories of self-driving features (UiC and NUiC).

Figure 5. The self-driving vehicle safety framework – detail

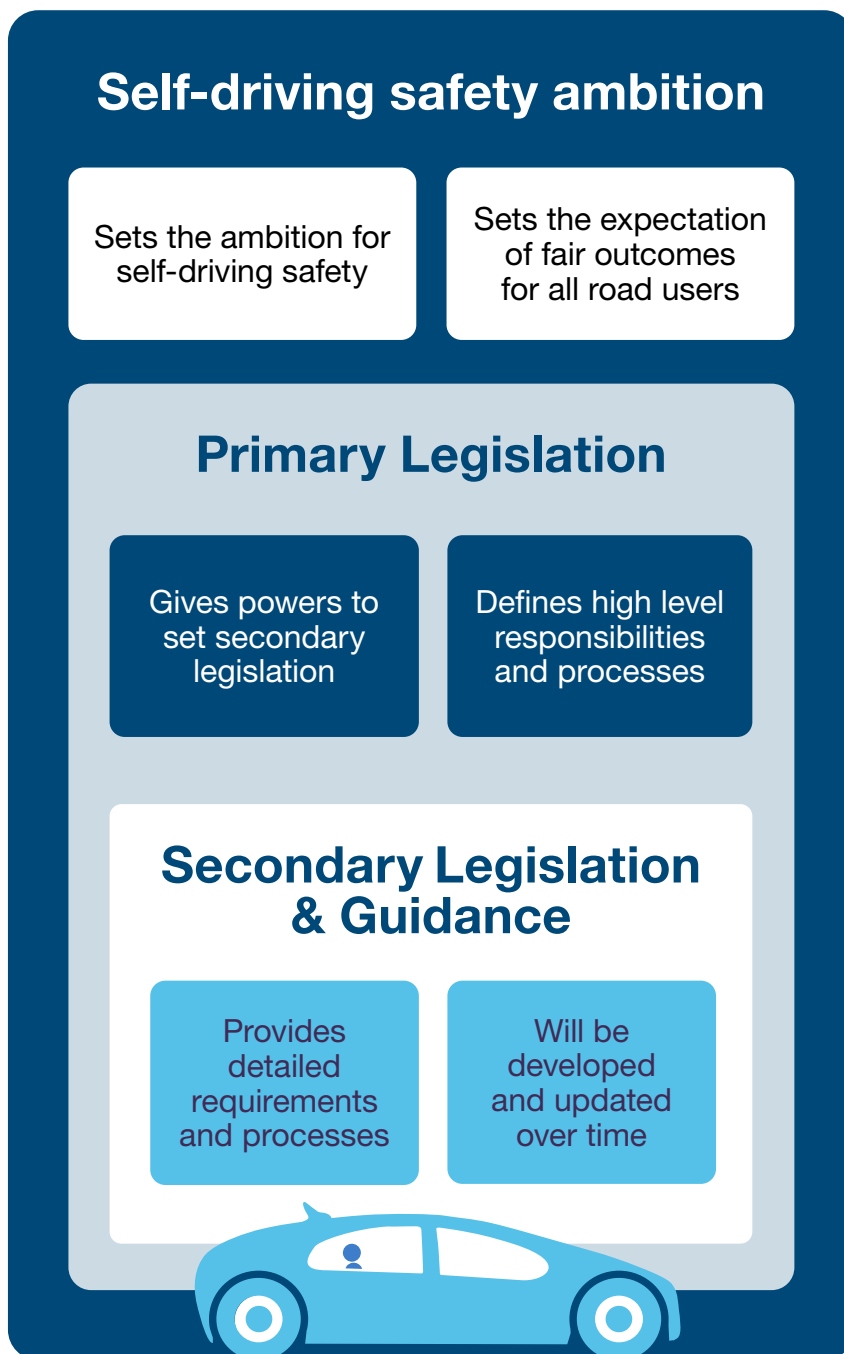


### 2.2.5 Enabling regulations

In order to implement the new self-driving safety framework, a new regulatory structure is needed. Primary legislation

will provide the foundation for this new structure. Secondary legislation will provide the frame, and guidance the internal layout. The safety ambition will act as the planning guidelines.

Figure 6. The relationship between the self-driving safety ambition, legislation and guidance

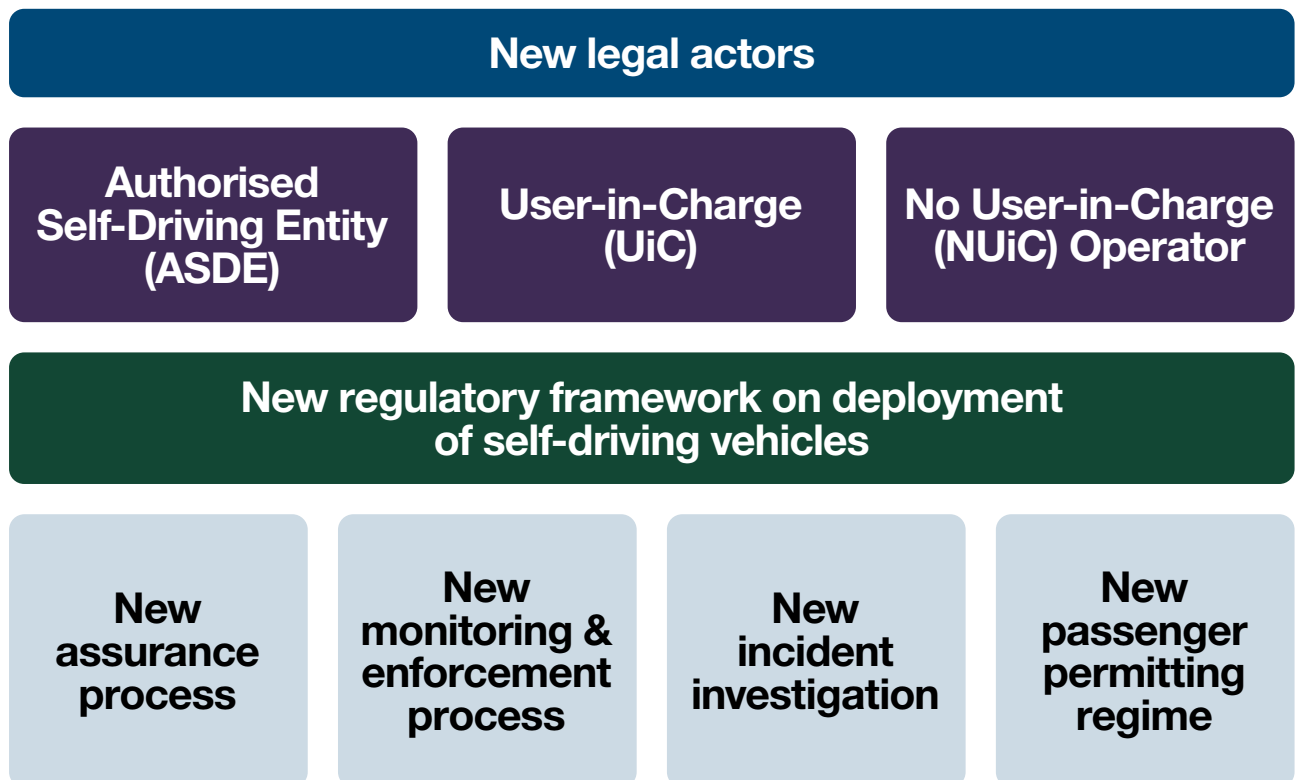


### New primary legislation

The Law Commissions identified the need for new primary legislation in order to ensure the safe and responsible deployment of self-driving vehicles. This is intended to be taken forward as part of

the Transport Bill which will be laid before Parliament in the 2022-23 session. It is government's intention that this primary legislation will create new legal actors and provide powers for new processes, including authorisation and in-use regulation (see Figure 7 below).

**Figure 7.** Key elements of the proposed primary legislation



### New secondary legislation and guidance

Government's intention is to develop secondary legislation that will establish the detailed process by which an ASDE obtains authorisation for their vehicle(s) and the process by which a NUiC operator receives a licence. This will include the requisite fees, evidence required, and appeals process. We also expect to publish further guidance on what constitutes a sufficient safety case by ASDE and NUiC operators, leaning on the CDEI's recommendations.

We intend to set out the National Safety Principles in statutory guidance, much as The Highway Code is presented today. They will clearly state how government will assess the safety of self-driving vehicles at the point of authorisation and beyond.

Likewise, we will detail the operational processes of the in-use regulatory scheme, including data requirements, such as what ASDEs and operators must submit, and how that data is disclosed to insurers where appropriate for them to meet their obligations under AEVA 2018.

We also expect to publish guidance to support compliance with the in-use regulatory scheme. Details of the passenger service permitting scheme are intended to be set out through secondary legislation, including what evidence applicants must submit to receive a permit and how they can demonstrate that the appropriate local authority has consented to the service.

We will also set out technical standards for automated vehicles as part of the GB type approval scheme. These standards will set clear requirements in relation to the performance and safe use of new automated vehicles with the intention of supporting (though not guaranteeing) a decision to subsequently authorise the vehicle as self-driving.

Regulations may also be supported by non-regulatory standards, that set out best practice. These are particularly useful in the early stages of technology development. There is detail on the work being done in the field of industry standards on page 46.

### **2.2.6 Government safety assurance processes**

To implement the new self-driving safety framework, government must introduce new safety assurance processes and update existing processes. Safety assurance is the process by which an organisation gains adequate confidence that a product, service, organisation and/or system achieves acceptable levels of safety. Safety assurance is therefore conducted by both private organisations and by government. This section sets out the work that government is doing to provide confidence in the safety of self-driving vehicles, for example developing technical requirements to be used in regulations, preparing the Department for Transport's

Motoring Agencies for different assurance processes and determining what will be needed to support drivers/users of the new technology. It also sets out the support that government is providing to industry to develop best practice in the safety assurance of self-driving vehicles.

### **CAVPASS**

CAVPASS (Connected and Automated Vehicles: Process for Assuring Safety and Security) is a programme of work launched by government in 2019 in response to the Law Commissions' first consultation paper on safety, which received overwhelming support for new safety assurance processes. In recognition of the breadth of issues that affect road and vehicle safety, CAVPASS has been designed to consider the wide range of government processes and systems that contribute to safety assurance.

The aim of CAVPASS is to put in place the processes, systems and capabilities necessary for government assurance of the safety and cyber resilience of connected and self-driving vehicles by 2025. The programme covers all road vehicle types and the whole life of the vehicle: development, manufacture, use and end-of-life.

Although CAVPASS is led by CCAV, the CAVPASS team includes staff from across DfT and its Motoring Agencies (Vehicle Certification Agency, VCA; Driver and Vehicle Standards Agency, DVSA; and Driver and Vehicle Licensing Agency, DVLA) as well as from other government departments and their agencies including Innovate UK, National Cyber Security Centre, NCSC; and the Law Commissions. The team's skills are wide-ranging and include engineering, social



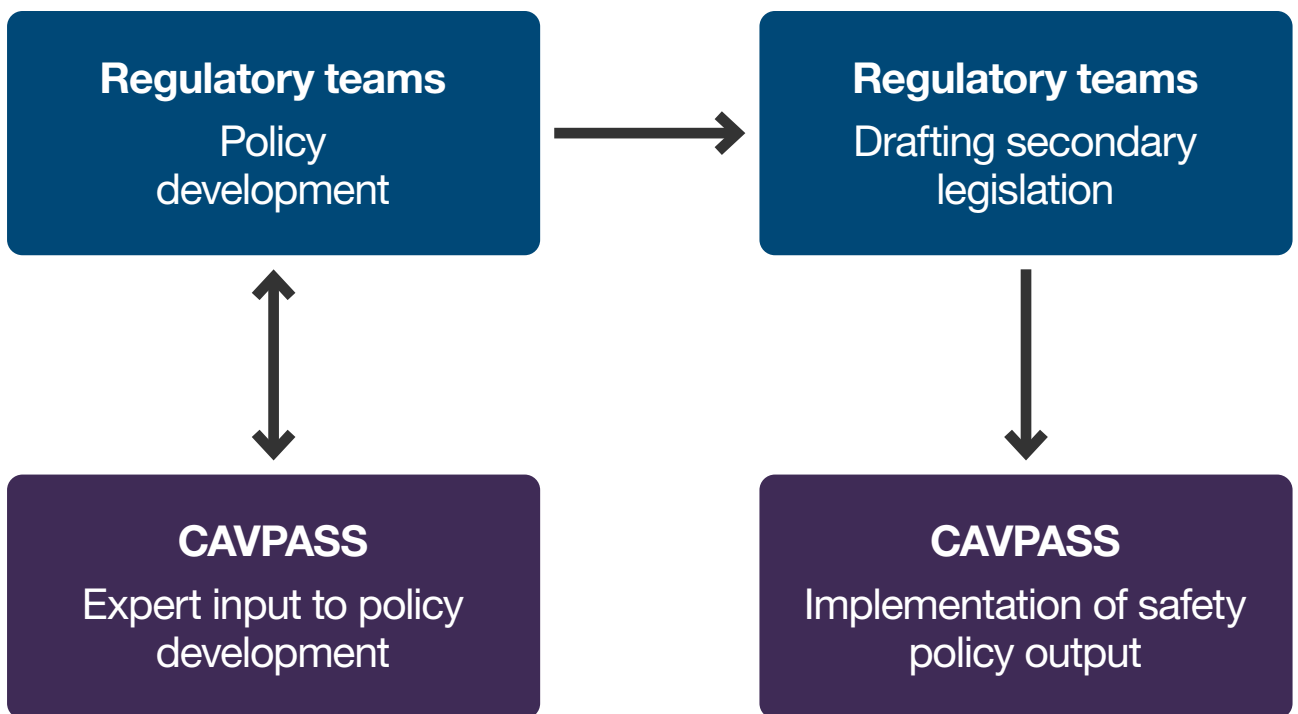
behavioural research, cyber security, policy development and regulation. Continued government skills development is a critical part of CAVPASS.

CAVPASS' work to date has covered a wide range of issues and topics. Annex E provides further information on some of the projects.

Since the publication of the Law Commissions' recommendations, the structure and content of CAVPASS has been reviewed to ensure that it covers

the issues and processes needed for the new safety framework. The CAVPASS team will work closely with the regulatory teams as they develop the detail needed for secondary legislation. CAVPASS is providing expert input into this detailed development and, once the policies and processes are finalised, CAVPASS will ensure the implementation of the processes (see Figure 8). These processes will be undertaken by DfT's Motoring Agencies. The CAVPASS workstreams are shown in Figure 9 and set out in further detail in the sections below.

**Figure 8.** The relationship between CAVPASS and regulation

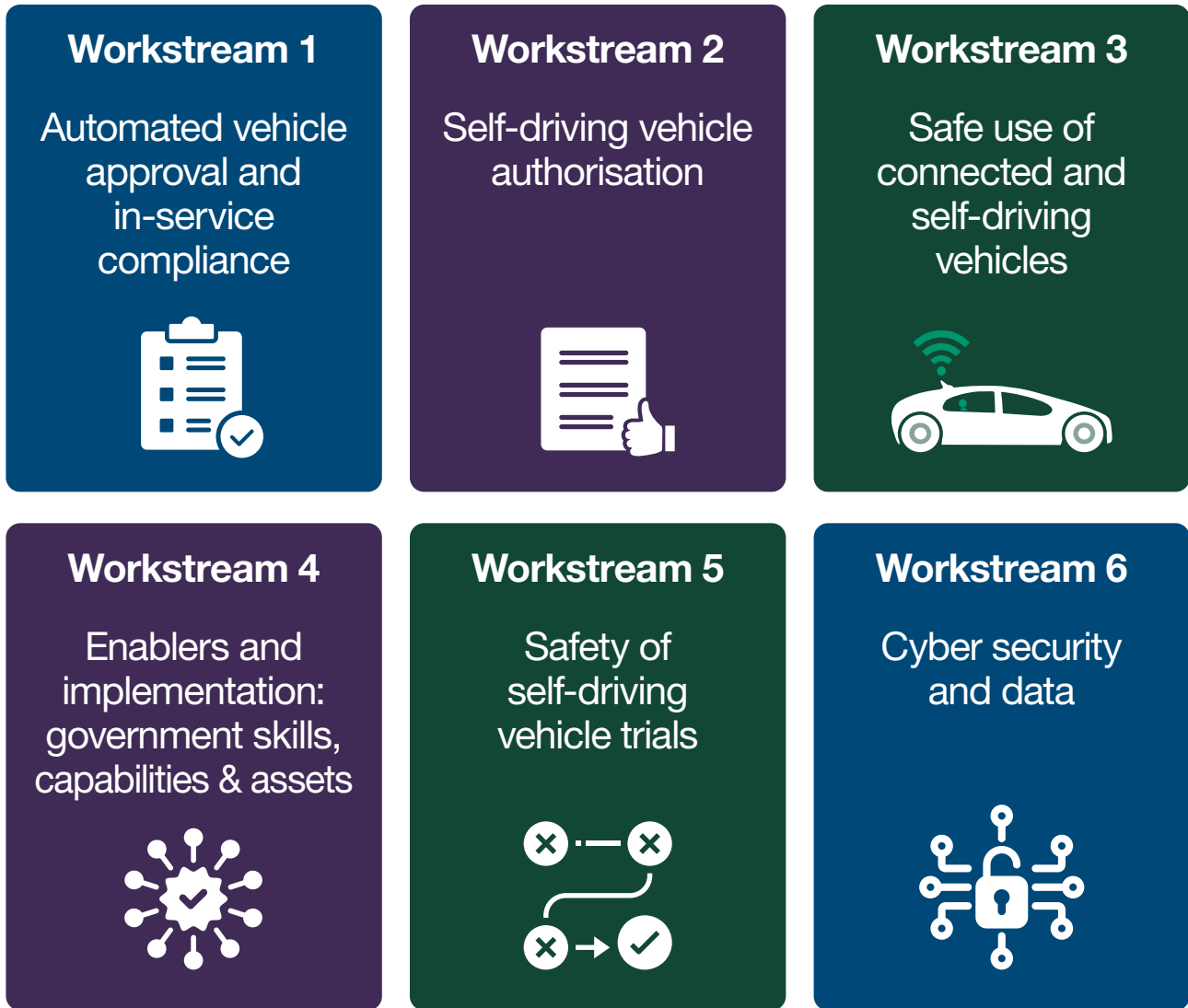


CAVPASS is supported by an Expert Advisory Panel (EAP) which was formed in May 2021 to provide advice and challenge to the CAVPASS programme<sup>23</sup>. Members of the EAP are drawn from outside government to provide input from a range of perspectives and bring expertise

from different sectors. EAP membership aims to cover academia, industry and representative organisations as well as drawing on expertise on relevant subjects such as safety assurance, cyber security, simulation, human-machine interface, public engagement, accessibility, etc.



Figure 9. CAVPASS workstreams



**CAVPASS Workstream 1:  
Automated vehicle approval  
and in-service compliance**

The purpose of this workstream is to develop the technical requirements, assessment methods and processes needed to support the safe trialling of automated vehicles (see Workstream 5), provide pathways to the authorisation decision to permit automated vehicles to drive themselves (see Workstream 2), and to subsequent safe use (see Workstream 3). The principal output of this workstream

will be a GB approval scheme enabling automated vehicles, in line with the Law Commissions’ Recommendation 8 (see Annex C).

In the summer of 2021, this workstream initiated a programme of research to help address some fundamental challenges identified, and to develop some of the foreseen supporting tools required for this workstream. This research phase was framed in the context of low-speed vehicles, which do not have a conventional driving position or driver controls. This use case

was identified as a priority due to the high level of interest in deployment of these vehicles in GB, the local context in which they would be deployed, and the lack of regulatory development in this area at international level. However, many of the learnings from the research phase are expected to be applicable to other use-cases and the outputs of this workstream will be developed with the aim of ensuring compatibility with other use-cases.

The programme of research consists of five work packages. Key activities across the five work packages include:

- Developing requirements for an automated driving system fitted to an automated vehicle, including identifying key safety expectations for an automated vehicle, and safety management systems covering best-practice safety procedures and practices for developers of automated vehicles.
- Identifying The Highway Code rules relevant to the use case, and classifying these rules by expected behaviour of the vehicle and a given scenario, and how compliance with these rules can be verified.
- Considering the role scenarios can play in evaluating safe behaviour of an automated vehicle, exploring multiple scenario generation methods and using these methods to create and store scenarios.
- Developing a toolchain to allow conversion between different scenario description languages.
- Identifying options for crashworthiness and occupant protection requirements for low-speed automated vehicles.

- Identifying key processes and data requirements to ensure that the safety performance of automated vehicles, once authorised as self-driving and placed in service, can be validated throughout the deployment life of the vehicle.

The research phase will conclude in July 2022 and, beginning in the summer of 2022, this workstream will transition to reviewing outputs from the research phase and developing a safety assurance framework.

### **CAVPASS workstream 2: Self-driving vehicles Authorisation**

The authorisation workstream was introduced to CAVPASS in response to the Law Commissions' recommendations. It is considering issues such as: the registration of an ASDE; the possible 'deployment conditions' to set on self-driving vehicles; what evidence must be provided by an applicant ASDE for authorisation; how an ASDE demonstrates on-going compliance; and the detailed administrative processes for authorisation.

### **CAVPASS workstream 3: Safe use of connected and self-driving vehicles**

Workstream 3 is considering the wide range of issues, beyond the vehicle itself, that contribute to safety. In particular, the way in which human drivers, passengers and other road users understand and interact with self-driving vehicles. For example, this workstream is reviewing whether changes are needed to driver training and licensing, and whether further additions or changes to The Highway Code are necessary. To support this, the workstream will include research into Human-Machine Interface (HMI) and interaction, safe behaviour when using a self-driving vehicle and safe

interaction with those outside the vehicle (e.g. vulnerable road users and other vehicles).

Other issues such as the implications of self-driving vehicles for insurance will also be considered, and the development and implementation of the NUIc operator licensing scheme is part of this workstream.

Workstream 3 will continue to support communication with drivers, other road users and the public on the safe use of self-driving technologies through the AV-DRiVE group. Further information on AV-DRiVE is provided in Chapter 4 on public understanding.

#### **CAVPASS workstream 4: Enablers and implementation**

Workstream 4 aims to ensure that government has the skills, capabilities, and access to assets needed to deliver and implement the safety assurance programme. Work includes the development of training modules for government experts (for example on machine learning and artificial intelligence), government recruitment of specialist staff, and exploring issues such as access to databases of scenarios for simulation.

This workstream also covers the development and implementation of the in-use regulation scheme. Specifically, it will look at how government manages information shared by ASDEs and operators to meet expectations set through the National Safety Principles, how existing enforcement activities conducted by DfT can be adapted to accommodate self-driving vehicles, including the investigation of traffic infractions, and the skills required for both these activities.

#### **CAVPASS workstream 5: Safety of trials**

Workstream 5 aims to support safe trialling of self-driving vehicles on our roads and to ensure the UK is industry's trialling destination of choice, building on the Code of Practice: automated vehicle trialling<sup>24</sup>.

The Code of Practice was updated in 2019 and committed to develop a process for supporting advanced trials. Support is being provided by a team of experts from CCAV, DfT, VCA, DVSA and DVLA. Each enquiry is being dealt with individually because each trial and set of circumstances is different. However, where common themes emerge, government will publish further guidance.

This workstream will also consider the safety and regulatory issues associated with remote driving in relation to the development of self-driving vehicles, as well as the challenge of clarity of responsibility in the period ahead of new legislation and the implementation of the new safety framework (see box below). In addition, this workstream will develop a process for safety case audits of government-funded trials – building on work so far (see Annex E) – to ensure both safety best practice and to provide learning for government and industry in the management and assessment of self-driving vehicle safety.

## Safe trials and early deployment

More complex trials and early deployment of self-driving vehicles, ahead of the implementation of the new safety framework set out in this chapter, must be carefully considered and supported if the UK is to reap early benefits from these technologies.

Discussions with trialling organisations have highlighted two potentially significant points that are likely to be common to many trialling organisations as their technology develops. The first is about trialling with a safety driver outside the vehicle (known as remote driving, external operation or teleoperation) and the second is how self-driving vehicles can be listed if they meet the definition in the Automated and Electric Vehicles Act 2018 (AEVA) prior to wider legislative change.

### Remote driving

While current UK law does not require a driver to be in the vehicle (and the Code of Practice makes this clear), there are numerous responsibilities placed on a driver that would most likely fall to a safety operator (e.g. not leaving a vehicle unattended). These have not been tested in Court and could be difficult to achieve in practice if done remotely.

Government is working with trialling organisations to consider the interpretation of existing legislation and, where necessary, have extensive powers to grant exemptions from construction and use regulations if this is considered safe and appropriate. These powers are part of government's toolbox to support future innovative trials as they move towards self-driving. As this is a new application of the exemption powers, exemptions are being considered on a case-by-case basis. Where common themes in interpretation and exemption are identified, further guidance will be provided.

In order to provide greater clarity on remote driving and provide a firm legal footing going forward, the Department for Transport has asked the Law Commission of England and Wales to undertake a piece of work to clarify the legal status of remote driving under current law and draw conclusions on its regulation<sup>25</sup>. They are currently inviting public view following the publication of their issues paper.

This is a rapid review which aims to draw tentative conclusions by the end of the year and publish advice to UK government by January 2023. Although the impetus for this work has come from the use of remote driving in the development and trialling of self-driving vehicles, the conclusions of the work will apply to remote driving of any road vehicle.

Remote driving also raises a number of safety issues. For example, high quality connectivity across the operational domain is likely to be safety-critical, and remote driving may introduce novel cyber security risks. Government is working with industry to consider the technical safety issues relating to remote driving.

## Early Deployment

Trialling of a self-driving vehicle with a safety driver is already possible on any UK road, providing the opportunity to safely test new technology in real-world situations. Once a vehicle no longer requires a safety driver either inside or outside the vehicle for its safe operation, it may meet the definition of a self-driving vehicle, as set out in the Automated and Electric Vehicles Act (AEVA) 2018.

AEVA defines a self-driving vehicle as one that is capable of safely driving itself without the need for monitoring or control by an individual and requires the Secretary of State for Transport to make a list of any such vehicles. Although the primary purpose of the definition is for insurance, it has provided the basis for considering how government will ensure the safe use of self-driving vehicles on GB roads, with the first use case likely to be vehicles that meet the requirements of the UN Automated Lane Keeping System (ALKS) Regulation.

It is the government's view that the occupant(s) of a vehicle that is listed by the Secretary of State is that they are not responsible for how the vehicle drives, does not need to monitor it and may turn their attention away from the road, provided the vehicle is driving itself in a valid situation. This is reflected in the new section on self-driving vehicles in The Highway Code. This approach aims to ensure that the driver or occupant of a self-driving vehicle is not held unfairly responsible for the vehicle's actions.

Clarity of legal responsibility for self-driving vehicles will be provided through primary legislation, as set out in this chapter. Government is working with trialling organisations and wider industry ahead of legislation to consider how best to manage and mitigate legal risks to ensure advanced trials and early deployment are supported.

Government will continue to support individual trials through CAVPASS workstream 5 and will consider the need to publish further guidance on trialling and early deployment.

### **CAVPASS workstream 6: Cyber security and data**

This workstream aims to ensure appropriate consideration of cyber and data security by developers and operators of self-driving vehicles, ensuring an appropriate level of cyber resilience. International cyber security regulations for vehicles (set at the UNECE)

will apply to self-driving vehicles and set out technical specifications. These regulations are being introduced into our national regulatory requirements. This workstream will consider what additional requirements may be needed for self-driving vehicles in addition to those provided in the UN Regulations. This will consider:



- Whether there are any legislative issues to conducting cyber research and development;
- What additional legislative cyber security requirements may be needed. This will consider the functions that enable a vehicle to be self-driving and whether the current UN regulation is sufficient to ensure that vehicle manufacturers adequately manage the risk of a cyber-attack. If it is not sufficient, this work will consider what additional requirements could be set;
- Whether any requirements are needed to facilitate forensic investigations should a cyber incident occur.

More broadly, DfT will work with partners across government to help industry understand and manage the cyber security risks to networks and information systems which arise from dependencies on external suppliers. DfT will ensure wider national security risks to the sector through foreign investment are addressed through the National Security and Investment Act 2021, while continuing to promote the UK as a great place to do business.

### Industry standards

The British Standards Institute (BSI) has been working with industry partners, local authorities and academia to develop a number of publicly accessible specifications (PASs) – a type of fast-tracked standard – related to self-driving vehicles<sup>26</sup>. These specifications set out good practice, and are reviewed over time to ensure they remain fit for purpose.

To date these specifications have largely focused on areas connected with safe trialling and development of self-driving vehicles covering topics ranging from operational risk management, to data collection and guidance on safety operators. The specifications have been adopted by developers to help ensure good safety practice in real-world trials. Wider BSI or ISO standards may also be useful in certain areas, for example when considering requirements for data or infrastructure.

Specifications and standards can provide a level of detailed technical or operational guidance that might not be appropriate in regulation. They can be used to support compliance with regulation, or be used alongside regulation as a means of industry demonstrating that good practice is being followed. Standards can be more easily and quickly updated and changed to reflect changes in technology, practices or terminology, which is particularly relevant for technologies such as self-driving that are developing rapidly.

Standards can also provide guidance to industry while regulation is being developed. Although there is a risk of divergence if standards and regulation are developed in isolation. To help minimise this risk BSI, the UK's National Standards Body, and its committees represent UK interests in the development of global standards in the self-driving vehicle areas via bodies such as International Standards Organisation (ISO). Some of BSI's PAS documents have been used to inform the direction of standardisation globally in relation to critical taxonomy for self-driving vehicles, for example PAS 1883 on Operational Design Domains.



# Securing the industrial and economic benefits of CAM

## This chapter explains how the UK is positioning itself to capture its share of the global CAM market.

It provides a response to the 2021 call for evidence on the future of CAM in the UK and describes how government will support industry's transition to commercialisation, including through a new £66 million 'Commercialising CAM' Programme of BEIS R&D funding. The chapter then sets out the UK's role in CAM trade and investment, including the opportunities available and government's plan for international engagement.

### 3.1 Responding to the call for evidence on the future of connected and automated mobility in the UK

The UK CAM sector has moved forward substantially since government's previous formal engagement in its role in supporting innovation, with technologies and services moving steadily from the R&D phase towards market entry. For this reason, we took the opportunity in June 2021 to refresh our evidence base in this area, exploring what – if any – role government had in the CAM sector as it approached market readiness. We invited the ecosystem to give its views on how CAM supports some of the government's key objectives, areas where the UK can be globally competitive, and the role that government can play to help ensure continued development, testing and deployment

of the technologies developed by UK companies within emerging global supply chains.

#### 3.1.1 What we consulted on

The purpose of the call for evidence is to strengthen government's understanding of the Future of CAM in the UK to:

1. Identify areas of expected UK competitive advantage in the future global CAM supply chain, and early opportunities for commercialisation.
2. Understand if there is still a case for government support beyond its regulatory function, and – if so – build up evidence for this, with a focus on where government support can be most effective in securing a larger share of the future global market in CAM services.
3. Identify if and how CAM technologies can support wider government priorities such as net zero, levelling up, and a strong economic recovery from COVID.
4. Understand if and how investment in CAM can help support future proofing of the UK's existing automotive, logistics and wider mobility industries, recognising the value chain will shift towards these technologies in the longer term.

5. Identify any cross-cutting opportunities on CAM with other modes such as aerospace, defence and maritime, and what international best practice can inform UK policy development.

### 3.1.2 Responses received

Fifty-five organisations responded to the call for evidence, with representation from across the CAM ecosystem (Figure 10).

A summary of responses from this call for evidence, giving further information on the perceived strengths and threats to the UK CAM ecosystem, as well as sector priorities for the next ten years, can be found in Annex F.

### 3.1.3 Government's response

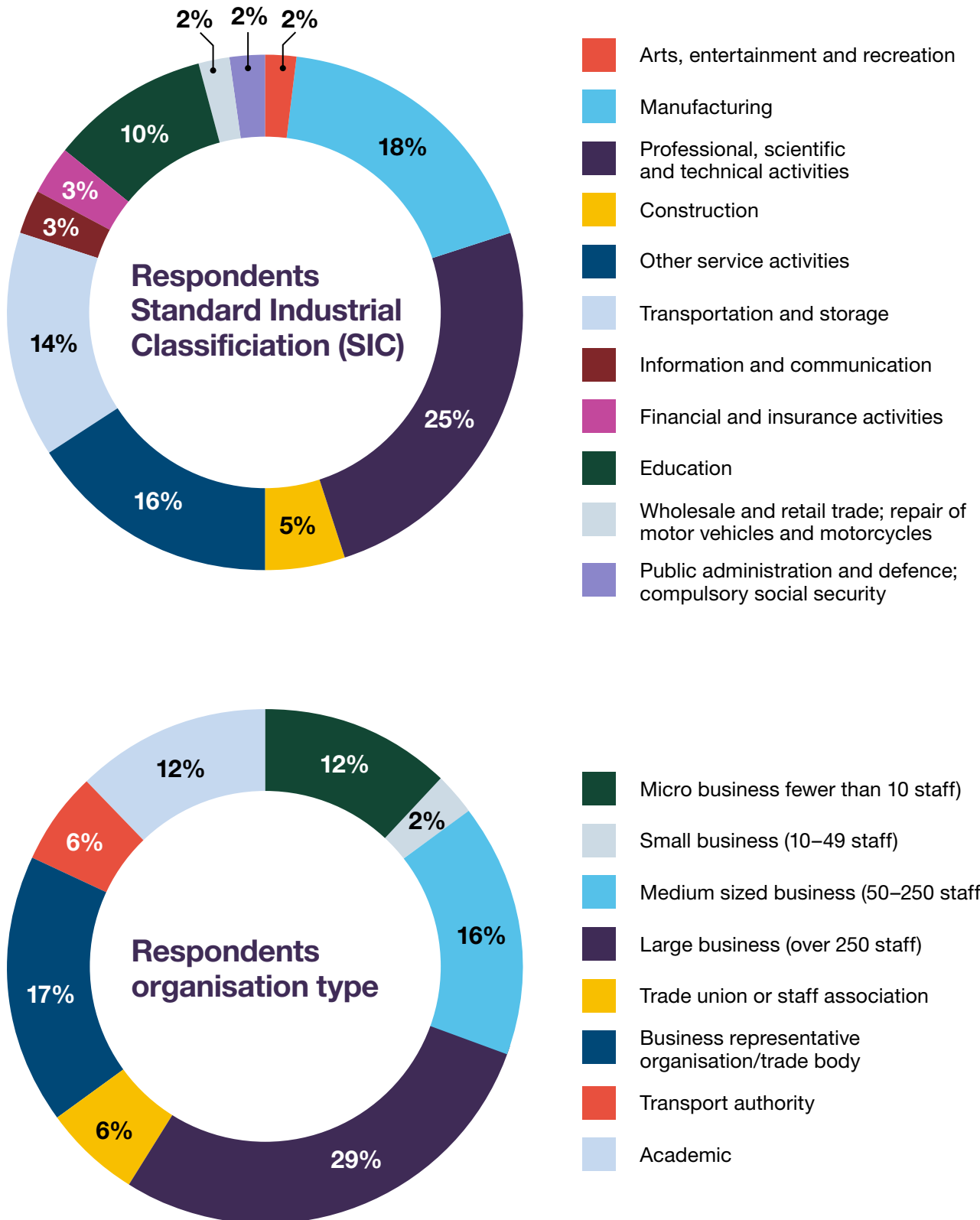
The call for evidence provided crucial insights into the economic, industrial and societal benefits of CAM and how the technologies can support government priorities. Responses also made clear the current and future opportunities and threats facing the UK sector as it seeks to scale up and commercialise technologies and services.

Stakeholders were clear that they felt government still has an important role to play in securing the UK's reputation as a leading destination to develop and deploy CAM. We have analysed the CAM sector's priorities up to 2030 and industry views on where government should focus our efforts to help secure the economic and industrial benefits of CAM.

We are grateful for the interest, support, and detailed feedback that we have received, despite the backdrop of a very challenging time for many organisations and individuals. We encourage all interested stakeholders to continue to engage with us as we work to make the UK the best place in the world to develop and deploy CAM technologies and services.



Figure 10. Graphical breakdown of respondents



The role of the government in supporting UK CAM

Table 2: Government action in response to the 2021 call for evidence into the ‘Future of CAM’

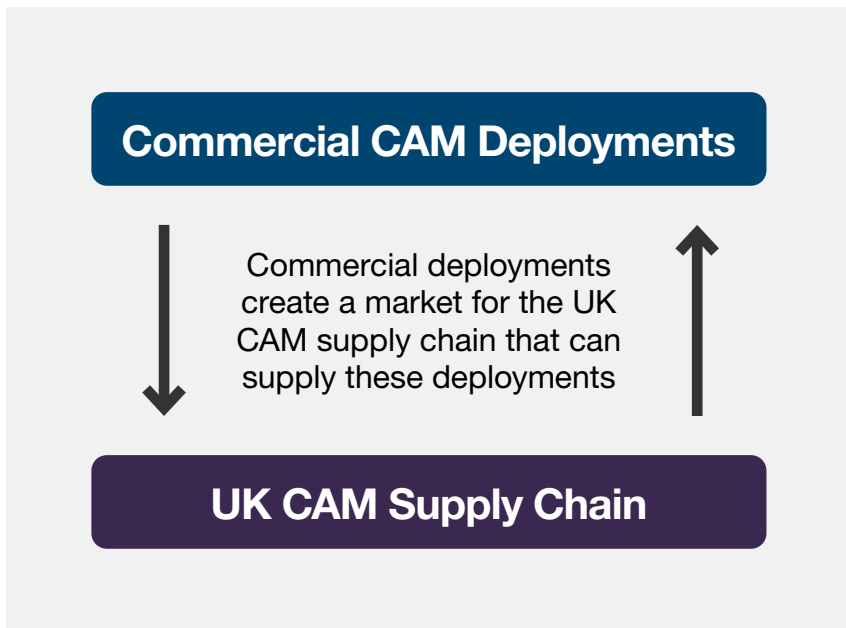
Theme	<p><b>Setting a clear vision and strategy for CAM in the UK:</b> Respondents advised that government should refresh its vision for CAM, setting out clearly to industry, investors, and the public what it wants from the technologies and how it will be delivered. This, it was argued, would inspire confidence for those investing in, or establishing themselves in the UK CAM sector.</p>	<p><b>Providing a comprehensive regulatory landscape that enables commercialisation of the technologies:</b> Respondents encouraged government to continue its focus on establishing a comprehensive legislative and safety framework that will enable the commercial use of CAM as soon as possible.</p>	<p><b>Providing financial support to stimulate innovation:</b> Respondents noted that the move towards commercialisation of CAM technologies and services requires both ambition and a healthy appetite for risk from private sector investors. Government can play a key role in encouraging commercialisation by de-risking investment, accelerating the readiness of CAM technologies and stimulating private investment to enable commercially successful CAM deployments in the UK.</p>	<p><b>Encouraging the training and skills that can serve a successful CAM sector:</b> The availability of the right skills and training to operate a thriving CAM ecosystem was considered by respondents as a significant threat to the future success of the sector. Government was urged to ensure that the work being undertaken by the Department for Transport (DfT), Department for Business, Energy and Industrial Strategy (BEIS), and the Department for Education (DfE) on future skills also addressed CAM.</p>	<p><b>Facilitating collaboration between industry, academia, and the public sector:</b> Respondents urged government to continue to act as a highly engaged partner to the UK CAM ecosystem, encouraging collaboration within the sector that has enabled the UK to punch above its weight internationally to date. This includes helping to bring together potential customers of the technologies – for example the freight and logistics sector – with the CAM ecosystem.</p>	<p><b>Working with the public to increase awareness and understanding of CAM:</b> Respondents highlighted that public trust in CAM is critical if the UK is to secure the benefits of CAM technologies and services. Government was encouraged to continue its social behavioural research and consider how it can help industry increase user understanding and acceptance of CAM.</p>
Government Action	<p>Government has, in response to the call for evidence, undertaken to publish this policy paper which sets out our vision and next steps for CAM in the UK.</p>	<p>Government has committed to creating a comprehensive legislative and safety framework that will support the safe commercial deployment of CAM in the UK, as set out in chapter 2 of this policy paper.</p>	<p>Government will fund a new 3-year Commercialising CAM R&amp;D programme, following the Spending Review 2021. Plans are set out further in the next section: ‘Supporting industry’s transition to commercialisation’.</p>	<p>Government will, through its new Transport Employment and Skills Taskforce, explore the future skills needed across the transport sector, including in vital tech specialisms such as artificial intelligence and cyber security; and identify actions to ensure skills and employment programmes can meet those needs. We will continue work, led by Department for Digital, Culture, Media and Sport (DCMS) to address the demand for digital skills, supported by CCAV’s expertise and connections to the CAM ecosystem. We are taking steps to increase the skills pipeline through DfE’s work, such as the introduction of various qualifications like Digital T Levels and Digital Apprenticeships. We have also introduced more flexible training routes into digital roles, including the choice of 33 different digital qualifications through “Free Courses for Jobs”.</p>	<p>Government will continue to encourage engagement between organisations in the CAM ecosystem, supporting the crucial work that organisations and groups such as Zenzic, the UK Automotive Council, CAM Testbed UK Society of Motor Vehicle Manufacturers and Traders (SMMT) and Automotive Electronics Systems Innovation Network (AESIN) undertake.</p>	<p>Government will continue our Social and Behavioural Research Programme and public engagement opportunities as set out in chapter 4. These will include deliberative research and engagement roadshows across the country, as well as the development of educational content to improve public understanding of self-driving vehicle technologies.</p>

### 3.2 Supporting industry’s transition to commercialisation

Government will ensure the UK builds upon progress made to date by shifting emphasis from developing CAM technologies towards their commercialisation. Our approach is supported by both the call for evidence and extensive engagement with the CAM ecosystem during the development of the government’s 2021 Comprehensive Spending Review process.

In practice, this will mean focusing our efforts for CAM innovation towards enabling the deployment of commercial CAM services and providing targeted support for CAM ecosystem capabilities to build a sustainable UK supply chain. Government plan to do this with a dual approach, as set out in Figure 11 and discussed in detail in Section 3.2.1 on the new ‘Commercialising CAM Programme.

**Figure 11.** Government will aid industry’s transition to commercialisation via a dual approach, de-risking early commercial deployments and services, and strengthening UK supply chain capabilities.



## Case Study: CAM Testbed UK

At the core of the UK's CAM offer is CAM Testbed UK, a comprehensive and coordinated set of six world-leading facilities, in which government and industry have invested around £200 million. CAM Testbed UK offers an environment for the modelling, simulation, testing, and trial deployment of connected and automated mobility solutions. It is the only place worldwide at which any company can take ideas from concept to development and deployment, both virtually and physically, all within a 3-hour drive. CAM Testbed UK is coordinated by Zenzic and backed by significant players globally.



The six CAM Testbed UK sites, spreading geographically from around Birmingham to London.

ASSURED CAV (HORIBA MIRA and Coventry University) is a globally unique facility that combines the ability to safely assess the limits of CAM vehicles in a controlled, configurable and connected environment. Located at HORIBA MIRA, this integrated CAM ecosystem enables seamless transition from virtual to controlled, to public test environments.



Midlands Future Mobility (MFM) offers a wide range of CAM solutions from a combination of campus (mini-city), urban, rural and highway roads in which trials can be supported. Covering over 200 miles (350 km), MFM's comprehensive trialing environment provides initial virtual development through to real-world trials and market deployment, which includes Safety Pool, the world's largest public scenario database for CAV safety simulations.

Convex, which is operated by University of Warwick, is an open platform for the commercial exchange of data to enhance and accelerate the development of new mobility products and services in CAM. The facility aggregates data from a diverse range of sources such as vehicles, infrastructure, and traffic control.

CAVWAY is the 1st new automotive proving ground to be constructed in the UK for over 50 years. It is a unique automotive facility that will support CAV testing and focus on both road junctions and flexible connectivity. The proving ground is designed for maximum flexibility and includes a multifunctional platform, allowing junctions of many different configurations to be simulated.

UTAC Millrbook-Culham (UTAC and UK Atomic Energy Authority) operates a testbed for the development of CAV technologies across two sites. It is the world's first 5G open testbed for transport, together with unique access to a 2,000-person adult population in a secure site and enables testing to capture human aspects of real-world operation for CAM, including Mobility as a Service (MaaS).

Smart Mobility Living Lab: London (SMLL) is the UK's most advanced connected urban testbed. Using public and private roads in Greenwich and Stratford, London, SMLL safely develops and validates new transport technologies in a real-world connected environment. The testbed offers an urban living lab and semi controlled test environments, plus support for simulation-based testing.

Central to this approach will be government's continued commitment to ensuring that its innovation and regulatory programmes are fully integrated and aligned in both timings and objectives.

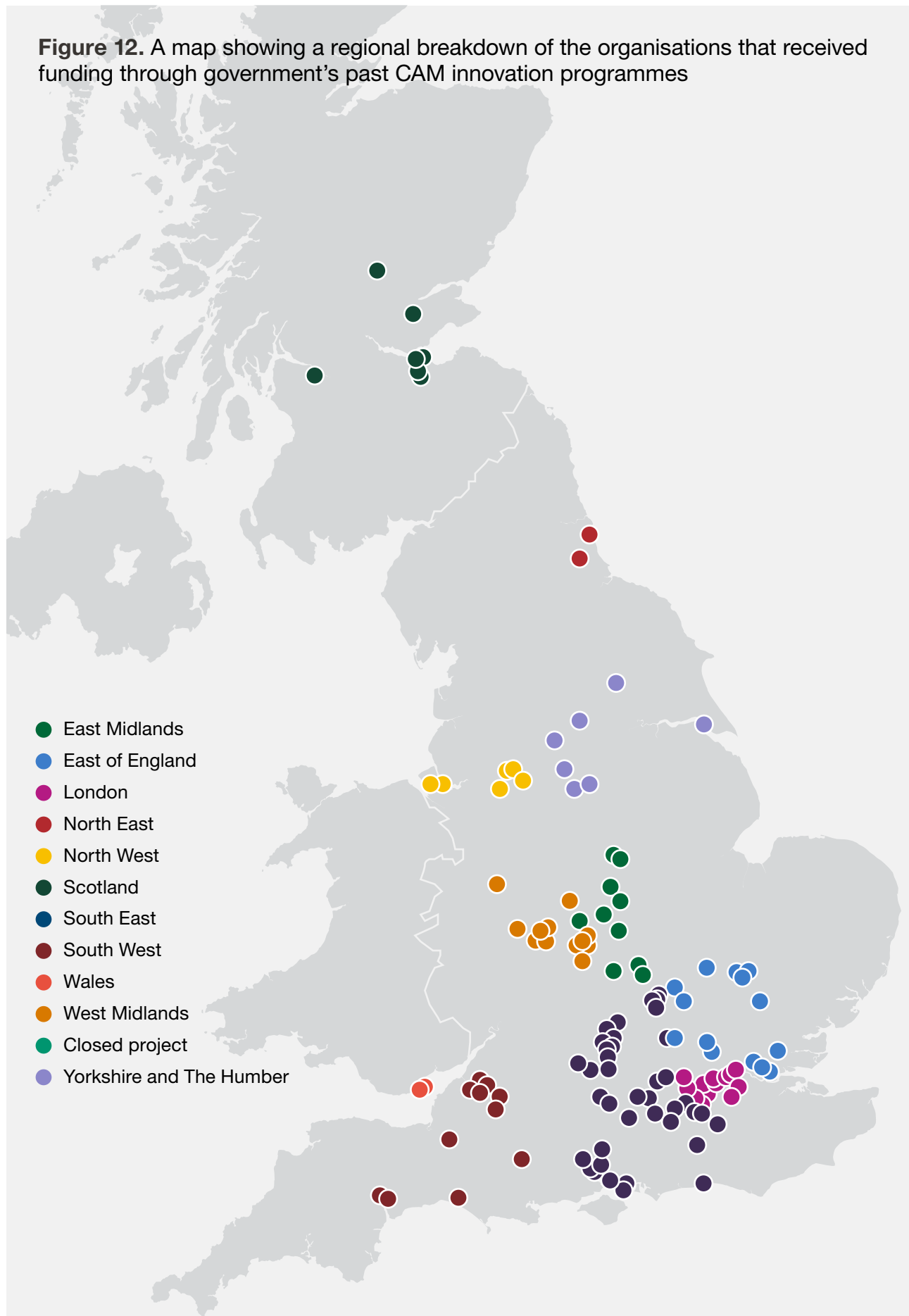
Government's new approach to CAM innovation will focus on securing transformative long-term outcomes for the UK:

- Increased investment for UK PLC: CAM vehicles, technologies, capabilities and services are predicted to be worth £750 billion globally by 2035<sup>27</sup>. The UK share of this value is estimated at £42 billion. UK CAM companies are already attracting significant investment from around the world. Public records show that of the companies who have received government grant funding to date, 35 have secured private investment totalling £790 million. The true level of

investment across the sector is likely to be much higher as this does not include investment in companies who have not received government funding nor the deals that have not been made public. Government's CAM innovation programme will look to amplify private investment in UK CAM companies by helping to accelerate the technology and service readiness levels towards commercial viability.

- Creation of new, high value jobs across the UK: government innovation funding will help to secure current CAM jobs in the UK and create new jobs in the sector as companies scale up operation to serve a commercial market. By 2035, the UK CAM sector could create more than 38,000 new skilled, well-paid jobs across the country in areas such as artificial intelligence, machine learning, robotics, communications, and cyber security/resilience. Figure 12 shows a regional breakdown of the organisations that received funding through government's past CAM innovation programmes: this suggests that the CAM sector already has a fair geographic spread across the UK, although it is still weighted toward the South East of England. Government will look to support the growth of the sector – particularly in the Midlands, Northern England, Scotland, Wales and Northern Ireland – so that jobs and opportunities are shared across the UK. The risk of jobs being displaced by automation should also be acknowledged. It is still too early in the development of these technologies to say what the implications will be, but we are monitoring the impacts closely and we expect any changes to be gradual, over years. Our aim is to ensure that we get the maximum value out of these new technologies, which includes ensuring that they create a mix of sustainable, high quality jobs in the UK, and providing opportunities for reskilling and upskilling those working with them.
- Improved transport outcomes for disconnected regions: government will encourage the establishment of CAM services in regions that have been traditionally underserved by public transport. CAM has the potential to offer new, more affordable and efficient transport options that could in some instances provide an alternative to traditional heavy or light rail infrastructure. Government's past innovation funding on CAM has been spread across the UK and we plan for this to continue with future funding.
- Support the future proofing of the UK's crucial logistics sector: The UK's logistics sector contributes £127 billion<sup>28</sup> to the economy and is becoming an engaged partner for CAM. In line with the Department for Transport's Future of Freight Strategy, government will support logistics companies to work with the CAM sector to establish use cases to support business productivity, mitigate skills shortages and support the move towards decarbonised transport.

**Figure 12.** A map showing a regional breakdown of the organisations that received funding through government's past CAM innovation programmes



## Case Study: CAVForth

Project CAVForth was awarded £4.8m of government funding to demonstrate a globally significant self-driving bus capability across the Forth Road Bridge between Fife and Edinburgh.

A world first, the project began in April 2019 and trials will run for six months from the end of 2022. Using full size, 12m, single deck self-driving buses operating with a safety driver, CAVForth expects to carry 10,000-12,000 passengers per week. It will provide a pilot bus service, in all weathers, using a complex 14-mile route each way, where it will need to navigate lane changes, higher speeds, roundabouts and possible alternative routing due to high winds.



The project consortium is led by Bristol-based Fusion Processing Ltd, which has developed the self-automated driving technology, building on previous government-funded projects. UK bus manufacturer Alexander Dennis is working with Transport Scotland who is providing infrastructure upgrades and management. Edinburgh Napier University and Stagecoach are also working together to do extensive public engagement throughout the trials. They will be engaging with users to understand their experience of the trials as well as areas for improvement for future services.

### 3.2.1 The 'Commercialising CAM' Programme

At SR 2021 government allocated £66 million of new BEIS funding over three years to support R&D that will lead towards commercially sustainable deployments of the technologies and a growing UK-based CAM supply chain, to encourage the development of CAM skills and continue to facilitate collaboration between industry, academia, and the public sector. The outcomes of the 'Commercialising CAM' programme will support the entire CAM ecosystem, encouraging a wide range of market participation, from large OEMs and Tier 1 suppliers to smaller technology developers and micro-businesses.

Delivered in partnership with Innovate UK and Zenzic, 'Commercialising CAM' is the mechanism by which we will take advantage of the UK's global leadership position, cultivating an exciting CAM market that will deliver economic growth and new high value jobs.

The programme and its position within the future of transport agenda will strengthen the wider automotive sector, working toward a resilient sector that can respond to future disruption. It will complement programmes from the government's Automotive Unit, the Advanced Propulsion Centre (APC) and its Automotive Transformation Fund (ATF), the Office for Zero Emission Vehicles (OZEV), Future of Freight, and the UK Shipping Office for Reducing Emissions (UK SHORE).

The programme, which has been developed in consultation with industry, will target intervention in the CAM sector in three key areas:

### **Enabling commercialisable CAM deployments across the UK**

Government launched an open competition via Innovate UK in May 2022, allocating £40 million in R&D grant funding to encourage commercialisable CAM deployments across the UK. Government is interested in supporting projects that move people and goods on public roads, private land, or segregated infrastructure. This could include, but is not limited to, self-driving shuttles that help transport people in areas under-served by public transport, last mile self-driving delivery services that improve customer experience, and self-driving logistics solutions in facilities such as ports or industrial estates. Part funded by government for three years, projects will be selected on their ability to solve a real-life business or transport problem and their potential for future commercial sustainability.

The funding provided is intended to de-risk private sector investment, providing the ‘last piece of the puzzle’ that allows the CAM sector to collaborate with investors and customers (including local or regional authorities, transport providers or authorities, retailers and logistics companies, and ports or other industrial facilities) to develop a service.

### **Securing the building blocks of a successful, commercialised, CAM ecosystem**

Government’s Commercialising CAM programme will provide R&D grant funding for projects that will help the sector to accelerate its technological capabilities and scale up commercial operations. The programme will help to remove barriers to commercialisation and deployment cited in the responses to government’s call for evidence. Funding will be focused

on helping the sector to solve the “last 20% problems” facing the supply chain and prepare companies as they look to accelerate commercial deployment in the UK and expand into global markets. This may be used to improve specific technological capabilities that help overcome barriers to deployment, but also improve innovators’ capacity to move the development of products which are essential for the supply chain towards commercial viability. This workstream will bolster UK CAM capabilities, supporting the development of a sustainable supply chain that can support a thriving CAM service and technology market in the future.

### **Encouraging CAM skills and coordinating the ecosystem**

Work undertaken for government by the Connected Places Catapult in 2020 identified a number of areas that government could address to ensure that the UK CAM sector is able to access required skills in the future. The foremost recommendations included increasing awareness of opportunities in the field and bringing industry and educators closer together.

Government will continue longstanding work to advance the development of vital digital skills, specifically by the DfE and DCMS. CCAV will work with the DCMS and support their work to address the demand for digital skills. These digital skills underpin many of the Ten Tech Priorities, including: Building a Tech Savvy Nation; Unlocking the power of data; Keeping the UK safe and secure; Unleashing the transformational power of tech and AI and; Levelling up digital prosperity across the UK. Also the DfE is taking steps to increase the skills pipeline, such as the introduction of various qualifications like Digital T Levels and Digital Apprenticeships. In addition, government has introduced more flexible training routes into digital roles, including the choice of 33 different digital qualifications through “Free Courses for Jobs” and also the 16 week Skills Bootcamp courses which are being rolled out in the UK.



Government is therefore continuing to support the Institute of Mechanical Engineering's (IMechE) Formula Student AI challenge, which integrates self-driving vehicle technologies with traditional automotive engineering higher education courses. Government support will enable the growth of the competition, allowing more universities to join and for IMechE

to provide sponsorship to students, enhancing the diversity of those taking part in the programme. The AI competition has already benefited more than 300 students since 2018 and we expect this to grow over the next 3 years (with government support) to over 50 universities and more than 1200 students over the spending period.

Government will continue to work with partners such as Zenzic, the UK Automotive Council and CAM Testbed UK to encourage collaboration within the CAM industry, and to support engagement with new markets for CAM, such as public transport, logistics and freight. Government will also continue to build its reputation as a thought leader by monitoring domestic and global CAM developments, undertaking crucial research into the opportunities and challenges presented by CAM (i.e., impact on infrastructure and decarbonisation) and helping promote and showcase the UK CAM sector in target markets. Key projects will include updates to Zenzic's 'UK CAM Roadmap to 2030' that will help to increase confidence and certainty amongst CAM investors, and continued research into understanding global market perceptions of the UK's CAM capabilities.

### 3.3 CAM Trade & Investment

The development of CAM technologies, services, and systems is a global endeavour. In recent years there has been a growing number of companies collaborating and competing across numerous regions and nations: from the West Midlands' automotive heartlands in the UK to California's Silicon Valley, the megacity environments of Shanghai and Tokyo, the

future transport cities of Singapore, Seoul, London, and Copenhagen, as well as the historic automotive centres of Detroit, Munich, and Stuttgart.

The shared achievements of government and industry to date have meant that today the UK is pursuing the societal and economic benefits of CAM from a position of strength, internationally. In 2020, KPMG's Autonomous Vehicle Readiness Index ranked the UK second among G7 economies, leading particularly on policy, legislation, and cyber security<sup>29</sup>. Government wants to leverage the UK's reputation as a leader in the development and deployment of CAM technologies to attract investment from around the world into the UK supply chain and support the export of homegrown technology and services.

This will be supported by the UK government's broader vision for an independent Global Britain that is pursuing the new opportunities that arise from becoming a sovereign trading nation, following the UK's decision to leave the European Union. Crucially, our trade and investment workstream will be underpinned by trade policy, investment and export support, led by the Department for International Trade (DIT).

Government's plan for driving international engagement on CAM and encouraging global trade and investment will be built on three themes, where the UK government will:

- Work with partners in government and industry to focus on strengthening key UK CAM markets, supply chains, and technologies
- Collaborate internationally on regulation and standards as global CAM policy develops
- Engage the international community to maintain and build on the UK's reputation as a global thought leader in CAM to help ensure that social benefits are shared

Figure 13. Graphic detailing international investment milestones for UK CAM

# International Investment Milestones

## 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 start-up, 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.

## 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.

## 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**.

## 2022:

- Wayve, 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 Flow, 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**.

### 3.3.1 The UK's trade and investment opportunity

Government has prioritised engaging the international CAM community since being established in 2015. This has led to notable successes from which we can build our renewed international focus. The UK CAM ecosystem is building a strong global reputation, with international

investors increasingly looking at British companies as compelling propositions to invest in and source from. At least £476m of foreign direct investment and 1,465 new jobs have been generated in the UK CAM sector during the period 2018 to 2022<sup>30</sup>. This investment has been from the world's most prominent automotive and technology markets including China, Germany, France, Israel, Japan, and the USA.

## Case Study: Aurrigo – Made in the UK, sold to the world



Aurrigo's zero emission automated airport luggage dolly was tested at Heathrow Airport.

Located on the old Humber factory site, Aurrigo began developing low speed self-driving pods in 2014 as part of one of government's first CAM projects. It was the first UK company to sell self-driving vehicles overseas and now has customers in Australia, Canada, China, Finland, Singapore, and the USA. Aurrigo manufactures pods, shuttles, and airport transport systems that use its self-driving technology.

Aurrigo has worked with Jaguar Land Rover, IBM, and with British Airways in a partnership which developed self-driving dollies used at Heathrow Terminal 5 to transport baggage airside.



## Case study: Wayve

Emerging as a spinout from the University of Cambridge in 2017, Wayve has since grown rapidly to become a globally competitive British automated vehicle start-up.

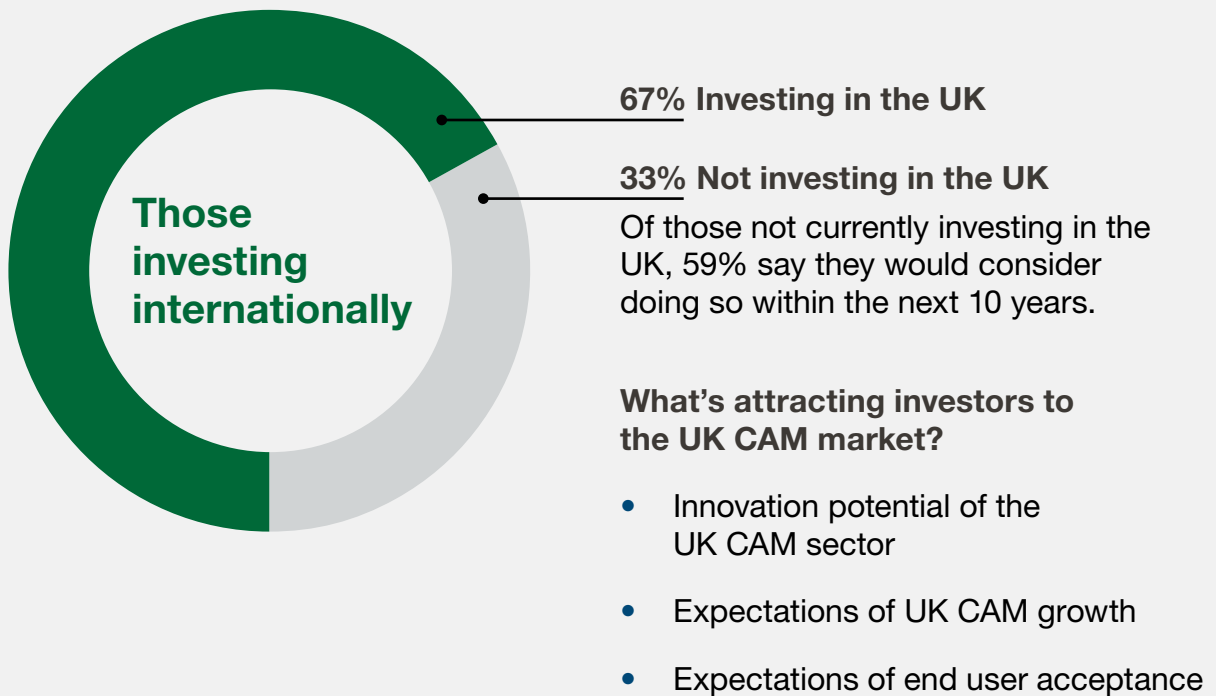
Based in London, the company has developed its 'AV2.0' technology that enables vehicles to 'learn' to drive as a human would during daily testing on public roads. Wayve has recently partnered with Microsoft to design the supercomputing infrastructure required to accelerate this deep learning in self-driving vehicles. Using its 'AV2.0' technology, Wayve's ambition is to be the first company to deploy self-driving vehicles in 100 cities globally.

To date Wayve has signed commercial partnerships with Ocado Group, Asda and DPD. Its investors include Balderton Capital, Firstminute Capital, Baillie Gifford and Sir Richard Branson. Wayve announced its \$200 million Series B funding round in early 2022, bringing the company's total equity raised to over \$258 million.

Wayve has been trialling its self-driving technology on London roads in recent years, using a combination of real world driving and simulation to improve performance and capabilities.



**Figure 14.** International companies investing in UK CAM or sourcing UK CAM products.





In 2021 government commissioned the ‘International Perceptions of the UK’s Connected and Automated Mobility Sector: Market Study’. This market research collected and analysed perceptions of the UK CAM sector from automotive sector stakeholders in Germany, USA, South Korea, Japan, and Israel. Responses to the study demonstrated that there is clear international interest and involvement in the UK as both an investment destination and a market from which to source CAM products and services. Although the study cannot present a definitive analysis of all international interest in UK CAM, it does paint a promising picture for the UK sector.

As shown in Figure 14, the study found that over two-thirds of respondents whose companies are already investing internationally in CAM have some form of investment in the UK, and almost 60% of those not currently investing in the UK would consider it in the next 10 years. Investors said that their interest has been driven by a perception of the country’s high innovation potential, an expectation of high growth in UK CAM, and an expectation of a high degree of end user or customer acceptance of CAM among the UK population. The top five offerings that respondents are currently investing in are:

- Artificial intelligence and machine learning software
- R&D capabilities
- Self-driving control systems
- CAM pods
- Original Equipment Manufacturers (OEMs)

The study also found that 69% of respondents who are procuring internationally are currently sourcing from the UK CAM market, and over two-thirds who are not sourcing from the UK would consider doing so in the next 10 years. Those procuring from the UK emphasised availability, quality, and the clarity and flexibility of the policy environment. The top five products currently being sourced are:

- R&D capabilities
- Sensors
- Self-driving control systems
- CAM pods
- Artificial intelligence and machine learning software

Future success cannot be taken for granted in a highly competitive global landscape. Government and industry must continue to collaborate by leveraging trade and investment opportunities, as well as identifying and overcoming challenges as they emerge.

### 3.3.2 A refined plan for international engagement

To secure the potential investments indicated in the study, government and industry must continue leveraging and promoting UK strengths internationally. These strengths, or unique selling points (USPs) in CAM technologies and services have been identified by both the UK sector and international markets with an interest in the UK. However, the UK’s strengths go further than just USPs in CAM technologies and services, and include an innovation friendly regulatory environment, access to the highest quality skills, and broader capabilities in automotive and transport supply chains, as well as financial, insurance and legal sectors.

**Unique Selling Points (USPs) of UK CAM technologies and services:**

- R&D, engineering, and innovation capabilities – including CAM Testbed UK, OEMs, and universities
- Artificial intelligence / machine learning software
- Self-driving control systems
- Sensors
- Simulation and modelling
- Data sharing, interoperability, cyber security
- Premium vehicle features (e.g. ALKS)
- Use cases such as CAM Pods, public transport, passenger vehicles, and freight and logistics



**Table 3: Areas of UK Competitive Advantage**

Key Pillars of CAM	UK Competitive Advantage
<p><b>Policy and regulation</b></p> <p>The UK is developing a supportive regulatory framework to enable the safe development and deployment of CAM in the UK, and we are working to shape regulation at an international level.</p>	<ul style="list-style-type: none"> <li>• The UK is ranked No.2 in the world in KPMG’s 2020 Automated Vehicles Readiness Index for Policy and Regulation</li> <li>• The UK has market leading regulation based firmly in safety and responsibility</li> <li>• Opportunities in the UK arise from strong collaborative relationship between government and industry</li> </ul>
<p><b>Broader supply chain strengths</b></p> <p>The UK’s broader industrial capabilities complement the CAM sector, opening companies up to a wider expert supply chain.</p>	<p>UK has strengths in:</p> <ul style="list-style-type: none"> <li>• Battery technology</li> <li>• Power electronics &amp; electric motors</li> <li>• Semiconductors</li> <li>• Cyber security</li> <li>• Location-based services</li> <li>• plus others<sup>31</sup></li> </ul>
<p><b>Skills</b></p> <p>The UK is recognised as a global centre for academia, R&amp;D and emerging technology skills.</p>	<ul style="list-style-type: none"> <li>• The UK has five of the top 20 universities in the world, and three of the top ten computer science universities in the world</li> <li>• Through the Office for Talent, government is making the UK the easiest country in the world for top innovative talent to enter through schemes including High Potential Individuals, Global Talent, Start-ups, Scale-ups, and Innovator visas.</li> </ul>

## Key Pillars of CAM

## UK Competitive Advantage

### Infrastructure

The UK is seen as having a mature CAM infrastructure at present compared to other markets. It is well positioned to roll out the comprehensive CAM infrastructure needed for widespread use of the technologies.

- Unique testing facilities such as CAM Testbed UK, offer a comprehensive, end-to-end testing ecosystem.
- The UK's world-leading expertise in data processing and analytics will support the integration of CAM into public infrastructure.
- Our ambition is that the majority of the population will have access to a 5G signal by 2027. DCMS has invested almost £200 million in UK telecoms innovation through the 5G Testbeds and Trials programme (5GTT), helping to establish our global leadership in this area, and supporting industry, academic institutions, and local authorities to realise the benefits of 5G.<sup>31</sup> (see section 4.3.3)

### Financial services and business environment

The UK is Europe's leading financial market and destination for start-ups seeking investment.

- In 2021 UK start-ups and scale-ups raised £29.4 billion, accounting for a third of the £89.5 billion that flowed into the European tech ecosystem.
- The UK has 115 unicorn companies, which is more than France and Germany combined.

### An independent trading nation

The UK government is taking advantage of the opportunities that come with having an independent trade policy, improving trade agreements, market access and investment policy.

- Government is putting the UK at the heart of a network of trade agreements, securing world leading innovation and digital chapters within Free Trade Agreements.
- As the UK establishes new trading relationships across the globe, innovation will be a focal point of our international partnerships.



Government's updated plan to boost CAM trade and investment will be delivered in partnership with DIT, among other relevant departments, underpinned by its strategic goals for investment and its Export Strategy.<sup>32</sup> This will build on work delivered in partnership with DIT to date, both in terms of developing policy centrally and utilising the global DIT network to send a clear message to international markets that the UK is at the forefront of the development and deployment of CAM technologies, control systems, software and services. DIT has already identified CAM modelling and simulation as a high potential opportunity for inward investment<sup>33</sup>, as well as the world-class offer of CAM Testbed UK, and will continue to work with

government to promote the UK's broader capabilities and supply chain opportunities. DIT will also continue to lead on attracting foreign investment into the UK CAM sector, supporting these investors to showcase and export their products globally and connect into international supply chains.

Our approach is designed to boost inward investment and exports for CAM, growing supply chains, creating jobs, and securing economic growth across the UK. In doing so we can help to ensure that the UK consolidates and grows its international reputation as is one of the best places in the world to develop and deploy the technologies. As such, government will undertake the actions set out in Table 4:

Ensure that the UK consolidates and grows its international reputation as is one of the best places in the world to develop and deploy the technologies







**Table 4:** Government commitments and actions on CAM trade & investment

Theme	<b>Working with partners in government and industry to focus proactive engagement on key CAM markets, supply chains, and technologies</b>	<b>Collaborating internationally as CAM policy develops globally</b>	<b>Engage the international community to maintain and build on the UK's reputation as a global thought leader in CAM</b>
Commitment	<p>The UK's position as an independent, sovereign trading nation will drive the pursuit of new trade and investment opportunities for CAM. Government will work with industry to identify high potential opportunities for CAM and priority international markets for targeted engagement. Government will also engage with stakeholders that represent broader UK strengths in supply chain, infrastructure and skills to promote consistency of message and collaborative working.</p>	<p>Government will continue to work with international partners on CAM innovation and industrial policy. We will collaborate with international governments and fora on standards and rules to enable global consistency in self-driving vehicle deployment where possible.</p>	<p>Government will continue to monitor global changes in the CAM sector and learn from developments around the world. We will also work with the UK CAM sector to engage with audiences around the world to share and promote knowledge and best practice where possible.</p>
Action	<ul style="list-style-type: none"> <li>• Monitor CAM developments in other countries and identify opportunities for UK companies to participate in international ecosystems.</li> <li>• Establish partnerships with relevant markets to promote the UK's high-quality offerings, such as CAM Testbed UK.</li> <li>• Continue to facilitate international engagement for UK industry, such as by supporting routes to overseas markets and global conference attendance.</li> <li>• Promote the Department for International Trade's High Potential Opportunities Programme in CAM Simulation and Modelling to foreign investors.</li> <li>• Work closely with the DIT automotive team to encourage inward investment in to the CAM sector</li> <li>• Help CAM companies to take advantage of DIT's new Export Support Service, trade hubs across England, Scotland, Wales and Northern Ireland and connect companies with DIT's overseas network.</li> <li>• Support the delivery of the government's trade agenda and CAM interests across the programme of FTAs. CCAV will work with DfT trade colleagues to identify, explore and address potential trade barriers for CAM businesses.</li> <li>• Continue to work with all areas of government to ensure that the skills required to serve a thriving CAM sector are attracted to the UK.</li> </ul>	<ul style="list-style-type: none"> <li>• Continue to negotiate technical standards and guidelines for automated driving systems, and guidelines and rules for use of self-driving vehicles.</li> <li>• Collaborate with international governments to build strong CAM markets where UK companies can do business with reduced barriers.</li> <li>• Continue the UK government's Economic Partnership with the Ministry of Economic Affairs, Labour and Tourism Baden-Württemberg in Germany for future economic cooperation.</li> <li>• Renew the UK's Memorandum of Understanding with the government of the State of Michigan to continue bilateral cooperation.</li> <li>• Collaborate with other countries on CAM policy under the UK's presidency for the International Transport Forum from June 2022 to May 2023.</li> </ul>	<ul style="list-style-type: none"> <li>• Monitor international industrial and regulatory developments.</li> <li>• Promote the UK leadership on areas of policy such as regulation, safety and cyber security.</li> <li>• Promote UK CAM projects and success stories internationally, including via global conference attendance.</li> <li>• Promote the government's broader work on transport innovation, such as the Future of Transport Strategy and Transport Decarbonisation Plan.</li> <li>• Proactively engage with the development of public reports by leading international market research companies and industry experts that analyse the global CAM market.</li> </ul>

**3.3.3 Delivering in partnership**

This programme of work will be coordinated by CCAV but will be delivered in close collaboration with partners both inside and outside of government. We recognise that

a joint approach that takes advantage of the expertise and capabilities in government, industry and academia is required if we are to meet our objectives of boosting trade and inward investment into UK CAM.

**Table 5:** CCAV collaboration with stakeholders

Partners  How CCAV will collaborate	Department for Transport	Department for Business, Energy and Industrial Strategy	Department for International Trade	Zenzic	Innovate UK	Department for Digital, Culture, Media, and Sport	Industry bodies and trade associations
	CCAV will work with Ministers and senior officials to develop deeper links with international markets that can add the most value to the UK CAM sector. We will help international businesses to understand UK CAM regulations and safety assurance policies. We will continue to monitor global regulation and engage with international forums on CAM technology.	CCAV will target our international work with BEIS to support the aims of the Integrated Review, and the Innovation Strategy objectives on innovation, long-term growth and boosting enterprise.	CCAV will continue to support DIT’s efforts to assist companies interested in investing, growing a business, and exporting in the UK CAM sector. Through the DIT’s High Potential Opportunities programme, CAM Modelling and Simulation will be promoted to international investors through the world-class capabilities of CAM Testbed UK.	CCAV will support Zenzic’s efforts to drive commercial deployment of CAM services and the growth of a thriving supply chain that will attract investment and enable the UK to become a major exporter in CAM. CCAV will also support Zenzic’s ongoing work to attract international companies to the globally unique CAM Testbed UK.	CCAV will help Innovate UK to offer opportunities for UK CAM companies to showcase their products and services at international tradeshows and connect with international supply chains.	CCAV will engage with DCMS on international aspects of the UK Digital Strategy, National AI Strategy, National Data Strategy, and National Cyber Strategy.	CCAV will engage with trade associations and business leadership forums such as the UK Automotive Council and its Intelligent Connected Autonomous Mobility (ICAM) subgroup, the Society of Motor Vehicle Manufacturers and Traders (SMMT) and Automotive Electronics Systems Innovation Network (AESIN) to learn about the international needs of industry, such as reducing barriers to export or accessing international talent.



# Delivering the Societal Benefits of CAM

Connected and automated mobility holds huge potential to improve the way we travel and move goods. This chapter aims to set out how CAM can best contribute to the society we want to see.

But how CAM is introduced to our transport network, the formats and business models rolled out, will vary in terms of how they support government policy objectives. For example, business models that make it easy to access flexible and high-quality shared and public transport options could help minimise carbon emissions, reduce the amount of parking/road space needed and improve access to jobs, services and education for those less able to own their own vehicle or drive.

By contrast, business models that lead to an increase in single occupancy commuting risk having a negative effect on our net zero objectives, active transport goals and congestion. The rate of uptake and integration of technologies into the fleet of vehicles on our roads could also have a big impact: for example, each self-driving vehicle is expected to be able to help reduce collisions associated with human error, so the quicker the roll out, the sooner the benefits come forward<sup>34</sup>.

We have a strong foundation to start from, through the government's Future of Transport Programme. Our departure from the European Union also allows government the freedom to develop policy that is bespoke to the needs of UK businesses and the public. The following sections aim to describe areas for further thinking, where we would like to understand what more is needed from central government to support optimum deployment of CAM technologies.



Table 6: Government actions to deliver the societal benefits of CAM

Theme	Future of Transport	Developing CAM with the public	Integrating with wider networks	Environment
How CCAV will collaborate	<p>Government will support implementation of CAM in line with the Future of Transport Urban Mobility Principles, and the forthcoming Rural Principles. We will engage across the CAM and transport sectors, and across all levels of government, to develop a position on how best to support the commercialisation, scale-up and deployment of new mobility services in ways which deliver the societal benefits we want to capture.</p>	<p>Government will take steps to support implementation of CAM that achieves the best outcomes for transport users recognising the need for continued engagement with the public. Over the coming year we will deliver a series of in-depth engagements and roadshows across the UK, ensuring representation from diverse communities to understand how the technologies should be implemented.</p> <p>Through the AV-DRiVE group we will be developing, testing and disseminating education materials to build the public's understanding of the technologies and their capabilities.</p> <p>Personal safety will be a key consideration in the development of self-driving vehicles, services and regulation.</p>	<p>Government will work with road authorities and others to prepare the UK's road network and infrastructure to benefit from the potential of connected and self-driving vehicles. We will continue to drive innovation through the development and promotion of standards, targeted research and engagement with education providers, that will provide road authorities with the guidance and skills they require.</p> <p>We will work together with industry to understand future connectivity needs on UK roads. This will form part of the delivery of the government's Wireless Infrastructure Strategy, which will set out a strategic framework for the development, deployment and adoption of 5G and future networks.</p> <p>We will build on the Connected Places Cyber Security Principles developed by the National Cyber Security Centre (NCSC) to ensure that transport applications such as CAM can be safely integrated into the smart cities of the future.</p>	<p>Government will encourage environmental benefits and avoid negative impacts on the environment e.g. inducing demand and raising vehicle miles travelled.</p> <p>We will consider how CAM contribute to delivering on our commitments in the Transport Decarbonisation Plan and 25 Year Environment Plan, drawing on the 'Connected and Automated Vehicle Decarbonisation Paradox Report', which identified five fundamental factors through which CAM may impact emissions.</p> <p>To enable this, we will consider the findings of our research into the role of self-driving vehicles in decarbonisation, including eco-driving, speed alignment with traffic conditions and right sized ride hailing and whether it could inform any potential future policy levers.</p>

## 4.1 Future of Transport

CAM is part of a wider revolution in transport, which includes zero emission technologies, new business models and modes, greater sharing of data and improved connectivity, and changing trends in how people travel.

All of these changes bring with them new opportunities, as well as potential new risks. This is why the Department for Transport launched its Future of Mobility: Urban Strategy, to ensure that the UK is well-placed to seize the benefits of new technologies and become a world-leader in future transport. The strategy set a principles-based approach to help us achieve desired outcomes. The principles take account of societal, economic and environmental benefits we want to secure from innovation in transport and how those benefits can be achieved. CAM is one of the technologies that could play a vital role in delivering these benefits, and the strategy's nine principles provide guidance on how the technologies are developed and deployed in urban areas. A similar set of principles is being developed as part of a Future of Transport: Rural Strategy which was recently consulted on, and will be published later this year<sup>35</sup>.

**The Future of Mobility: Urban Strategy sets out nine principles for the development of the future transport system. The following list takes those principles and applies them specifically to the CAM sector:**

- CAM vehicles/services must be safe and secure by design.
- CAM services must be available to all parts of the UK and all segments of society.
- CAM must lead the transition to zero emissions.
- Walking, cycling and active travel must remain the best options for short urban journeys.
- Mass transit must remain fundamental to an efficient transport system, and CAM may have a role to play in delivering options for this.
- The marketplace for CAM must be open to stimulate innovation and give the best deal to consumers.
- CAM must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.
- CAM must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.
- Data from CAM services must be shared where appropriate to improve choice and the operation of the transport system.

The forthcoming 'Future of Transport: Rural Strategy' will aim to ensure that rural communities are able to benefit just as much from changes in transport. Feedback to our 2021 consultation on a Rural Strategy identified a wide range of issues in rural and remote communities that new technologies such as CAM could help address. For example, the high levels of private car dependency in rural areas could be lessened by the deployment of shared CAM services, and the poor provision of public transport in rural and remote areas could be supported by more frequent, demand responsive-driven CAM services. Poor transport links can contribute to create societal and economic issues, such as loneliness, exclusion from the economy, and isolation. More demand responsive services can help tackle isolation, bringing people together and enabling their access to jobs, healthcare, education, and other services.

There is a clear link between CAM deployment and the government's 2018 Inclusive Transport Strategy (ITS)<sup>36</sup>, building on the core ITS principle that technological advances and new business models and services are available to all parts of society in order to deliver government's ambition for people with disabilities to have the same access to transport as everyone else. Elements of the legislative framework recommended by the Law Commissions support the delivery of CAM technologies that is accessible by design, notably the accessibility panel advising on passenger service deployments, which government is committing to implement as a non-statutory panel. As the CDEI review has recommended, the proposed authorisation process will also ensure self-driving vehicles do not unfairly discriminate against certain people,

as well as vulnerable road users. This is a good example of how government will take forward its inclusivity commitments as the technologies are deployed, but there is more to do. Government, working with local government, will also continue to consider how over the longer term, CAM technologies may enable transport services that better serve people with disabilities and others who are less able to access conventional forms of transport.

#### **4.1.1 Delivering CAM which fulfils Future of Transport Principles**

The remaining sections of this chapter build on several of the Future of Mobility: Urban Strategy principles, to explore the challenges and opportunities for CAM.

As the sector moves towards the first commercial services, this is the right moment to think about how to ensure that potential is realised. Government wishes to see deployment of CAM and other emerging technologies that is consistent with our Future of Transport and ITS principles.

At the highest level, government, local authorities, industry, and the public must work together to make our ambitions for CAM a reality. By identifying the wide range of societal, environmental, and economic challenges created or worsened by poor transport provision, CAM can be developed as a viable solution to long-standing issues. As these technologies develop, we must ensure that they are trialled and deployed in a diverse range of communities, in rural and urban areas, to ensure the benefits of CAM are delivered for all segments of society.

## Case Study: Solihull's Self-Driving Transport Programme

Stimulated by the forthcoming HS2 Interchange, Solihull Metropolitan Borough Council is preparing for significant growth. Transport modelling illustrates that reliance on single occupancy motor vehicles will not be sustainable: their growing usage will create unmanageable levels of congestion and prolonged journey times. As well as meeting its urban transport demands, Solihull needs to connect its many isolated rural communities, a number of which are currently underserved by traditional public transport bus services. In addition, 39% of Solihull's carbon emissions are related to transport. To solve these mobility challenges, new forms of affordable, accessible, and clean shared transport are required.

In response, Solihull has developed a range of real-life applications of self-driving transport to respond to the Council's ambition of realising the significant potential cost, safety and environmental benefits of this technology for its residents. Solihull Council has purchased its own self-driving shuttle and has been undertaking trials in the vicinity of the planned HS2 Interchange. Successful passenger carrying operations have been demonstrated at the National Exhibition Centre (NEC) and Birmingham Airport over the past 12 months, providing significant learning to the Council and its partner organisations.

Alongside these innovative solutions around the HS2 / NEC / Birmingham Airport sites, other potential uses for self-driving shuttles that offer the opportunity to provide alternatives to car use include: linking dense 'car-centric' new build residential developments to rail stations; providing satellite villages with new and flexible solutions to access larger towns; and providing direct, 24/7 mobility solutions to workers in the north of the Borough to facilitate employment at NEC / Resorts World / Airport sites. These services, if successfully implemented, have the potential to improve lives in Solihull, providing new and affordable access to jobs, services and education.

The Council intends to continue to work with partner organisations in its programme of self-driving transport development with the aim of ultimately providing commercially viable shared mobility solutions across the Borough.

We will therefore engage across the CAM and transport sectors, and across all levels of government, to develop a position on how best to support the commercialisation,

scale-up and deployment of new mobility services in ways which deliver the public benefits we want to capture.

## 4.2 Developing CAM with the public

Government wishes to see a transport network that is safe, reliable and inclusive. CAM technologies will form a part of that network, and for services to deliver for society, they must be designed with the people who will use them, must have the public's buy-in, and must not be imposed on people.

### 4.2.1 Public engagement and research

Working with the public is essential to ensure that the technologies developed meet people's needs: removing barriers to accessing transport (e.g. availability and accessibility) and ensuring that the systems deployed take people and goods where they need to go. Otherwise, trust in the technologies could be impacted, damaging the potential for CAM more broadly.

Developing these technologies and services without the public will impact the speed of uptake and therefore the ability to harness the societal benefits that the technologies could bring.

To determine demand and public acceptability, we must understand what the public want from the technologies, their concerns and gaps in the current transport provision that could be addressed, in particular by self-driving vehicles. Widespread public understanding and acceptance will also be necessary to ensure that the technologies developed are accessible and work for all.

Our work to date has shown that while understanding, acceptance and willingness to use self-driving vehicles is growing, it is still low, with 83% of the public having some concerns. However, we also know that

engaging with the public has the potential to improve awareness and understanding of the technologies and to build acceptance and trust.

Government has carried out several research programmes focussed on in-depth engagement with members of the public to understand their needs and concerns, and where these might differ across different groups. This work has enabled government to start developing and implementing the appropriate measures to address their needs and build public acceptance of the technologies. For example, Chapter 2 highlights the importance of regulation and standards for public acceptability of self-driving vehicles and sets out the actions government is taking to address this. We will be continuing to increase the programme of work on public engagement and research, both in terms of scope and the complexity of the topics explored.

Our focus going forward will be to increase the breadth and geographic spread of our engagement. We will ensure that we engage with people across all areas of the UK and demographic backgrounds, with a particular focus in the upcoming years on those that have previously been under-represented and areas where little engagement has occurred so far. Over the coming year, we will be running a series of roadshows and in-depth engagement to keep building awareness and acceptance of the technologies, as well as to gather views on how it should be implemented. Looking further ahead, this programme will continue to grow to ensure that the public remains central to the development and deployment of self-driving vehicles.



### 4.2.2 Embedding public outreach into CAM R&D

Government funded research projects provide ideal opportunities to demonstrate CAM technologies to the public and build understanding. Examples of successful outreach undertaken to date by government-funded CAM projects include Oxbotica's Project Endeavour, who partnered with road safety charity Brake in 2021 to increase public understanding about self-driving vehicle safety. DG Cities has also undertaken effective outreach via government-funded projects, recently touring the UK to learn from the public about incidents that they have experienced on UK roads and to explain how these can be used to ensure the development of safer self-driving vehicles.

In the Commercialising CAM programme outlined in Chapter 3, government will allocate separate funding to help boost the CAM sector's communications capabilities, enabling more public outreach as part of government-funded projects. Activities will include engagement with local communities as well as primary and secondary education outreach to build understanding of the technologies and trust in their capabilities and safety.

### 4.2.3 Education & Public Understanding

Making education available for the general public is necessary to ensure that they know whether they are using a self-driving vehicle (as opposed to a driver assistance system), that they know how to use it appropriately and that they understand the responsibilities that they retain when in a self-driving vehicle. It's also important for there to be understanding amongst those not using the vehicles, for example pedestrians, cyclists, public transport users and other road users.

As an important step in enabling the education of drivers who may soon use vehicles with self-driving technologies, government has laid an amendment to The Highway Code in Parliament which came into force on the 1 July 2022. This creates a new section to explain driver responsibilities and rules about the use of self-driving vehicles, for example: that a driver must remain able to respond to a transition demand in case the vehicle needs to hand back control; and that some activities will continue to be restricted while others may be possible while a vehicle is safely driving itself in accordance with instructions. There is much more to do in this space, and so we have set up the AV-DRIVE group, bringing together industry, regulators and safety organisations to promote accuracy and consistency in how the public is communicated with about the capabilities and limitations of CAM technologies. This group oversaw the development of SMMT's guiding principles for marketing self-driving vehicles that were published in November 2021 (see box below). Through this group, we will develop educational materials, and test them with the public, to ensure that they improve accurate understanding of the technologies and that they are clear and accessible to all. The current focus is on ALKS (and other user-in-charge self-driving vehicle technologies) including the development of a toolkit to support industry and public bodies to communicate clearly and consistently. In the longer term, the focus will expand to the use of other self-driving technologies, including those that do not require a user-in-charge, as they become commercially available.

## AV-DRiVE: SMMT Guiding Principles for Marketing Self-Driving Vehicles

One of the first outputs of the AV-DRiVE group are the SMMT guiding principles for marketing self-driving vehicles, published November 2021.

- A self-driving feature must be described sufficiently clearly so as not to mislead, including setting out the circumstances in which that feature can function.
- A self-driving feature must be described sufficiently clearly so that it is distinguished from an assisted driving feature.
- Where both self-driving driving and assisted driving features are described, they must be clearly distinguished from each other.
- An assisted driving feature should not be described in a way that could convey the impression that it is a self-driving feature.
- The name of a self-driving or assisted driving feature must not mislead by conveying that it is the other – ancillary words may be necessary to avoid confusion – for example for an assisted driving feature, by making it clear that the driver must be in control at all times.

### 4.2.4 Personal Safety

One of the key findings from our research to date has been the need to differentiate between road safety and personal safety when discussing the safety impacts of self-driving vehicles, as well as the potential tension emerging between the two. Whilst the public recognise the potential for self-driving vehicles to improve road safety by reducing collisions, there were concerns about the unintended consequences on personal safety, particularly for shared forms of transport. Thinking about the removal of the human driver on public or shared transport led to the perceived risks to personal safety feeling more pronounced, with concerns around personal vulnerability due to the lack of an impartial authority in the vehicle.

Specific risks were around accessibility or an increase in the likelihood of antisocial or criminal behaviour. Whilst this was mentioned throughout our research, these concerns were particularly prominent for women, older adults and those with mobility impairments. For women and older adults, the greatest reported feelings of risk to personal safety were when thinking about travelling at night where the removal of a person of authority on board could increase the chance of other passengers being inebriated or abusive.

Personal safety will be a key consideration in the development of self-driving vehicles, services and regulation. This is consistent with the Department for Transport's commitment to ensuring our transport network is safe for all, and government will

have regard to the recommendations set out in the women's safety champion recent report<sup>37</sup> in implementing the proposed new legal framework for self-driving vehicles. For example, in proposed passenger service licensing arrangements, operators of self-driving public transport would be required to evidence the processes in place to ensure the personal safety of those travelling on self-driving passenger service vehicles.

## 4.3 Integrating with Wider Networks

### 4.3.1 Road Networks

Connection to vehicles travelling on the network, often referred to as Vehicle to Infrastructure (V2I), enables improved network intelligence and delivery of data services to users based on their location and type of vehicle. These dynamic services, for example 'Road Works Warning', 'In Vehicle Signage' and 'Green Light Optimized Speed Advisory' connect road users directly to information sent out by traffic management centres. Distribution of this information can improve the efficiency of the road network, for example minimising breaking/accelerating to save time and also reduce environmental impacts. Some data services have already been piloted on the A2M2 Connected Corridor, and on many local authority roads.<sup>38</sup> Details have been published in the State of the Connected Nation report prepared by the Transport Technology Forum (TTF).<sup>39</sup>

### Infrastructure and operational implications of CAM

Self-driving vehicles will need to be able to safely operate using existing infrastructure and therefore we do not anticipate any immediate changes in current road maintenance practices.

However, some advanced functionality of new connected technologies (e.g. to maximise efficiency and provide advanced warning of hazards) may require road authorities to develop their networks to derive full benefits. More widely, there is likely to be a clearer need for physical networks and digital records to match, and potentially a need for work to be carried out to reconcile the two. Therefore, increasing prevalence of connected and self-driving vehicles may lead to road authorities choosing to revisit their approaches to:

- Physical infrastructure – existing elements of the network, which includes things like static signings and markings, traffic control and information systems and detection systems that collect data on traffic movements to enable effective management of the network;
- Digital Infrastructure – existing digital channels, data management.

Many of these adaptations are understood already but the methods of delivering them, for example standards and guidance, are not fully developed or ready for deployment. So, there are a number of areas where further work is required and where existing work needs to be maintained.

In addition, road authorities need to develop the necessary skills to support the roll out of infrastructure and services to optimise road networks with the data available. Government has committed to working with education providers, the professional institutions, training and accreditation bodies to ensure the right courses are being offered to provide the skills new technologies require, and that professional registration of engineering and technical staff reflects the skill-sets needed to support CAM operation.<sup>40</sup>

This links to the road management duties, powers and other provisions set out in legislation, which need to keep pace with change: government will keep these under review.

### Physical Infrastructure

Guidance will be required from government to ensure that road authorities can invest in their existing traffic control systems to both deliver dynamic data services and also benefit from the richer source of network intelligence offered by connected vehicles, which will enable improved network management. Work in this area is already happening through the National Highways Digital Roads programme, which will act as a model for other road authorities.<sup>41</sup> National Highways Digital Roads vision sets out how they will continue to harness data, technology, and connectivity to improve the way the Strategic Road Network (SRN) is designed, built, operated and used. This will enable safer journeys, faster delivery and an enhanced customer experience for all. National Highways are now focussing on the next roads period and the picture for 2030 is beginning to emerge. Work in this area has identified Connected Services as a key focus to 2030; our world is connected and we have access to information at the click of a button. National Highways will continue to explore and adapt the approach of embracing greater levels of connectivity to provide better experiences and capabilities for their people and customers.

Continued research is needed to improve understanding of the full implications of self-driving vehicles for road authorities. In the shorter term, National Highways will focus on exploring the operational impact of self-driving vehicles on the SRN. This will include the impact of ALKS and other emerging forms of self-driving technologies

on operational procedures, such as the traffic management of incidents. National Highways will also be researching road layout, lane markings and roadwork design, digitisation and implementation standardisation to support other use cases of self-driving vehicles.

### Digital Infrastructure

The National Highways Digital Roads Programme also tackles the digital infrastructure implications; National Highways are adopting a digital-by-default approach to everything across the organisation and lifecycle of the road network. The shift will continue to 2030, helping to shape the culture and what we do. Initial work in this area (Connected Vehicle Data Research Project) for the DfT developed a strategy based on the hypothesis that “The intelligence that connected vehicle data provides will be invaluable in helping plan and operate a better road transport network – and at a lower cost.<sup>42</sup> This will provide benefits for the environment, congestion, safety and the economy.”

The project identified the current and near-future opportunities for connected vehicle data to improve traffic management operations and it describes a framework for realising the benefits of using that data, including the interventions required. The seven key groups of data services, which cover all the services currently used in the UK or likely to be used in the next five years are shown below.

Figure 16. Opportunities for connected vehicle data





Government will engage with road authorities to discuss specifications and promote deployment of these services. There are incentives for authorities to work towards implementation of smarter parking and asset management services, in particular because of the cashable savings identified in the Connected Vehicles Data Report. National Highways is aiming to be an early deployer of connected services on the SRN through the Digital Roads Programme.

### Single Network

There is currently a distinction between CAM data services that will be used for urban and inter-urban situations. An interface needs to be defined to ensure users experience the same quality of service over the entire network. Government is exploring potential research on creating a 'national architecture' to bring together the work on the SRN and the local road networks through managed system integration. The logical next step would be to build on successful but small-scale trial projects by delivering a project along the lines of 'Talking Traffic' as a catalyst for the at-scale roll out and refinement of data services across the entire network.

To support this "one network" approach, DfT will continue to drive innovation, develop and promote standards, organise the 'national access point' and be a single point of contact for suppliers and authorities. National Highways are also continuing to deliver the vision of Digital for Customer (Digital Roads); connectivity will improve our information provision to customers, through their preferred in-vehicle mediums. The aim is to make better use of data to provide a more streamlined and personalised approach to customer engagement, making sure the

engagement is digitally enabled and offers two-way interactivity. National Highways are continuing to work closely with third parties to make a shift towards more integrated and demand led end-to-end journeys, supporting new technology adoption and striving towards a connected country.

### 4.3.2 Mass transit systems

CAM could also offer a new mass transit option, integrated into our existing and planned transport system, as an alternative to traditional modes such as rail and bus. Operating on fully segregated "track" infrastructure (no access for vehicles, pedestrians, or cyclists), self-driving vehicles could provide a public transport service that is safe, zero-emission, demand responsive and flexible, and cost effective. Unlike for public road use, which requires planned changes to legislation, self-driving vehicle services on fully segregated routes could potentially be regulated under existing arrangements for guided transport or guided bus systems.

Government has committed to explore this potential use of CAM further and is working with industry partners, local and regional government and transport bodies to understand the potential costs and benefits of the technologies compared to traditional modes, as well as the circumstances where it may be advantageous. As part of this work, government's Commercialising CAM competition is allocating over £1 million to enable feasibility studies to establish the real-life potential of automated vehicles as a mass transit solution. We are also undertaking work to confirm whether regulations in place today can be applied to this use case.

### 4.3.3 Wireless networks

Good 4G coverage is crucial to supporting existing needs, from navigation to passenger entertainment. Currently, 60% of UK roads have 4G in-vehicle coverage from all four mobile network operators (MNOs), with 96% coverage from at least one operator<sup>43</sup>. However, there is more to be done, particularly for rural roads and the £1billion Shared Rural Network Programme will provide guaranteed extra coverage to 16,000 km of roads<sup>44</sup>.

Future wireless networks offer a huge potential for innovation, and through the £200 million 5G Trials and Testbed Programme, we have funded trials on

connected vehicles such as 5G-Cal, which saw connected and self-driving 40-tonne trucks driving around the Nissan Plant in Sunderland. DCMS launched the £200 million 5G Testbeds and Trials (5GTT) Programme in March 2017, to build the case for 5G by investing in projects across the UK to deploy and test 5G technology. The majority of projects ran until the end of March 2022, but 11 selected projects have secured additional time for delivery in Spending Review 2021, allowing for the continuation of benefits. Furthermore, the government's Digital Connectivity Infrastructure Accelerator, a collaboration between DfT and DCMS, has launched a series of pilot schemes through which local

## 5GTT Transport related projects

**5G-CAL** – Self-driving 40-tonne trucks driving around the Nissan Plant in Sunderland. This takes self-driving vehicles to the next level of safety-critical driving – 5G supports fast and highly reliable communication between the vehicle and control centre on the site to assure safe and efficient operations at Europe's most productive car plant. **Smart Junctions**. AI-enabled cameras form a 5G mesh network across traffic junctions in Manchester. By collaboratively gaming the junction control lights the project has shown it can reduce traffic congestion by 20%. The project also deploys an innovative business model that resells surplus bandwidth on the network so that it is effectively a free service for the Greater Manchester Transport Authority.

**5G Logistics**. This project links Avonmouth Port with two industrial parks testing the ability of 5G to support Freeport requirements to securely and reliably track bonded goods as they move from the vessel bringing them into the country until they are ready for onward transport. **West Midlands Road Sensor Network**. A wide area 5G sensor network taking the Smart Junctions concept to cover the core route network of the WM region. This project also includes looking at road maintenance and air quality to drive quality of life and productivity benefits across the region.

**Milton Keynes Create**. MK have built a private (but open) city-wide 5G network that supports autonomous vehicles used for delivering anything from shopping to pizzas to manufacturing components, as well as a service that gets citizens from the rail station to the MK Dons Stadium.

authorities and mobile network providers are working together to accelerate the deployment of networks through the use of publicly owned infrastructure.

Toward the end of 2021, DCMS ran a call for evidence on the development of a wireless infrastructure strategy, to help us better understand what wireless connectivity the UK will need over the next decade and what more needs to be done to deliver it. To prepare the UK for the full potential connected vehicles have to offer, DCMS and DfT will work together with industry to understand future connectivity needs on UK roads. This will form part of the delivery of the government's Wireless Infrastructure Strategy, which will set out a strategic framework for the development, deployment, and adoption of 5G and future networks.

#### 4.3.4 Transport Applications in Connected Places

Connected places, or 'smart cities', can be defined as a community which utilises advancing technologies to deliver services within the built environment – for example by collecting and analysing data. These technologies, which take the form of sensors, networks, applications and 'Internet of Things' devices have the potential to provide a range of tangible benefits to society. From a more efficient management of traffic which reduces pollution, through to facilitating efforts to save money and resources and enhancing the quality of living for citizens.

Operating within these connected places, CAM technologies providing passenger and logistics services could be designed to integrate and interact with broader digital networks to enhance the way people and goods are moved. This connectivity would

improve management of the road network by enabling real time communication between vehicles and transport infrastructure. It could improve and reduce the costs of infrastructure maintenance by using vehicles to monitor the wear and tear of roads and sharing this data with transport planners. It would enable more effective monitoring, predicting, and controlling of route demand, enabling the better design and use of public transport and space, and making our communities more attractive places to live.

The consequence of this is that the more road services depend on connectivity, the more connectivity must be considered as a part of the wider road infrastructure alongside more conventional aspects. Early planning has ensured that our key highways are equipped with substantial capacity for wired communications, and as discussed throughout section 4.3 they must continue to evolve to keep pace with the needs of users and the requirements of network safety.

The government recognises that for communities to capitalise on the benefits of these technologies, particularly where they become increasingly integrated into existing local and national digital networks and infrastructure, efforts will need to be made to ensure that security is protected. In 2021, The National Cyber Security Centre (NCSC) published a set of principles which are designed to help ensure the security of connected places and their underlying infrastructure, so that they are both more resilient to cyber-attack and easier to manage.<sup>45</sup> Furthermore, the National Cyber Strategy 2022 set out the government's aim to "build on the NCSC's security principles for connected places to reduce the risks posed to businesses, infrastructure, the public sector and citizens", and

‘to strengthen the capability of local authorities...to buy and use connected places technology securely’.<sup>46</sup>

This programme of work is ongoing, led by DCMS and NCSC, and will be factored into our efforts to realise the transport and wider societal and economic benefits that CAM unlocks in a safe and sustainable way.

## 4.4 Environment

In the UK, transport is the largest emitting sector of greenhouse gas (GHG) emissions, producing 24% of the UK’s total emissions (2020), of which 90% is emitted from road transport.<sup>47</sup> 53% of transport emissions originate in rural areas despite rural areas only containing 17% of the population.<sup>48</sup> Transport also has significant impacts on the natural environment and air pollution is the largest environmental health risk in the UK.

In July 2021, the Department for Transport published the Transport Decarbonisation Plan – the first such plan in the world – which sets the transport sector on the path to net zero by 2050, in line with the Paris Agreement. In the 25 Year Environment Plan, we also set out a vision for this generation to be the first to leave the environment in a better state than we found it and pass on to the next generation a natural environment protected and enhanced for the future.

This section explores how CAM could be a useful tool to help deliver on our commitments in the Transport Decarbonisation Plan and 25 Year Environment Plan. However, first we need to develop an understanding of the interactions between CAM and the environment, encouraging the opportunities which deliver choice for the user and environmental benefits.

Government commissioned the Connected Places Catapult to conduct a literature review of the various mechanisms through which CAM may impact the sustainability of road transport.

The ‘Connected and Automated Vehicle Decarbonisation Paradox Report’<sup>49</sup> identified five fundamental factors through which CAM may impact emissions, but concluded it was unclear whether the overall impact of CAM deployment on the UK’s total carbon emissions would be positive or negative without further research.

Key mechanisms through which CAM could lower GHG emissions include eco-driving which enables more efficient adjustment of the vehicle speed in alignment with traffic conditions (with the potential to lower greenhouse gas emissions between 7 – 16%<sup>50</sup>), or right sized ride hailing in which optimally sized vehicles are allocated to each trip (with the potential to improve the fleet efficiency by 30-35%<sup>51</sup>).

Key mechanisms that risk higher GHG emissions as self-driving vehicles are deployed in the UK are induced demand for travel as vehicles can serve a wider population (such as the 25% of the adult population who currently do not hold a driving license<sup>52</sup>) or higher powertrain demands associated with the operation of sensing, computing, and communicating devices (which could increase GHG emissions by 3-20% per vehicle<sup>53</sup>).

Innovation and R&D are key to achieving our decarbonisation goals by ensuring there is a pipeline of solutions and the continuous development of new ideas. We will consider the findings of our research into CAM’s role in decarbonisation and whether it could inform any potential future policy levers.







# Annex A: Government Departments and Agencies



# Centre for Connected & Autonomous Vehicles

CCAV was established in 2015 as a joint government unit between the Department for Transport (DfT) and the Department for Business, Energy and Industrial Strategy (BEIS). CCAV works across government, industry, and academia to make the UK one of the world's premier development and deployment locations for connected and automated mobility, including self-driving vehicles.

CCAV's parent government departments with significant policy overlap



HM Government departments and units with a policy interest.



DfT leads the UK's trade policy area which is of great importance to UK CAM exports.



DCMS leads policy for data, digital infrastructure and skills, and has provided funding towards CAM projects



OAI is the joint government unit between DCMS and BEIS responsible for policy on artificial intelligence, including those found in CAM and SDVs



The CDEI is a government expert body enabling the trustworthy use of data and AI

Transport agencies with a policy interest



The Law Commission of England and Wales, and the Scottish Law Commission undertook a four year review into the regulatory framework for automated vehicles



Zenzic is a company within the Advanced Propulsion Centre (APC) UK, which was created by government and industry to accelerate the self-driving revolution in the UK



HM Government, through CCAV and other government departments, will work with the devolved administrations of Scotland, Wales and Northern Ireland



The UK's innovation agency, involved in funding CAM projects



# Annex B: Glossary & Abbreviations







## Glossary

Term	Definition
<b>Advanced Driver Assistance Systems (ADAS)</b>	Vehicle-based intelligent systems developed to automate / adapt / enhance vehicle systems for safety and better driving.
<b>Authorised Self-Driving Entity (ASDE)</b>	Under the intended new framework, an ‘Authorised Self-Driving Entity’ is a new legal entity which will put an automated vehicle forward for authorisation as having self-driving features. It may, for example, be the vehicle manufacturer, or a software designer, or a joint venture between the two.
<b>Autonomous / Automated Vehicles (AV)</b>	‘Automated’ can refer to a wider range of automation, including technologies which are not capable of self-driving, such as automated assistance technologies. In industry and legal settings, automated is often used to describe self-driving technologies, see below.
<b>AV-DRiVE</b>	The ‘Automated Vehicle Driver Responsibility in Vehicle Education’ group involving industry, regulators and road safety organisations. This group is considering what information and resources will be provided to drivers to ensure self-driving vehicles are used safely once introduced on our roads.
<b>Combined Authorised Self-Driving Operator (CASDO)</b>	Under the intended new framework, a ‘Combined Authorised Self-Driving Operator’ (CASDO) refers to a single organisation acting as both an ASDE and NUiC operator.
<b>Connected and Automated Vehicles Process for Assuring Safety and Security (CAVPASS)</b>	The ‘Connected and Automated Vehicles Process for Assuring Safety and Security’ programme aims to develop and implement the standards, testing and monitoring processes to ensure that the trialling, deployment and on-going use of connected vehicles, and those with self-driving features and capabilities are safe and resilient to cyber-attack.
<b>Connected Vehicles (CV)</b>	Connected vehicles are vehicles that use any of a number of different communication technologies to communicate with the driver, other vehicles on the road, roadside infrastructure, and to other systems and services via the Cloud.
<b>Dynamic Driving Task (DDT)</b>	A term used to describe the real-time operational and tactical functions required to operate a vehicle in on-road traffic. It includes steering, accelerating and braking together with object and event detection and response.
<b>No User-in-Charge (NUiC) Vehicle</b>	Under the intended new framework, a ‘no user-in-charge vehicle’ is a term to refer to a vehicle fitted with only a ‘No User-in-Charge’, or Category 2, Automated Driving System (ADS) feature. This means it will not be fitted with standard driving controls, as a vehicle with a ‘User-in-Charge’, or Category 1, feature must be. Therefore, it is likely to be novel in design and must be overseen by a NUiC Operator.

<b>No User-in-Charge (NUiC) Operator</b>	Under the intended new framework, a NUiC operator is a licensed operator for vehicles which do not require a user-in-charge, and can therefore drive for the entire journey with any humans in the vehicle merely as passengers. Responsibility for the behaviour of these vehicles would remain with the ASDE, but the NUiC operator would be responsible for overseeing the wider operation of the vehicle and taking on the non-dynamic driving task responsibilities, such as ensuring the vehicle has appropriate insurance, that would otherwise remain with the User-in-Charge.
<b>Original Equipment Manufacturer (OEM)</b>	Original equipment manufacturer is an organization that makes devices from component parts bought from other organization. In this context, we use the term to refer to tier 1 automotive manufacturers which integrate products, components and services to deliver a finished vehicle to the market.
<b>Self-Driving Vehicle/ Vehicle with Self-Driving Features/ Capabilities</b>	<p>‘Self-driving’ vehicles are those in which operation of the vehicle occurs, in at least some circumstances, without direct driver input to control the steering, acceleration, and braking. These vehicles are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode.</p> <p>We also use the term “vehicles with self-driving features/capabilities” to specifically describe vehicles which may be driven by a human for some/most of the time while also being equipped with one or multiple features that are approved to take control for only certain parts of a ‘journey’.</p>
<b>User-in-Charge (Uic)</b>	Under the intended new framework, a ‘user-in-charge’ is an individual who is in the vehicle and in a position to operate the driving controls while a Category 1 (user-in-charge) self-driving automated driving system feature is engaged. The user-in-charge is not responsible for the dynamic driving task, but must be qualified and fit to drive. They might be required to take over following a transition demand from the automated driving system. They would also have obligations relating to non-dynamic driving task requirements including duties to maintain and insure the vehicle, secure loads carried by the vehicle and report accidents. An automated vehicle would require a user-in-charge unless it is authorised to operate without one.

## Abbreviations

Abbreviation	Term
<b>ADS</b>	Automated Driving System
<b>AEB</b>	Autonomous/ Advanced Emergency Braking
<b>AI</b>	Artificial Intelligence
<b>BEIS</b>	Department for Business, Energy and Industrial Strategy
<b>CAM</b>	Connected and Automated Mobility
<b>CAV(s)</b>	Connected and Automated Vehicle(s)
<b>CCAV</b>	Centre for Connected and Autonomous Vehicles
<b>CDEI</b>	Centre for Data Ethics and Innovation
<b>DCMS</b>	Department for Digital, Culture, Media and Sport
<b>DIT</b>	Department for International Trade
<b>DfE</b>	Department for Education
<b>DfT</b>	Department for Transport
<b>DVLA</b>	Driver and Vehicle Licensing Agency
<b>DVSA</b>	Driver and Vehicle Standards Agency
<b>NCSC</b>	National Cyber Security Centre
<b>R&amp;D</b>	Research and Development
<b>RSIB</b>	Road Safety Investigation Branch
<b>RSSF</b>	Road Safety Strategic Framework
<b>SRN</b>	Strategic Road Network
<b>VCA</b>	Vehicle Certification Agency
<b>VRU</b>	Vulnerable Road User
<b>V2I</b>	Vehicle-to-infrastructure
<b>V2X</b>	Vehicle-to-everything





# Annex C: Full list of Law Commissions' Recommendations

## A New Automated Vehicles Act

**Recommendation 1.** A new Automated Vehicles Act should be introduced to regulate automated vehicles on roads or other public places in Great Britain.

The UK, Scottish and Welsh Governments should work together to introduce a uniform scheme that will apply across Great Britain.

### The Test for Self-Driving

**Recommendation 2.** The new Act should set out a test which a vehicle must satisfy before being authorised as having a self-driving ADS feature.

For a feature to be self-driving, the authorisation authority must be satisfied that it can control the vehicle so as to drive safely and legally, even if an individual is not monitoring the driving environment, the vehicle or the way that it drives.

Vehicles that rely on ADS features to issue transition demands to users-in-charge may be authorised as self-driving provided that the transition demand:

- (1) issues clear, multi-sensory signals;
- (2) gives the user-in-charge sufficient time to gain situational awareness before the end of the transition period; and

(3) has sufficient mitigation against the risk of a injury or damage if the user-in-charge fails to take over in response to the demand.

Vehicles should not be authorised as self-driving if an individual is expected to respond to objects or events in the external environment (such as low impact collisions and emergency vehicles) in the absence of a transition demand.

### Activities by The User-in-Charge

**Recommendation 3.** AV regulators should develop guidance regarding activities that a user-in-charge may (or may not) undertake. This guidance should be included in The Highway Code and publicised by government.

**Recommendation 4.** Initially, it should be an offence for a user-in-charge:

- (1) to use a mobile device (contrary to regulations 110 of the Road Vehicles (Construction and Use) Regulations 1986);
- (2) to be in a position to see a non-handheld screen (contrary to regulations 109 of the Road Vehicles (Construction and Use) Regulations 1986) unless the screen cuts out at the start of a transition demand; and
- (3) to sleep.

## Unwitting Take-Overs

**Recommendation 5.** The UK government should work within the UNECE decision-making structures to ensure that safeguards are in place to prevent unwitting take overs by the user-in-charge.

Safeguards against unwitting take overs should also be part of domestic GB type approval.

## The Secretary of State's Safety Standard

**Recommendation 6.** The new Act should require the Secretary of State for Transport to publish a safety standard against which the safety of automated driving can be measured. This should include a comparison with harm caused by human drivers in Great Britain.

**Recommendation 7.** In exercising their functions, the authorisation authority and in-use regulator should have regard to the published safety standard.

## Pre-Deployment Safety Assurance

**Recommendation 8.** The Secretary of State for Transport should establish a domestic AV technical approval scheme to approve vehicles with ADS features which do not have UNECE approvals and which are intended for use on GB roads.

**Recommendation 9.** The new Act should establish an authorisation scheme for vehicles equipped with ADS features to be used in Great Britain. The scheme should be administered by an authorisation authority.

**Recommendation 10.** For a vehicle or vehicle type to be authorised in Great Britain as self-driving as having self-driving features, a prospective Authorised Self-

Driving Entity (ASDE) must submit the vehicle or a vehicle representative of the type to the authorisation authority. Before granting authorisation, the authorisation authority must be satisfied that the vehicle or vehicle type:

(1) has obtained approval (through one of the GB whole vehicle approval schemes);

(2) can drive itself safely and legally even if an individual is not monitoring the driving environment, the vehicle or the way it drives;

(3) can record location data for detected collision events and ADS activation/deactivation; and

(4) is supported by a suitable ASDE which has demonstrated its ability to comply with relevant laws (including laws on data protection and environmental protection).

**Recommendation 11.** The authorisation authority should assess each ADS feature in relation to the vehicle with which it is presented. If authorisation is granted, it should state whether each ADS feature is authorised for use with or without a user-in-charge.

**Recommendation 12.** To become an ASDE an applicant must:

(1) be of good repute;

(2) have appropriate financial standing;

(3) submit a safety case and an equality impact assessment to the authorisation authority.

**Recommendation 13.** Authorisation should be conditional on the ASDE undertaking ongoing duties. These should include:

(1) assuring their AV will continue to drive safely and in accordance with road rules throughout the lifetime of the vehicle;

(2) disclosing information where required by law or if required to do so as a condition of the authorisation process;

(3) co-operating with the authorisation authority, the in-use regulator and the Road Safety Investigation Branch.

**Recommendation 14.** The new Act should give the Secretary of State for Transport power to specify requirements as to good repute and appropriate financial standing.

**Recommendation 15.** The authorisation authority should provide guidelines on the information to be included in the safety case and equality impact assessments, and assess both documents as part of authorisation.

**Recommendation 16.** The new Act should provide regulation-making powers to specify:

(1) the application process and fees;

(2) who should assess whether a vehicle is capable of self-driving safely;

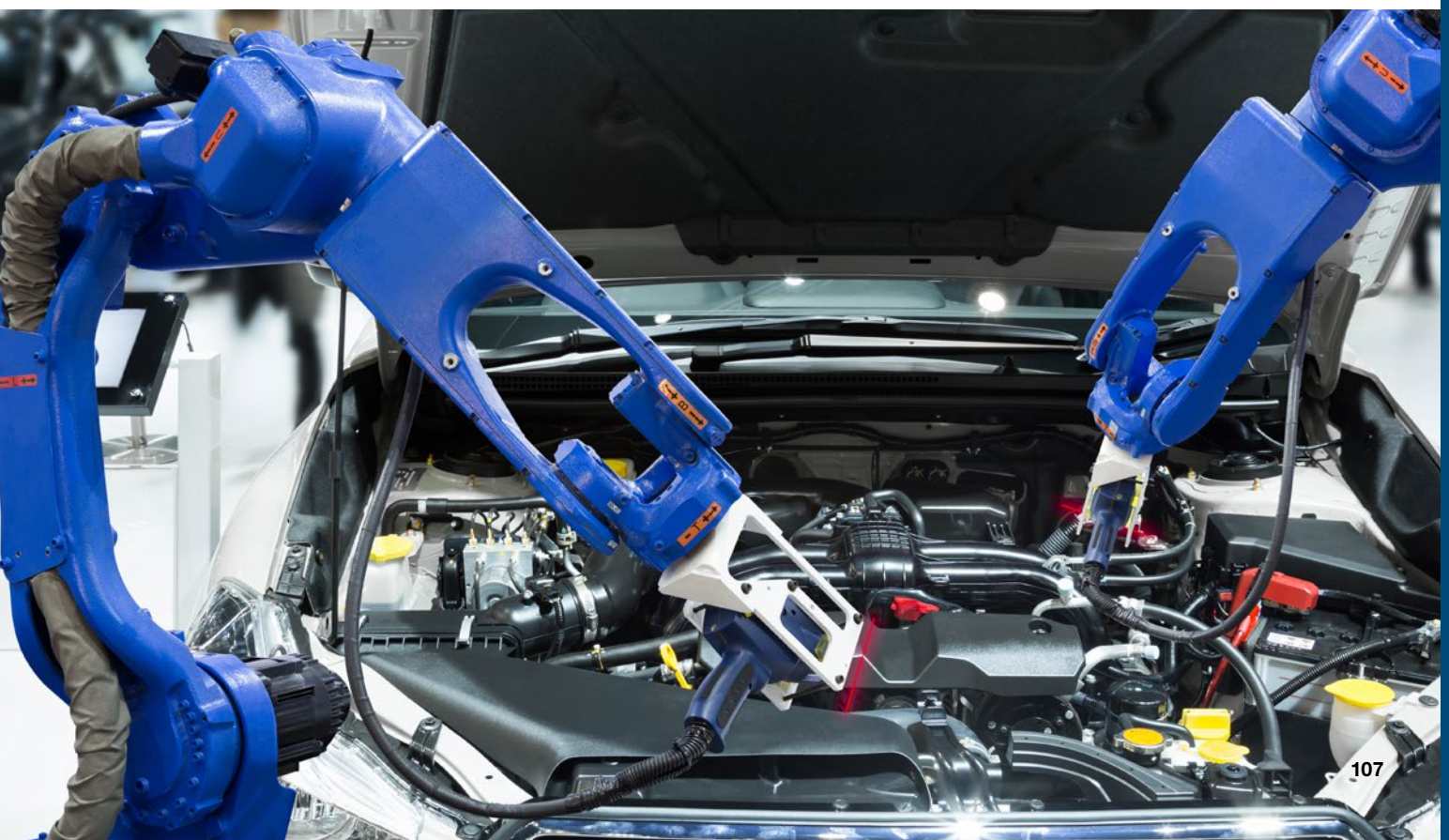
(3) the procedure for doing so;

(4) the criteria for doing so; and

(5) the format of a decision (including the outcome for each ADS feature).

The new legislative framework should also require that if authorisation is granted, it should state whether the AV is authorised for use with or without a user-in-charge.

**Recommendation 17.** The new Act should provide a process for appealing against an authorisation decision.





## In-Use Safety Assurance

**Recommendation 18.** The new Act should establish an in-use safety assurance scheme which gives an in-use regulator responsibilities to monitor the safety of authorised AVs and investigate infractions involving AVs, and powers to enforce its decisions.

**Recommendation 19.** The in-use regulator should be under a statutory obligation:

- (1) to collect and analyse data to measure the safety of automated driving against the Secretary of State's published safety standard;
- (2) to publish their findings; and
- (3) to explore a range of possible measures to assess automated driving safety.

**Recommendation 20.** The in-use regulator should be given powers to collect relevant data from ASDEs and NUIc operators so as to allow the regulator to compare the safety of automated and conventional vehicles.

**Recommendation 21.** The in-use regulator should be under a statutory obligation:

- (1) to investigate traffic infractions referred to it; and
- (2) if the infraction has been caused by the ADS feature/s, apply a flexible range of regulatory sanctions.

“Traffic infraction” refers to an action (or inaction) which forms part of the dynamic driving task and which (if conducted by a human driver) would make the human driver liable for a criminal offence or civil penalty.

**Recommendation 22.** The in-use regulator should work with police and local authorities to establish a protocol which

enables traffic infractions involving AVs to be investigated efficiently and effectively.

**Recommendation 23.** The in-use regulator should have power to require ASDEs to provide suitable, clearly worded and easily comprehensible information to owners, users-in-charge and registered keepers throughout the life of a vehicle.

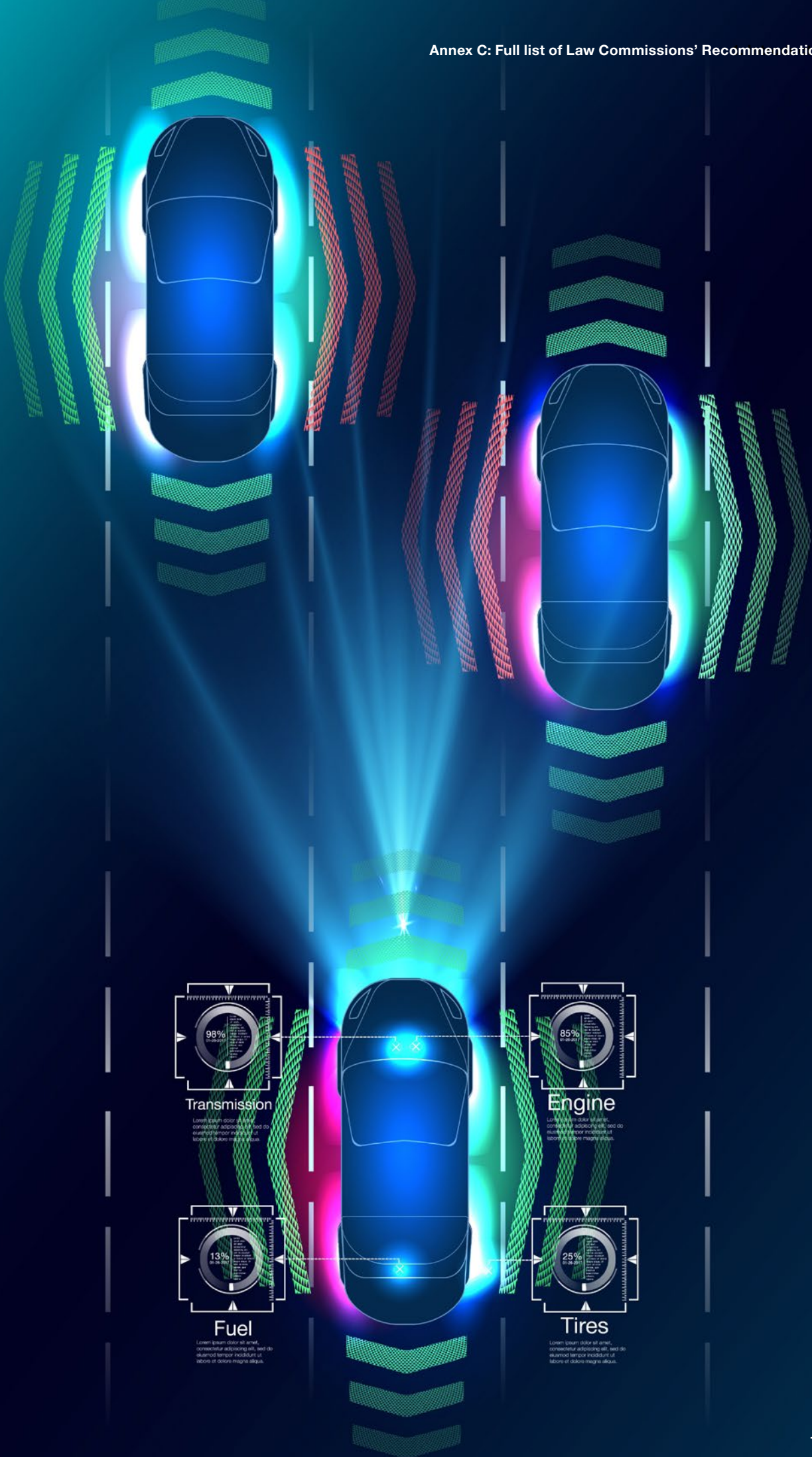
**Recommendation 24.** The in-use regulator should have statutory powers to impose the following regulatory sanctions:

- (1) informal and formal warnings;
- (2) civil penalties;
- (3) redress orders;
- (4) compliance orders;
- (5) suspension of authorisation;
- (6) recommendation of withdrawal of authorisation; and
- (7) recommendation of attendance at a restorative conference.

**Recommendation 25.** The regulatory functions of the in-use regulator should be made subject to sections 21 and 22 of the Legislative and Regulatory Reform Act 2006 through the procedure set out in section 24(2) of that Act.

**Recommendation 26.** Regulations should give the Secretary of State the power to set the maximum amount for civil penalties imposed by the in-use regulator.

**Recommendation 27.** Compliance orders issued by the in-use regulator should be outcome oriented for technical issues but may be specific for issues which require the ASDE to communicate information to users.



**Recommendation 28.** The new Act should create a right to appeal against decisions made by the in-use regulator.

**Recommendation 29.** The in-use regulator should have power to apply for a search warrant to obtain information which is relevant to an investigation.

**Recommendation 30.** The in-use regulator should be under a duty to engage with those with an interest in the safety of automated vehicles, including local traffic authorities, the emergency services, road user groups and experts in the field.

### A Forum to Collaborate on Road Rules

**Recommendation 31.** The UK government should establish a forum for collaboration on how road rules, traffic laws and guidance such as The Highway Code should apply to automated driving.

### Collision Investigation

**Recommendation 32.** An independent collision investigation unit should be given responsibility for investigating serious, complex and high-profile collisions involving automated vehicles.

### Cybersecurity

**Recommendation 33.** The in-use regulator should have responsibility for developing and encouraging best practice with regards to ongoing AV cybersecurity. Where a lack of security gives rise to a safety concern, the regulator’s powers to deal with safety concerns should apply.

### Marketing Driving Automation

**Recommendation 34.** It should be a criminal offence to engage in a commercial practice in connection with driving

automation technology designed for use on roads or in public places if the commercial practice uses:

- (1) the terms “self-drive”, “self-driving”, “drive itself”, “driverless” and “automated vehicle”;
- (2) any other terms prescribed by the Secretary of State for Transport by regulations; or
- (3) any symbol or kitemark approved by the authorisation authority to identify authorised ADS features;

unless the driving automation technology is specified as a self-driving feature by the authorisation authority under the authorisation scheme recommended in this report.

The offence should not be committed if the only use of the driving automation technology is by a person who, as part of their employment, test drives vehicles equipped with driving automation technologies (a “safety driver”).

**Recommendation 35.** It should be a criminal offence to:

- (1) engage in a commercial practice;
- (2) which creates a likelihood of confusion among the public (or a part of the public) licensed to drive;
- (3) over whether a driving automation technology needs to be monitored when used on a road or public place;
- (4) when that driving automation technology has not been specified as a self-driving feature by the authorisation authority.

**Recommendation 36.** A due diligence defence should be available in respect of both offences (recommendations 34 and 35) if:

- (1) the commercial practice giving rise to the offence was engaged in from outside Great Britain; and
- (2) the person engaging in the commercial practice took all reasonable precautions and exercised due diligence to prevent drivers in Great Britain from being misled.

**Recommendation 37.** The new Act should give the enforcement agency powers to accept voluntary undertakings and to apply to a court for civil enforcement orders in respect of both offences (recommendations 34 and 35).

**Recommendation 38.** The new Act should require the Secretary of State for Transport to nominate an enforcement agency responsible for pursuing civil enforcement and preventing the offending conduct.

### The Role of a User-In-Charge

**Recommendation 39.** The new Act should define a user-in-charge as an individual who is in a vehicle and in position to operate the driving controls while a relevant ADS feature is engaged. For these purposes, a "relevant ADS feature" is an ADS feature in an authorised vehicle which the authorisation authority has specified as self-driving for use with a user-in-charge. An ADS is engaged from when it is switched on until:

- (1) an individual takes control of the vehicle;
- (2) (where the ADS issues a transition demand), the transition period ends; or
- (3) (where the vehicle comes to a stop), an individual switches off the ADS or the

engine; the ADS issues an alert to say that the trip is completed; or the user-in-charge leaves the vehicle voluntarily.

**Recommendation 40.** It should be an offence to be a user-in-charge:

- (1) without a licence authorising them to drive a motor vehicle of that class;
- (2) while disqualified from obtaining a licence;
- (3) with a false declaration as to any relevant disability or prospective disability;
- (4) with uncorrected defective eyesight;
- (5) when under the influence of drink or drugs;
- (6) with alcohol concentration above the prescribed limit; and
- (7) with concentration of a controlled drug above the specified limit.

**Recommendation 41.** It should be an offence to cause or permit an unqualified or unfit person to act as a user-in-charge.

**Recommendation 42.** It should be an offence to be carried in a vehicle without a user-in-charge while an ADS feature specified for use with a user-in-charge is engaged. Persons should be guilty of the offence if they knew or ought to have known that:

- (1) the vehicle did not have a user-in-charge; and
- (2) a user-in-charge was required.

**Recommendation 43.** A provisional licence holder should be entitled to act as a user-in-charge if accompanied by an approved driving instructor in a vehicle with dual controls.



**Recommendation 44.** While a relevant ADS feature is engaged, the user-in-charge should not be liable for any criminal offence or civil penalty which arises from dynamic driving. The immunity should not apply if the user-in-charge has taken steps to override or alter the system so as to engage the ADS when it is not designed to function. The immunity should cease if the user-in-charge deliberately interferes with the functioning of the ADS.

**Recommendation 45.** The user-in-charge should continue to be responsible for the following matters which do not arise from dynamic driving:

- (1) Duties to carry insurance;
- (2) Duties to maintain the vehicle in a roadworthy condition;
- (3) Any parking offence which continues after the ADS feature is disengaged;
- (4) Duties following accidents to provide information and report accidents;
- (5) Duties to ensure that child passengers wear seatbelts;
- (6) Duties relating to loading; and
- (7) Strategic route planning, including duties to pay tolls and charges.

The new Act should include a regulation-making power to adapt the lists of dynamic and non-dynamic offences in the light of experience, including a power to allocate some or all roadworthiness responsibilities to the ASDE.

**Recommendation 46.** A user-in-charge should not be liable for any of the driving offences set out in sections 1 to 3A of the Road Traffic Act 1988. Instead, a user-in-charge should be liable for a new offence of using a vehicle in an obviously dangerous state. The offence would be committed where:

- (1) the user-in-charge used the vehicle in a dangerous state; and
- (2) it would be obvious to a competent and careful user-in-charge engaging the ADS that using the vehicle in its current state would be dangerous.

In deciding whether the vehicle is in a dangerous state, regard should be had to anything attached to or carried on or in it and to the manner in which it is attached or carried.

An aggravated form of the offence should apply where the use caused death or serious injury.

**Recommendation 47.** The new Act should create a defence to any driving offence committed in the period immediately following a handover. The defence should be that the defendant's driving did not fall below the standard reasonably expected of a competent and careful driver in the circumstances.

**Recommendation 48.** The new Act should provide that a user-in-charge who fails to respond to a transition demand will acquire the legal responsibilities of a driver at the end of the transition period.

**Recommendation 49.** The new Act should create a specific defence applying to driving offences committed in Scotland by the driver of an automated vehicle with a user-in-charge function where:

- (1) the accused was required to resume driving upon the expiry of a transition demand;
- (2) the accused's ability to resume driving was seriously impaired by a sudden medical condition;
- (3) this condition or impairment was not caused by the accused; and
- (4) the condition could not reasonably be anticipated by the accused.

### NUiC Operator Licensing

**Recommendation 50.** It should be an offence to use a vehicle on a road or other public place without a driver or user-in-charge unless:

- (1) it is equipped with an ADS feature authorised for use with no user-in-charge in that operational design domain; and
- (2) arrangements are in place for the vehicle to be overseen by a licensed NUiC operator.

**Recommendation 51.** To obtain a NUiC operator licence, the applicant must show that it:

- (1) is of good repute;
- (2) has appropriate financial standing;
- (3) conducts its operation from one or more centres within Great Britain; and
- (4) is professionally competent to run the service.

**Recommendation 52.** The new Act should give the Secretary of State for Transport power to specify requirements as to good repute, appropriate financial standing and operating within Great Britain.

**Recommendation 53.** To demonstrate professional competence, the applicant must submit a documented safety management system, setting out all safety related roles and the competence required for each.

**Recommendation 54.** To obtain a NUiC operator licence, the applicant should submit a safety case, showing how safety will be assured. Among other things, the applicant's safety case should set out:

- (1) how oversight will be provided to vehicles, including suitable connectivity, equipment, staff training and rest breaks;
- (2) incident management, including communication with passengers, road users and the emergency services, together with measures to remove vehicles causing an obstruction;
- (3) systems, expertise and equipment to maintain vehicles, install updates and ensure cybersecurity;
- (4) data management;



(5) whether safety relies on any element of remote driving, and (if so) how this will be done safely; and

(6) ways to learn from mistakes, including links with local authorities, highway authorities and the police.

Where an ASDE and the NUiC operator are the same entity, the entity may submit a joint safety case covering both roles, to be assessed by the authorisation authority.

In other cases, the safety case should address the ASDE's written specifications for what must be done to ensure safe operation.

**Recommendation 55.** When granting a licence, the regulator should specify the responsibilities which fall on the NUiC operator in the terms of the licence.

**Recommendation 56.** The new Act should give the regulator powers to impose the following regulatory sanctions on NUiC operators:

- (1) informal and formal warnings;
- (2) civil penalties;
- (3) redress orders;
- (4) compliance orders;
- (5) suspension of licence;
- (6) withdrawal of licence; and
- (7) recommendation of attendance at a restorative conference.

**Recommendation 57.** A NUiC operator should be under an obligation to respond to requests from the in-use regulator for information to monitor the continued compliance of NUiC operation. This would

include information to compare the safety of NUiC vehicle operations with that of conventional vehicles.

**Recommendation 58.** The regulator should have powers to inspect remote operation centres.

**Recommendation 59.** The duration of a NUiC operator licence should be set in secondary legislation. Initially, the duration should be five years.

**Recommendation 60.** The new Act should place responsibility for NUiC operator licensing on the Secretary of State for Transport.

## NUiC Passenger Services

**Recommendation 61.** The new Act should empower the Secretary of State for Transport and the Scottish and Welsh Ministers to issue interim permits for passenger services designed to use NUiC vehicles. The holder of an interim passenger permit would not be subject to taxi, private hire or PSV legislation.

- (1) A permit should only be granted if:
  - (a) in the opinion of the accessibility advisory panel (recommendation 63), the service is likely to add to knowledge of how to provide automated services for older and disabled passengers by involving them in the service's design;
  - (b) consultation has taken place with relevant highway or road authorities and the emergency services; and
  - (c) any necessary consents from the licensing authority or the local transport authority have been obtained.
- (2) The consent of the licensing authority would be necessary if:

- (a) the service operates within its licensing area; and
  - (b) would require a taxi or private hire licence if it had a driver.
- (3) The consent of the local transport authority would be necessary if:
- (a) the service would be a “local bus service” if it used a conventional vehicle with a driver; and
  - (b) the proposed area of operation is covered by a bus franchising scheme.
- (4) Each year, the permit holder should publish a report on the operation of the service, highlighting how the service safeguarded passengers and how it met the needs of older and disabled passengers.
- (5) There should be power to make the permit subject to conditions. These may (among other things) specify the number of vehicles to be used; the geographic location in which it takes place; the ability to charge fares; participation in a ticketing scheme; and notifying timetables to the Traffic Commissioners.
- (6) The permit should be of specified duration.

**Recommendation 62.** It should be a condition of a “Tier 1” NUiC operator licence that a NUiC vehicle should only provide passenger services in accordance with the terms of an interim passenger permit.

**Recommendation 63.** The new Act should establish an accessibility advisory panel to advise on granting interim passenger permits and assist in the development of national minimum accessibility standards for NUiC passenger services. The accessibility advisory panel should include:

- (1) the Equality and Human Rights Commission;
- (2) representatives for disabled and older persons; and
- (3) representatives from industry.

**Recommendation 64.** In the longer term, the Secretary of State for Transport should set national accessibility standards to apply to all self-driving passenger services using NUiC vehicles.

### The Duty of Candour

**Recommendation 65.** The new Act should create the following criminal offences:

Offence A: non-disclosure or misrepresentations by the ASDE

When putting forward a vehicle for authorisation as self-driving, it should be an offence for the ASDE to

- (1) fail to provide information to the regulator; or
- (2) provide information to the regulator that is false or misleading in a material particular

where that information is relevant to the evaluation of the safety of the vehicle.

The ASDE should have a defence if it can show that it took reasonable precautions and exercised all due diligence to prevent the wrongdoing.

Offence B: non-disclosure or misrepresentations by a NUiC operator

When applying for NUiC operator licence, it should be an offence for the applicant to

- (1) fail to provide information to the regulator; or



(2) provide information to the regulator that is false or misleading in a material particular

where that information is relevant to the evaluation of the safety of the operation.

The NUiC operator should have a defence if it can show that it took reasonable precautions and exercised all due diligence to prevent the wrongdoing.

Offence C: non-disclosure and misrepresentations in responding to regulators' requests

When the regulator responsible for either pre-deployment or in-use safety requests information from an ASDE or NUiC operator it should be an offence for the recipient to

(1) fail to provide information within the scope of the request; or

(2) provide information to the regulator that is false or misleading in a material particular

where that information is relevant to the evaluation of the safety of the vehicle or the way that it operates.

The ASDE/NUiC operator should have a defence if it can show that it took reasonable precautions and exercised all due diligence to prevent the wrongdoing.

Offence D: the consent or connivance of senior managers

Where the ASDE/NUiC operator has committed Offence A, B or C, a senior manager would also be guilty of the offence if it took place with their consent or connivance.

A senior manager should be defined as a person who plays a significant role in:

(1) the making of decisions about how the ASDE/NUiC operator is managed or organised, or

(2) the management of the safety assurance process.

Offence E: offences by the nominated person.

Where the ASDE/NUiC operator has made a non-disclosure and misrepresentation in circumstances covered by offence A, B or C, the person who signed the relevant safety case or response to the request for information ("the nominated person") would also commit the offence.

The nominated person would have a defence if they can show that they took reasonable precautions and exercised all due diligence to prevent the wrongdoing.

Offence F: aggravated offences in the event of death or serious injury following misrepresentation or non-disclosure.

Where a corporation or person commits Offences A to E, the offence should be aggravated where the misrepresentation or non-disclosure:

(1) related to an increased risk of a type of adverse incident; and

(2) an adverse incident of that type occurred; and

(3) the adverse incident caused a death or serious injury.

## Wrongful Interference

**Recommendation 66.** Legislative amendment should clarify that the tampering offence in section 25 of the Road Traffic Act 1988 applies to anything that is physically part of an automated vehicle, including sensors, and any software installed within it.

**Recommendation 67.** The offence of taking a conveyance without authority under section 12 of the Theft Act 1968 should cover all motor vehicles.

**Recommendation 68.** In England and Wales it should be an aggravated offence to wrongfully interfere with an AV, the road, or traffic equipment contrary to section 22A of the Road Traffic Act 1988, where the interference results in an AV causing death or serious injury.

**Recommendation 69.** The mental element for the aggravated offence (recommendation 68) under section 22A should be intention to interfere with a vehicle, the road or traffic equipment.

## Civil Liability

**Recommendation 70.** Section 1 of the Automated and Electric Vehicles Act 2018 should be amended to replace the current listing procedure with the authorisation procedure recommended in this report. The provisions of the Automated and Electric Vehicles Act 2018 concerning civil liability (sections 2 to 6 and 8) should apply to any vehicle authorised as having self-driving features under the scheme set out in Chapter 5 of the Law Commissions' report.

**Recommendation 71.** The UK government should review product liability law (including the Consumer Protection Act 1987) to take account of the challenges of emerging technologies. The review should cover product liability as a whole, rather than be confined to automated vehicles.

**Recommendation 72.** The UK government should put in place measures to provide compensation in respect of uninsured authorised vehicles, equivalent to that provided for under section 2(1) of Automated and Electric Vehicles Act 2018.

**Recommendation 73.** The authorisation authority should require data to be collected and stored to process insurance claims. The required data should include (but need not be limited to) the date, time and location of each occasion when:

14. a self-driving ADS feature is activated or deactivated;
15. a transition demand is issued; and
16. a collision is detected.

The required data should be stored for 39 months from the date when it is recorded and, where a request is made for it within that period, until the required data has been given to the insurer.

**Recommendation 74.** The new Act should impose a duty on those controlling AV data to disclose data to insurers, where the data is necessary to decide claims fairly and accurately.

**Recommendation 75.** The in-use regulator should have a statutory power to issue a code of practice on AV data, to which all those disclosing data must have regard.

# Annex D: Detailed comment on the Law Commissions' Recommendations

In 2018, government asked the Law Commission of England and Wales and the Scottish Law Commission (the Law Commissions) to conduct a review of driving legislation to prepare for the introduction of self-driving vehicles on GB roads.

The Law Commissions' final report<sup>54</sup>, including recommendations to government, was published in January 2022. A full list of the recommendations is provided at Annex C. This document provides the government's response to the recommendations, setting out the framework for the safe, legal and fair deployment of self-driving vehicles. It does not take each recommendation individually, but this Annex identifies those recommendations on which government makes specific comment.

### Primary legislation

The Commissions' first recommendation calls for a new 'Automated Vehicles Act' to 'regulate automated vehicles on roads and other public places in Great Britain', emphasising the need for uniformity across the country. We agree, and we seek to implement their recommendations in the forthcoming Transport Bill. We will work closely with the Devolved Administrations

to ensure that devolution issues are being adequately addressed.

### The use of self-driving vehicles

In line with the Commissions' fourth recommendation on activities the UiC should not be permitted to perform, we have amended the Construction and Use Regulations 1986 to allow the use of the vehicle's in-built display screen to view content not relating to driving or the vehicle systems whilst a vehicle is lawfully driving itself. We expect these display screens in self-driving vehicles to automatically switch off if a transition demand is issued. Offences relating to viewing other screens or using handheld mobile phones remain unchanged. Government will keep under review what activities may be safe for a UiC to perform whilst a vehicle is driving itself, in light of available evidence. Recent changes to The Highway Code have also highlighted the need for the driver to retake control when prompted to do so,



and hence the need for them to remain fit and ready to drive (sober, awake, in the driver's seat and so on). Under the new framework, occupants would be classed as passengers during the operation of a no user-in-charge (NUiC) feature, and would not be considered drivers so could not commit driving offences relating to screens or fitness to drive.

As mentioned in section 3.3 CAM Trade & Investment, the UK government already engages extensively in international fora, like the United Nations Economic Committee for Europe's (UNECE) Working Parties 1 and 29. This engagement will continue to address the Commissions' fifth recommendation. Indeed, Regulation 157, covering Automated Lane Keeping System (ALKS), has already set clear requirements for how a user can take over control of the vehicle which are designed to avoid unintended takeovers. This has set a precedent which may inform any future regulations, whether domestic or international, relating to UIC features.

In their third chapter, the Commissions consider the distinction between driver assistance and self-driving. We discuss this threshold in detail in section 2.2.4 on Continuous Learning.

### **National Safety Principles for Self-Driving**

We have already addressed the need for a set of National Safety Principles for self-driving in Chapter 2. This implements the Law Commissions' sixth and seventh recommendations, which refer to a 'safety standard' to which the Secretary of State must have due regard when exercising his regulatory duties.

### **Authorisation, the ASDE, and vehicle approval**

The introduction of the authorisation decision will be a crucial component in the safety assurance of self-driving vehicles, implementing Recommendation 9 on pre-deployment safety assurance. It would determine when it is safe to allow a vehicle to drive itself using one or more self-driving features. A self-driving feature would not necessarily be a distinguishable combination of software or hardware but rather a function of the vehicle's onboard technology, which would interact with the occupant(s) and may make certain demands of them.

A Category 1 feature would require a user-in-charge to respond to a transition demand in order to be used safely. Comparatively, a Category 2 feature would not require intervention by an occupant to ensure the safety of the vehicle, but it would need to be overseen by a licensed NUiC Operator. We cover this below.

We expect to build on the concept of the monitoring test as part of the authorisation decision, as was developed for the listing of ALKS (see section 2.2.2), implementing part (2) of Recommendation 10 relating to a vehicle's ability to drive itself. Similarly, government intends to ensure domestic approval regimes can accommodate advanced vehicle technologies, thereby implementing part (1) of Recommendation 10 as well as Recommendation 8, both of which relate to technical approval. We discuss parts (3) and (4) of Recommendation 10 below. As recommended by the Commissions in Recommendation 11, we expect the published record of authorisation to include an identification of features fitted and whether each feature is authorised for use with or without a UIC.

Recommendation 12 identifies the criteria for an ASDE, another fundamental component in the safe regulation of self-driving vehicles. We intend to consult in further detail on aspects like good repute ahead of secondary legislation and would welcome engagement with stakeholders to understand what ASDEs could look like. Whilst we agree with Recommendation 13 on the ongoing duties of ASDEs, following further discussion with the Commissions, we believe these duties go wider than the recommendation suggests.

We intend to set the following, broad duties on the ASDE:

- Ensuring that vehicles drive safely and legally throughout their life (which includes remaining compliant with their authorisation),
- Ensuring cybersecurity,
- Updating the safety case and any assessment of fairness,
- Providing data to the regulator,
- Communicating information to users, owners, and registered keepers,
- Continuing to meet ASDE requirements (such as financial standing and good repute),
- Processing data in compliance with data protection law,
- Collecting, storing, and sharing data to process insurance claims,
- Co-operation with government and other necessary parties.

This is a non-exhaustive list, and we will specify the final list once we take legislation to Parliament. The detail of these duties will be set out through secondary legislation, and we will consult on them in due course.

Furthermore, in discussion with the Commissions, we believe it could have been clearer that government may set 'deployment conditions' on individual authorisations. In line with the existing definition of automated vehicles, which specifies that vehicles may drive themselves 'in at least some circumstances or situations' (AEVA 2018). We would not want to hamper innovation by requiring ASDEs to demonstrate their vehicles can drive themselves safely and legally outside their intended deployment context. Therefore, setting conditions on an authorisation will be sensitive to the evidence an ASDE can supply in their safety case.

For example, an ASDE may not be able to provide sufficient evidence that their vehicle can meet the requirements for authorisation in low levels of light associated with night-time. It would be a limit on innovation to deny the ASDE authorisation. Instead, in this example, we intend to enable the regulator to issue an authorisation, but one which prevents the vehicle legally driving itself at night-time.

We welcome views from stakeholders on what conditions they feel could foster innovation and enable them to obtain authorisation in specific circumstances. This will also be subject to consultation ahead of secondary legislation. This will also be subject to consultation ahead of secondary legislation.

We will consult on and provide further detail in relation to Recommendation 15 on safety cases and assessments that will avoid unintended data bias or other unfair outcomes, which could otherwise lead to discrimination, promote accessibility for different types of disability, and help mitigate any impacts on vulnerable road users. These will be key pieces of documentation needed for authorisation and will require close working with stakeholders. The overall authorisation scheme, including an appeals process, will be subject to further consultation ahead of secondary legislation.

### In-use Regulation

We agree with the Commissions that an in-use regulatory scheme must be established to ensure self-driving vehicles remain safe and legal throughout their lives and to collect evidence for the overall safety of self-driving compared to conventional driving. This may be best thought of as regulating the vehicle's deployment as a vehicle that is permitted to drive itself.

As part of ensuring vehicles' safety, it is important that government has the ability to investigate what the Commissions refer to as traffic infractions as well as other instances of non-compliance by an ASDE or NUIc Operator. We will consult in further detail on the implications of Recommendation 20. This will help determine what data will need to be collected under a broad power.

We will consult in further detail on the implications of Recommendation 20. This will help determine what data will need to be collected under a broad power.

On Recommendation 21, relating to traffic infractions, we would like to clarify that, in

consultation with the Law Commissions, we have concluded that we do not think it will always be possible to determine causation of an infraction by an ADS feature, certainly in the early days. An inability to determine causation by the wording of part (2) of the recommendation would seriously hinder government's ability to apply sanctions to non-compliant ASDEs (or operators). Instead, we believe sanctions could apply when there is evidence that the vehicle was driving itself, as will already be determined for insurance purposes. We will clarify the meaning of 'traffic infraction' as part of future consultation. We will ensure that Recommendation 22 on a protocol for AV traffic infraction investigation is met ahead of the new scheme coming into force.

We support the idea behind Recommendation 23; that a user of a self-driving vehicle must understand how the vehicle operates in order to use it safely, and we highlight it as a likely ASDE duty. Manufacturers already provide information through the owner's manual to help drivers understand their vehicle and already. Through the AV-DRiVE group, government has been working closely with the Society of Motor Manufacturers and Traders (SMMT) and others to provide guidance to users of the first vehicles fitted with ALKS. We will continue this close engagement going forward, especially as vehicle sophistication increases.

We also note that the need to communicate may go beyond the user to the vehicle owner and registered keeper. We will also consult on the implications of Recommendation 23 ahead of secondary legislation.

As recommended in Recommendation 25, we intend to ensure the in-use regulatory scheme abides by the Regulators' Code,

subject to the Legislative and Regulatory Reform Act 2006, and will address this in more detail ahead of the scheme coming into force.

In Recommendations 30 and 31, the Law Commissions highlight the need for dedicated consultative mechanisms for self-driving vehicle regulation, especially on road rules. In their responsible innovation report, the Centre for Data Ethics and Innovation (CDEI) have proposed how to operationalise these recommendations with the creation of a new science advisory committee – the Committee on Automated Vehicle Ethics and Safety (CAVES) – a sub-group of which will look at road rules.

Government intends for the forthcoming Transport Bill to include provisions for a Road Safety Investigation Branch (RSIB), implementing Recommendation 32. Though its remit will be wider than just self-driving vehicles and it is not expected to be fully operational until 2025/6, it will be very important that the RSIB is able to investigate any collisions involving self-driving vehicles to determine how such collisions can be avoided in the future but without seeking to attribute blame.

This is a little different to the in-use regulatory scheme. Though we echo the principle set out by the Commissions that the regulatory scheme for self-driving vehicles should move towards a 'no-blame culture' and should improve learning across the sector, we also believe it will be important to apply appropriate sanctions on ASDEs where there is evidence of a lack of due diligence by the ASDE that led to an incident. We expect that infractions by self-driving vehicles will be rare, enabling us to move towards a safety culture more like the aviation sector, but it is nonetheless important that ASDEs whose vehicles fall

below the threshold can be appropriately penalised.

Though cyber-security was beyond the scope of the Law Commissions' review, we support their proposal, at Recommendation 33, for cybersecurity being part of the in-use regulatory scheme. We will consult on this in due course.

### **Marketing self-driving vehicles**

We support the Commissions' proposal for new offences relating to the misleading marketing of self-driving technology. We cannot allow a loophole to emerge whereby a disreputable developer decides not to put their vehicle forward for authorisation but nonetheless confuses consumers into thinking it is safe to use it as self-driving. This implements the strong support across the Commissions' consultations for a ban on unauthorised self-driving vehicles.

We would like to clarify, however, that following discussion with the Commissions, we have concluded that we would not wish these new offences to apply to interactions between businesses. A business that will not use the vehicle, but may be intending to seek authorisation in the future, is not at risk of using a vehicle unsafely. Instead, it is end-users who are most likely affected by misleading marketing. Therefore, we think it would be permissible for one business to sell their ADS to another claiming that it is self-driving even if it had not been authorised within a vehicle. Similarly, a business claiming that they are designing self-driving technology ahead of authorisation, would also be permissible as it does not imply an end-user can use the technology as self-driving, only that it is intended to be once authorised.



More details in relation to Recommendation 37 on enforcement agency powers will be available as the Bill goes to Parliament and thinking is on-going as to how to meet Recommendation 38 on nominating an enforcement agency.

### **The User-in-Charge**

We strongly support the concept of the user-in-charge recommended by the Commissions and will seek to implement this concept in primary legislation. If a vehicle is authorised to drive itself, the ASDE would be responsible for its behaviour, and so the driver should not be held responsible.

Once drivers hand over control to a self-driving feature, they would become users-in-charge, who are responsible only for compliance with traffic rules not relating to the behaviour of the vehicle on the road, such as ensuring the vehicle has appropriate insurance, is roadworthy, loaded correctly and children in the vehicle are wearing seatbelts and in the appropriate seats.

The user-in-charge must hold a valid driver licence for the vehicle because they would become a driver with all associated responsibilities if they take over control, or at the end of the transition period if they fail to respond to a transition demand. However, a user-in-charge would rightly have an expectation that a self-driving vehicle will behave safely as set out in the safety case submitted by the ASDE for authorisation. So we intend for the user-in-charge to be protected from prosecution if the vehicle issues a transition demand in a dangerous situation where a careful and competent driver would not be able to avoid a collision, or if at the end of a transition

demand the vehicle does not perform the expected Minimum Risk Manoeuvre.

### **The No User-in-Charge (NUiC) Operator**

The No User-in-Charge Operator is an important, new legal actor under the regulatory framework. Where a vehicle is fitted with a Category 2 ADS feature, it is important that a suitable operator is licensed to pick up the non-dynamic driving task responsibilities that would otherwise be held by the user-in-charge, such as ensuring the vehicle is roadworthy and has appropriate insurance. Likewise, the operator must ensure they can safely remotely oversee the vehicle when it is driving itself, though how this can be done safely will need to be explained by the ASDE when seeking to obtain authorisation for the feature. Importantly, a NUiC operator does not take over responsibility for the vehicle's behaviour (the performance of the dynamic driving task) from the Authorised Self-Driving Entity (ASDE). Instead, they are ensuring safe use of the technology by the vehicle's passengers, who can be expected to bear no responsibility for any element of the vehicle.

Furthermore, the operator may not necessarily be offering a public service. This is covered below on passenger-only services. An operator running a non-public service may choose to lease their vehicles to paying customers, operating something akin to a car club. We think there are many different business models opened up by the new operator concept, enabling the creation of an entirely new market.

We agree with the Commissions that an ASDE and NUIc Operator could be the same entity, and also believe this is likely to be common early on. Where these two actors combine, we refer to them as a Combined Authorised Self-Driving Operator (CASDO). We will clarify ahead of secondary legislation how a CASDO may obtain an authorisation and NUIc license.

### Passenger-only services

We agree with the Commissions' recommendations for a new permitting scheme for passenger-only services, where no driver is present. This new scheme will be subject to consultation ahead of secondary legislation.

Having considered the recommendation, we have decided to move away from the terminology of 'interim' permit, though we agree with the Commissions that this bridges a gap where the vehicle has no driver and that more learning is needed before any broader changes are made to passenger licensing. We also agree that it makes sense to have a bespoke system for self-driving passenger services whilst the technology is so nascent. We also believe the scheme could extend to trials which are operated with the intention of having no driver. This too will be subject to consultation.

Whilst we fully support the need for a new accessibility advisory panel to sign off permits, we do not believe it need be statutory for the moment. Instead, we commit to establishing an identical panel in time for commencement of the permitting regime, though this panel will not be established through legislation. The Secretary of State for Transport will need to pay due regard to accessibility when issuing a permit. We also expect that

this panel would help design a national minimum standard for the accessibility of self-driving passenger service vehicles over time as learning improves.

### The Duty of Candour

We agree with the Commissions' sixty-fifth recommendation on the new duty of candour offences. It is important that, with the asymmetry of information inherent to this nascent technology, government has a final resort to penalise ASDEs and NUIc operators who fail to disclose, or mislead in the disclosure of, safety-relevant or operational information.

We expect prosecutions to be very rare as the industry has expressed a strong desire to cooperate with government on the safety of self-driving vehicles.

### Wrongful interference

We support the Commissions' recommendations relating to wrongful interference. We intend for recommendation 66 to be addressed as part of the forthcoming Transport Bill but will apply more broadly than just self-driving vehicles. More details will be available as the Bill enters Parliament.

Further details of the other amendments to existing tampering and interference offences will also be available as the Bill enters Parliament, though no other offence will be extended beyond self-driving vehicles.

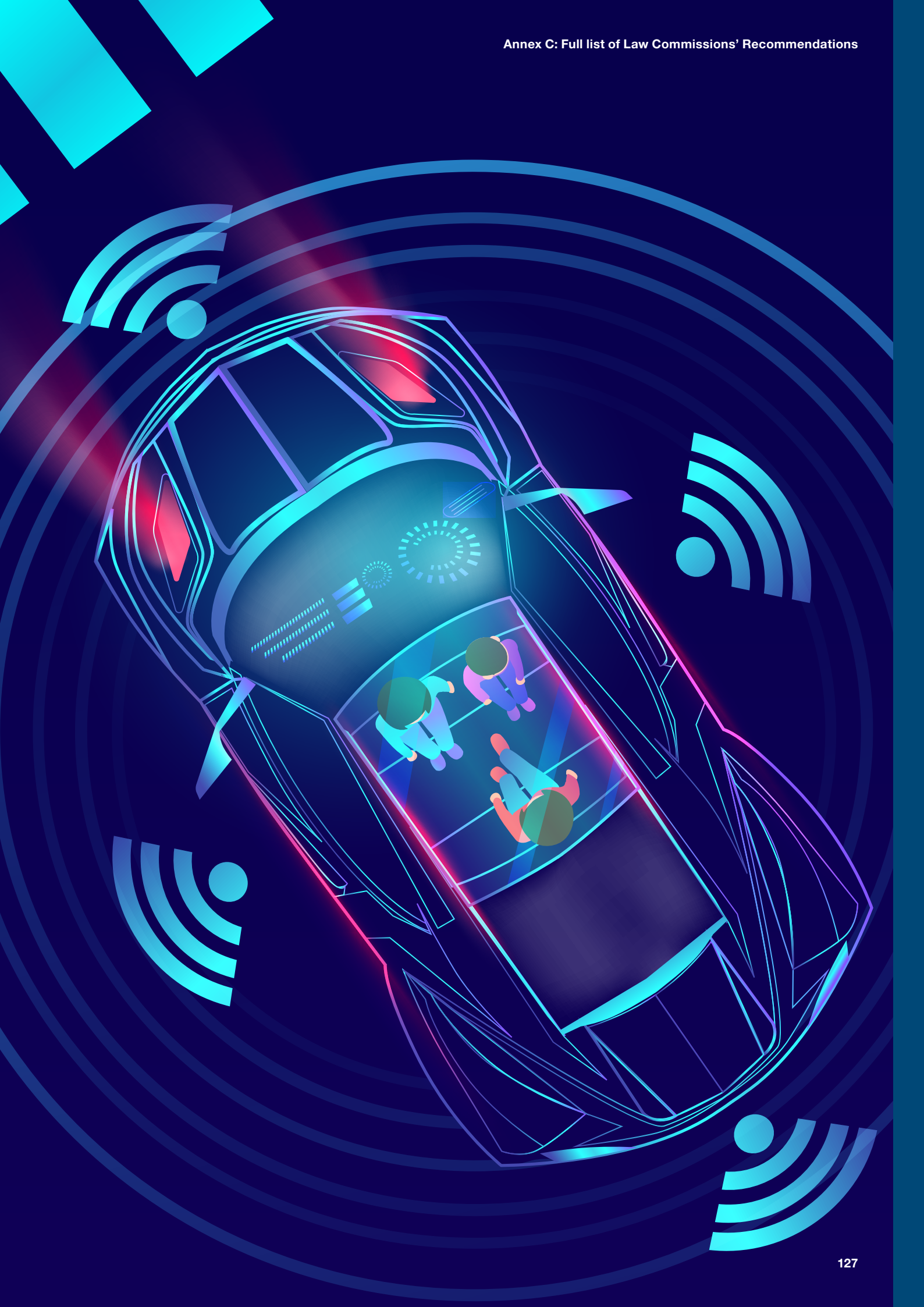
## Civil Liability

The Automated and Electric Vehicles Act 2018 has been a central focus of self-driving vehicle regulation since receiving Royal Assent in 2018. It laid the foundations for the new regulatory framework we seek to bring forward in the forthcoming Transport Bill. However, though it has lent its definition, in part, to the new scheme, it is now right that the authorisation decision replaces 'listing' (see section 2.2.2), which is more limited in scope. Any vehicles that have already been listed by the time the new framework is commenced will have time to convert to authorisation prior to the regime coming into force. The Secretary of State's List will be replaced by authorisation records. We will work closely with the Motor Insurers' Bureau (MIB) to ensure measures are in place for uninsured self-driving vehicles in time for the first self-driving vehicles being either listed or authorised (whichever comes first).

Recommendation 71 on reviewing product liability law highlights a very important issue and we will be engaging more widely with government to understand next steps.

Recommendation 73 relates to data for insurance claims. Government has already had a series of productive conversations with manufacturers and insurers on the collection, retention, and sharing of data relevant for insurance purposes. Stakeholders agree this is an important issue and we will consult on the details of this new data regime ahead of secondary legislation.

We also agree that the in-use regulatory scheme should be able to issue a Code of Practice on data disclosure. This is without prejudice to guidance issued on broader data issues, as discussed in the CDEI Responsible Innovation report, but this guidance is not within scope of the future legislative changes discussed above. We will consult on the details of this Code in due course.





# Annex E: The self-driving story so far

The following provides an illustrative summary of responses to the 2021 call for evidence. It is not exhaustive. There will be omissions and information has been anonymised or omitted where permission for publication was not provided. The absence of a suggestion from this report does not mean it will not be considered as we continue to gather evidence, engage with stakeholders and further develop policy.

### Government action so far

To date, government intervention has been focussed on enabling a comprehensive regulatory framework to enable the development of self-driving vehicles, and on accelerating UK development of the technology. Achievements include:

- Joint investment, in partnership with industry, of over £440 million in both world-leading research and development projects and CAM Testbed UK, with the latter offering a unique, interoperable set of trialling environments to attract global companies to the UK.
- Investment in connectivity trials, including the A2/M2 ‘connected corridor testbed’. This enabled vehicles to communicate road safety information using roadside equipment, and tested connectivity technology on different road types, 2018-2020.
- The globally recognised, innovation-friendly Code of Practice for automated vehicle trialling.
- The launch of the Connected and Automated Vehicle Process for Assuring Safety and Security (CAVPASS), which will develop a comprehensive safety and security assurance process for connected and self-driving vehicles.
- The Automated and Electric Vehicles Act (2018), which included the world’s first legislative definition of an automated vehicle and made provisions for suitable insurance.
- The world-leading, three-year Law Commissions’ Review into a new legislative framework in Britain for self-driving vehicles.
- The launch of Zenic’s ‘UK Connected and Automated Mobility Roadmap to 2030’ (2019).
- Announcing that we expect vehicles with Automated Lane Keeping System technology to meet the requirements for listing as self-driving (decisions will be made on a case by case basis through vehicle approval).

These achievements have helped secure the UK's global reputation as a leading early market for CAM. Research undertaken by KPMG and WSP for government in 2021 showed that the UK is viewed internationally as having an ecosystem with strengths in R&D capabilities, skills and technologies such as automated control systems, artificial intelligence and machine learning, and sensors. This is in addition to having high innovation potential and an expectation of both high growth in UK CAM and of a high degree of potential end user or customer demand.

### Existing self-driving vehicle legislation and amendments

The Automated and Electric Vehicles Act 2018 (AEVA) was the first legislation to provide specific provision for self-driving vehicles. Part 1 of AEVA, which was commenced in April 2021, focuses on insurance for self-driving vehicles and supports quick access to compensation for victims of a crash involving a self-driving vehicle, addressing a concern that if a vehicle does not have a driver then it may be unclear who the victim should seek redress from.

AEVA includes a legal definition of a self-driving (automated) vehicle, which is a vehicle that, in the Secretary of State's opinion, is capable of safely driving itself without the need for monitoring or control by an individual. AEVA requires the Secretary of State to maintain a list of vehicles that meet this definition, although there are currently no vehicles listed. The Law Commissions concluded that AEVA remains fit for purpose for self-driving vehicle insurance purposes, but that the current listing process should be replaced by the new authorisation process

(see section 4.1): government supports this view and will legislate to this effect.

Government expects any vehicles that have been listed under AEVA by the Secretary of State for Transport before the new provisions come into force will be able to meet the monitoring test and other vehicle-specific requirements under authorisation. However, government will need to assess the suitability of their respective Authorised Self-Driving Entity (ASDE), for example whether it is of good repute and sufficient financial standing.

Regulatory standards for automated vehicles are being developed both in the UK and internationally. The UK recognises the value of continuing to work with our international partners on global regulation. Harmonised standards support international development, sale and use of self-driving vehicles globally, and will continue to do so, with UK support. We have ensured that the regulatory framework proposed by the Law Commissions is consistent with international regulations.

The UK is an active and influential member of the United Nations Economic Committee for Europe's (UNECE) long-standing Working Parties that consider the technical standards and use requirements for road vehicles, known as WP29 and WP1 respectively. The UK is also a member of a new Group of Experts (GE.3) set up by the UNECE Inland Transport Committee under WP.1 to draft a new international legal instrument on the use of self-driving vehicles in road traffic.

## Recent UNECE areas of focus:

An extension to the ALKS regulation for use in other types of vehicle came into force in June 2022. In the same month, a further amendment was approved to enable its use at higher speeds and with lane change capability which is due to come into force in January 2023 (WP29).

Cyber security and software update regulations (WP29). These regulations introduce specific requirements and procedures for how the cyber security of a vehicle should be provided for and maintained and how software on a vehicle may be updated once in use. They also require management processes to be in place to monitor and respond to cyber threats as well as ensure that software updates are done in a controlled and auditable manner. These processes are audited regularly to certify continued compliance.

Drafting of a new legal instrument on the use of self-driving vehicles in road traffic (GE.3).

Agreement of a Resolution which creates guidelines for how drivers may safely perform activities not related to driving while self-driving vehicles are driving themselves (WP1).

Adoption of an amendment to the Vienna Convention to provide clarity that the requirement for a vehicle to have a 'driver' can be met where it is being driven by an approved automated (self-) driving system. The UK supported the amendment on the basis that clarity in law is important for road safety, and several contracting parties felt that an amendment was necessary to ensure legal clarity in their territories. However, in the UK's interpretation of the Vienna Convention as it was, and in UK law, there was sufficient flexibility to consider an automated (self-) driving system as capable of meeting some of the requirements of a driver that relate to the dynamic driving task (WP1).

For self-driving vehicles in particular, however, there is a need to consider national and local contexts. Compliance with national road traffic rules is of paramount importance and a self-driving vehicle's ability to drive safely in one country does not necessarily translate to safe driving in another. Both road rules and public expectations may differ.

This was evident throughout government's work to consider the safe use of vehicles fitted with ALKS on Great Britain's roads. Government undertook a call for evidence on the safe use of ALKS on Great Britain's roads in August 2020 and published a summary of responses, and next steps, in April 2021.<sup>55</sup>



This highlighted the importance of compliance with local road traffic rules, as well as issues such as user understanding and fair delegation of responsibility. Using ALKS as a first potential use case for self-driving vehicles government has implemented changes to regulation and statutory guidance.

[Government has adapted the Road Vehicles (Construction and Use) Regulations 1986 to allow drivers to view content not related to the driving task through the built-in infotainment system of listed self-driving vehicles while those vehicles are driving themselves. Drivers will then be able to use those screens for leisure or work purposes during periods when they do not need to engage with the driving task.]

Following consultation, government has added a new section to The Highway Code on the safe use of self-driving vehicles to clarify driver responsibilities and the rules on the use of vehicles with self-driving features. Driver education is key to road safety, and alongside this amendment we are working with stakeholders to ensure there is a good understanding of how to use self-driving features before commercial deployment. The creation of the AV-DRiVE group brings together government, industry and road user groups to consider driver and road user communications. See Chapter 4 for further information on AV-DRiVE.

### **CAVPASS work to date**

The CAVPASS programme aims to put in place the processes, systems and capabilities necessary for government assurance of the safety and cyber resilience of connected and self-driving vehicles by 2025. Ongoing work is set out in Chapter 2.

Development of Low Speed Automated Driving (LSAD) standards has been an initial focus of the CAVPASS programme as this was identified as a likely early use case for self-driving vehicles and an area where international regulation was lacking. Launched in 2021 this work covers a range of issues, as detailed in Chapter 2.

Building VCA capability has been another key area of CAVPASS work. It has included the establishment of a new self-driving vehicle team, development of testing protocols for vehicles with ALKS technology, the purchase of measurement and testing equipment to support VCA test capabilities, and the development and delivery of new training modules on cyber security.

Support for trials of self-driving vehicles has been provided to several trialling organisations in order to register trial vehicles for use on the road. Each trial and set of circumstances is different so there is no single 'process' for support: each enquiry is dealt with individually. Working with trialling organisations has provided valuable insight into the safety and regulatory issues faced when trialling a self-driving vehicle, particularly as the technology develops and trials become increasingly complex. This has helped to shape future work.

Work has also included the development of a process for Independent Safety Case Audit (ISCA) of government-funded trials. As the capability of self-driving technology develops and the complexity of trials increases, the risks associated with trials also increase. This is particularly true for trials on public roads and/or trials of vehicles without an on-board safety driver. In addition to the rigorous safety assurance and due diligence expected of

a trialling organisation, government will require all CCAV-funded trials to undergo an Independent Safety Case Audit by the VCA. This will provide government with an additional level of confidence in the safety of government funded trials. It will also provide a valuable learning opportunity for the VCA and trialling organisations.

### **Safety and cyber resilience research**

Government has undertaken a number of research projects looking at a range of safety and cyber resilience issues for self-driving vehicles. These have been undertaken with the support of Innovate UK and Zenzic, and in collaboration with industry and academia.

The following four projects were managed by Zenzic on behalf of government:

#### **Cyber resilience**

The Cyber Resilience project set out to develop a proof-of-concept on how connected and self-driving vehicles will detect, understand, and report emergent cyber threats in real time. This project included the development of tools with the potential to provide cyber-attack resilience when applied to a real-world automotive application (such as braking) whilst considering both technical and commercial viability.

The project established a proven methodology and set of tools which demonstrate adherence to existing cyber regulations and proposed “blockchain” technology as one of the methods suitable to provide the necessary cyber resilience. This method, and the evidence produced by it, is capable of being tested in court or by publicly appointed regulators and has the potential to provide, on a per vehicle basis, a real-time compliance argument.

### **Interoperable simulation**

This project aimed to create a seamless experience for simulation testing across CAM Testbed UK and enable the testbeds to maximise their collective capability. It established an end-to-end Verification and Validation (V&V) pipeline for simulation and undertook comprehensive stakeholder engagement to inform two accompanying publications: a simulation roadmap and a stakeholder report.

The resulting pipeline employed a scenario-based approach, supports verifying both the self-driving system as well as the simulation toolset itself, and aligns with associated international standards for functional safety of road vehicles.

### **V2X Services**

The V2X Services project aimed to develop a scalable architecture for V2X (vehicle-to-everything) – the technology that allows for data exchange between vehicles, vulnerable road users and infrastructure. The project reported on the country’s existing capabilities and initiatives before developing the architectures required to enable widespread V2X infrastructure and testbed support.

A standardised system to deploy V2X services was created, and the architecture was implemented into the infrastructure at both Horiba MIRA and Millbrook, allowing for stakeholders to test and develop their cooperative intelligent transport systems at these sites.

## Consumer rating scheme

This project aimed to develop a consumer rating scheme for self-driving vehicles. The protocol reflected simulation and physical testing to provide a consumer facing output. The initial test case was to draft protocols for a consumer rating assessment of Automated Lane Keeping Systems (ALKS).

Government also funded four industry-led projects, run and managed by Innovate UK, supporting the development of safety assurance processes through practical application. All projects aimed to advance understanding of the safe and secure removal of the safety driver from self-driving vehicles:

### AZORA

AZORA, Assured Zero Occupancy with Remote Assistance, resulted in the creation of a safety assurance tool for advanced trials in the UK, which was developed and agreed by industry experts. It also led to a series of witnessed tests of fully driver-out vehicles at Culham Science Centre, accompanied by an industry workshop to review and discuss the safety assurance tool.

### SPACES

SPACES, Safe Pathway to Autonomous Control Externally Supervised, was a project dedicated to the safe operation of 'Auto-Shuttles' using remote monitoring without an onboard safety supervisor. The project assessed the additional safety requirements that arise because of remote supervision, both in terms of implementation and engineering.

## SAVOR

SAVOR, Safely Advancing Vehicle Automation On Roads, was a project exploring the key requirements to apply remote monitoring and teleoperation to automated vehicles, including the automation software stack, the communication requirements and the remote monitoring and control interface.

The project derived key understandings around the feasibility of remote monitoring and teleoperation to reduce the operational costs as an offset for CAV technology cost. It also tested and assessed the technologies necessary for remote monitoring and teleoperation, particularly in relation to the minimum communications delay for safe operation.

### ENCODE

ENCODE, ensuring cybersecure deployments of driverless teleoperated vehicles, was a project with a focus on the cyber security analyses and mitigations associated with a "multi-driver" system, through contributing research and evidence to industry standards and best practices. It looked to build understandings for their inherent liabilities and enable overarching visibility via a proof-of-concept fleet monitoring system.

In the project demonstration, two "multi-driver" vehicles were operated simultaneously across two different cities (London and Oxford) on public roads. The "Drive-by-wire" system that was developed allowed for seamless switching of vehicle operation between manual, autonomous and remote operation. For this trial, the remote operator demonstrated the ability

to switch from one vehicle to another and teleoperate them remotely to assist the ADS when identifying that the environment was outside its ODD.

The following projects were also funded by government to fill identified knowledge gaps:

### **Safety Pool Scenario database**

The Safety Pool Scenario Database, being led by WMG/University of Warwick, is a three-year project and is currently the largest database of CAV scenarios worldwide. Scenarios describe a short scene of interest and enable developers and assessors to better view, understand and assess an ADS's behaviour.

The project has been running for a year, and since it started numerous improvements have been made to the database features and inputs, including new scenarios being added, additional detail on user-interfaces, capability for scenario searching & storing, improved scenario organisation and test bed identification. It now also aligns and integrates with the CAVPASS / LSAD GB Type Approval Programme.

### **Safe MRX**

The Safe MRX project was led by the Connected Places Catapult (CPC) to clarify the concepts of minimal risk manoeuvres (MRM) and minimal risk conditions (MRC), collectively known as MRX. The project developed a risk-based framework for deciding whether MRM/MRC functionality is adequate and built understandings for the main challenges and specific technical requirements for MRM/MRC functionality based on the current state of knowledge.

### **Sensor assurance**

This project centred around research carried out by the National Physical Laboratory (NPL) and the Met Office to understand differences in sensor performance under different weather conditions and create standardised metrics to reflect any degradation of a sensors' performance, which may result in an ADS making unsafe or unpredictable decisions.

The project was able to prove a real-world testbed concept to reliably understand the changes in the performance of different types of CAV Sensors under different weather-related conditions. This testbed concept generates accurate sensor data under both controlled and naturally varying conditions and the effects of both rain and fog degradation on different sensor types are observed quantitatively in the experimental data.

By the end of the project, the project determined the required set of measurements for an "operational" testbed, a more comprehensive understanding of contributing factors to AV sensor degradation and a verifiable approach for incorporating the simulation of sensor data and the effect of degradation due to weather and lighting conditions into a Virtual Test Environment (VTE).

This research, along with planned future work, will all feed into the development of the safety assurance framework.



# Annex F: Summary of findings for the BEIS call for evidence on the future of UK CAM

The following provides an illustrative summary of responses to the 2021 call for evidence. It is not exhaustive. There will be omissions and information has been anonymised or omitted where permission for publication was not provided. The absence of a suggestion from this report does not mean it will not be considered as we continue to gather evidence, engage with stakeholders and further develop policy.

### **Strengths of and threats to the UK CAM Ecosystem**

The UK CAM sector was described by most respondents as strong, despite some areas of the supply chain being in their infancy. Respondents noted that the sector's ecosystem was highly engaged and collaborative. This a key strength that has been bolstered through funded collaborative research and development programmes, the strong interaction between private, public sectors and academia, and ongoing support from government, Innovate UK, and Zenic. In terms of industrial expertise, automated control systems and simulation, cybersecurity, and the wider automotive supply chain, including sensors, vehicle design and manufacturing were highlighted as areas where the UK was perceived to have particular strengths. It was noted by one respondent that these technologies could have far reaching impacts that

would be felt by more than just those organisations directly involved in the CAM ecosystem with spill over into other modes of travel and industrial sectors.

A potential future lack of investment in UK CAM was seen as the greatest threat to the sector. Specifically, this point reflects ongoing difficulties in accessing private finance to scale up operations, especially when compared to some other international markets. Government has previously heard from industry that barriers to scaling include venture capital (VC) investors being deterred by uncertainty and unfamiliarity in the future of CAM and opting to invest in other technology sectors where returns are seen as more reliable and the market more mature. In this context, government investment is seen as a tangible, targeted signal of support for an emerging sector which informs investor confidence, de-risks investment, accelerates and amplifies the opportunity, and helps anchor it in the UK.

Respondents to the call for evidence also noted that the decarbonisation of the automotive sector was an absolute priority and could mean that the required focus from industry and government on electrification could disincentivise investment in CAM. This risks compromising the UK automotive sector in the long-term by missing out on the benefits that other markets may have reaped from investing in CAM. There was

concern that this could lead to the UK losing its status as a leading destination for CAM innovation and deployment, potentially leading to the UK being a technology ‘taker’ rather than a technology ‘maker’ and lose the economic and societal benefits of a strong homegrown CAM sector. A government commitment to CAM both in terms of a renewed strategy and new funding support to de-risk CAM innovation was seen as critical to mitigating this threat.

Respondents praised the progress made by government to date on developing a comprehensive regulatory and legislative environment that can enable the use of CAM in the UK. In particular, the UK’s flexible approach to safe testing and trialling of new CAM technologies was seen as a strength. However, respondents also reaffirmed that regulation and legislation must develop in step with technological advances, ensuring that it enables rather than prevents CAM services and technologies from entering the mainstream market.

Respondents praised the UK’s wealth of engineering, systems, and technology skills as well as the unique community of engineers, policy makers, and business developers that work in the country. The strength of the UK’s academic and start-up/ small and medium sized enterprise (SME) communities were also highlighted as a significant factor in the strength of British innovation and research. However, issues in commercialisation and manufacturing skills availability within the UK were identified as potential weaknesses and highlighted the risk of “reimporting” technologies developed here but manufactured elsewhere. Respondents highlighted that relatively high labour costs and barriers

to accessing talent (for example, being unable to find where necessary skills are located or find contacts for the individuals) were weaknesses when compared to some international counterparts.

Growth in UK CAM and of a high degree of potential end user or customer demand.

### **Sector priorities for CAM up to 2030**

Respondents set out that the overall priority for the CAM ecosystem over the next 10 years should be to make the UK an excellent environment in which to start or grow a CAM company and to make it internationally successful. A focus on government innovation support, a comprehensive and innovation-friendly regulatory and legislative framework, and a clear strategy for the deployment of CAM were seen as crucial to enabling companies in the UK to scale up and become commercially successful and globally competitive. In addition, respondents believed that government should encourage the uptake of CAM in the freight use-cases, enabling an early commercial market for the technologies and future-proofing the UK’s logistics sector.







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