

# INNOVATION IS **GREAT**

CONNECTED AND AUTOMATED VEHICLES



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# Foreword



*– Iain Forbes,  
Head of the Centre  
for Connected  
and Autonomous  
Vehicles*

**Connected and automated vehicle (CAV) technology is set to play a major role in the exciting transport revolution happening today in the UK, helping to improve and level up transport across the nation by making every day journeys greener, safer, more flexible and more reliable.**

The potential benefits of the technology in the UK are vast. We want to see the technology make transport greener, cheaper and more efficient; to better connect rural communities, giving everyone better access to education, to work or simply to seeing friends and family more often; to call an end to urban congestion, with traffic lights and vehicles speaking to each other to keep traffic flowing; and to make our roads safer, reducing human errors that can lead to accidents.

As well as providing improved transport for all, we believe that CAV technology could also deliver huge economic benefits. The market in the UK could be worth between £52 billion and £62 billion by 2035, capturing around 6 per cent of the £907 billion global market, creating tens of thousands of jobs.

It is with these opportunities in mind that the Centre for Connected and Autonomous Vehicles (CCAV) was established in 2015; an expert unit that is shaping the safe and secure emergence of CAV, making the UK the best place in the world to develop and deploy the technology and ensuring that all areas of society can benefit from its potentially transformative effects.

Driven forward by the UK Government's ambitious, clear and comprehensive Future of Transport strategy, CCAV is developing regulation, investing in innovation and skills and engaging the public to create a thriving CAV sector. It is uniquely placed to bring together world class expertise from across the public, private and academic sectors to create an environment in the UK for the technology where innovation, safety and regulation are delivered in unison.

The work undertaken by CCAV and its partners within Government has already ensured that the UK has a proven track record in supporting CAV innovation. It has enabled joint public and private investment of £440 million into new technologies, developed world leading regulation such as the 2018 Automated and Electric Vehicles Act and the UK Code of Practice and has helped to influence international standards. It is also establishing the UK as a global powerhouse for the safe testing of CAV.

A varied climate, unique and advanced real-world trialing provided by Testbed UK and complex urban environments such as London, Birmingham and Manchester mean that if you can make CAV technology work in the UK, you can make it work anywhere. Collaborating across Government, an ambitious programme is also being undertaken to ensure the UK's road network and other critical infrastructure is ready to allow CAV to operate.

The UK already has a global reputation as a great place to do business. A new business starts up in the UK every 75 seconds, and it is home to 5 of the top 10 fastest-growing businesses in Europe and 4 of the top 10 Universities in the world.

With the global market for cleaner, safer and more efficient transport growing rapidly, the UK is using its long history of transport innovation, a world-class research base and many established transport technology companies to build an environment that attracts even more innovative businesses to invest and locate in the country. With an ambitious, clear and comprehensive strategy from Government to drive forward a holistic Future of Transport agenda there has never been a better time to invest in the UK CAV sector.

## UK CAV timeline

- **2014** £31m investment into Four Cities Driverless Car Trials
- **2015** The Centre for Connected and Autonomous Vehicles (CCAV) is established
  - Code of Practice for testing automated vehicles is launched
- **2016** £29m investment into 21 projects
- **2017** £93m R&D investment into 25 projects
  - Key Principles of Cyber Security for CAV guidelines launched
  - Zenciv created to coordinate Testbeds and help accelerate CAV adoption
  - £102m development investment into four Testbeds
  - Future of Mobility Grand Challenge launched
- **2018** £32.6m R&D investment to support 22 projects including off-road tech
  - £32.4m investment into four testbeds for CAV data exchange and automated driving on highways, rural roads and parking
  - £41m R&D investment into three 'pilot' CAV services in a public or semi-controlled environment
  - £17m Simulation and Modelling investment into six projects
  - The Automated and Electric Vehicles Act creates a compulsory automated vehicle insurance
- **2019** CCAV launches three year review of the regulatory framework for the safe deployment of automated vehicles with the Law Commissions of the UK
  - UK CAV Code of Practice updated
  - Future of Mobility Urban Strategy released
  - Launch of CAVPASS, a project to create a new safety regime for CAVs
  - UK Connected and Automated Mobility Roadmap to 2030 launched by Zenciv
  - Social Behavioural Research Report published
  - Law Commission Consultation Paper 1 and Consultation Paper 2 published
- **2020** Launch of the Future of Transport Urban Strategy Regulatory Review

# Why the UK?

✓ The Aurigo AutoDrive pods are designed to transport people efficiently on the last stage of their journey from transport hubs to and from a wide range of destinations. The UK Autodrive Project helped launch the Aurigo company.



**The UK industry could be worth £62bn by 2035**

**£440m**

*Joint investment by government and industry into more than 90 projects involving over 200 organisations*

## Cross-sector collaboration

**The UK maintains its place at the forefront of the development and deployment of CAV innovation and technology, from solving issues relating to fundamental connected and automated vehicle technologies, control systems, software and services.**

What sets the UK apart is our close and unrivalled cross-sector collaboration between government, industry and academia for CAV development and regulation, supported by an excellent research base and world class innovators. In a 2018 poll of businesses<sup>1</sup>, the UK was voted the best place in Europe for such cooperation.

## Innovation-friendly environment

Our innovation-friendly environment attracts investment from around the world, and we focus on global collaboration across critical areas of testing and development, regulation and standards to accelerate the safe deployment of CAV technologies.



◀ UK manufacturers such as JCB are leading the way in the development of automated industrial vehicles, such as this driverless JCB Compact Track Loader

By developing supportive CAV regulation, expediting public acceptance and establishing the appropriate skills pipeline we will ensure a strong societal foundation upon which CAVs can be successfully deployed in the UK. Our emphasis on assuring the safety and security of CAV technology will support both public acceptance and safe deployment. The UK's automotive policy is seen as a model for other countries and is guided at every stage by industry, providing a strong foundation for CAV policy.

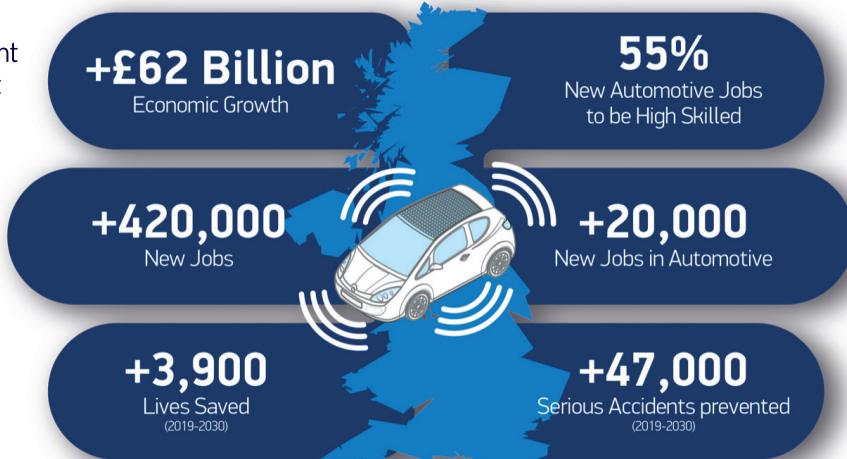
Indeed, research<sup>2</sup> undertaken by the Society for Motor Manufacturers (SMMT) has shown that the UK is a world leader in three macro parameters: enabling regulations, enabling infrastructure and market attractiveness.

## Widescale deployment

Widescale deployment of CAV technology will fundamentally change the parameters of driving and has the potential to bring benefits to industry, consumers and the public.

We are working to ensure the foundations are in place to launch CAV services at scale, including our world-leading regulation

on insurance in the Automated and Electric Vehicles Act 2018, and a comprehensive review of legislation by the Law Commissions. According to KPMG's 2020 Autonomous Vehicles Readiness Index the UK remains among the world's most advanced AV markets, scoring particularly highly on policy and legislation.



It is estimated that **1 in every 5** miles travelled by consumers in the UK could be automated by 2030

<sup>1</sup> Source: ABPI

<sup>2</sup> <https://bit.ly/342qDuZ>

Graphic: SMMT

# Ensuring safety and security



Five is carrying out live trials of automated Ford Mondeos in London

MOVE\_UK is an automated driving research project focusing on addressing the issues of validation of automated driving systems technology

**Safety is at the heart of the UK's work to support the development and deployment of CAV technology and it will be fundamental in gaining public support for widescale deployment. The UK has a flexible regulatory environment which supports both innovation and safety for the public.**

The UK Code of Practice for testing automated vehicles on public roads was published in 2015 and the UK is recognised as one of the most open testing environments in the world.

This code makes clear that tests of automated vehicles are possible on any UK road, without the need to secure permits or surety bonds, as long as they comply with UK law, including having:

- › A driver, (in or out of the vehicle) who is ready, able, and willing to resume control of the vehicle;

- › A roadworthy vehicle; and
- › Appropriate insurance in place

Building on the Code of Practice, in September 2019 Government announced CAVPASS (Connected and Automated Vehicle Process for Assuring Safety and Security), a project to develop a world-first comprehensive safety and security assurance process to support the safe commercial deployment of automated vehicles.

This project will harness the UK's world-leading expertise in vehicle safety, cyber security and artificial intelligence and will work with industry, academia and international partners to create a system capable of tackling the complex safety and security considerations necessary for the wide-scale deployment of automated vehicles.

## Cyber security

Cars are no longer just a means of transport; they are becoming highly connected with increasing levels of automation. To support this development, CAVs must remain safe, secure and resilient in the face of cyber threats.

Ranked number one in the world for cyber security in KPMG's 2020 Autonomous Vehicles Readiness Index, the UK has rapidly growing cyber clusters centred around our world-famous universities and the UK's world-leading Government Communications Headquarters (GCHQ). UK companies are ideally placed to provide expert, trusted advice and services to mobility businesses worldwide.

In 2017 Government published The Key Principles of Cyber Security for

## Significant steps

**The UK is not only at the forefront of CAV testing but is also pushing the boundaries of the social benefits the technology can achieve.**

- › In April 2019 Five began road-trialling its automated Ford Mondeos in London.
- › September 2019 saw the opening of Autonomous Village, a CAV test facility at Millbrook Proving Ground with over 40 miles of test track, a simulator suite and a private mobile network.
- › In October 2019 Oxbotica and the DRIVEN consortium demonstrated the capabilities of a fleet of self-driving vehicles in London's complex urban environment.
- › Automated pod manufacturer Aurrigo is currently working with Blind Veterans UK to test last-mile solutions for the visually impaired in Brighton.

Connected and Automated Vehicles. This guidance is aimed at all parties involved in the manufacturing supply chain, from designers and engineers, to retailers and senior level executives. The principles provide an holistic approach to considering the security of vehicles and their wider ecosystem, throughout the whole vehicle life cycle.

Building on these principles, the British Standards Institution (BSI) worked with government and industry to develop a new standard on vehicle cyber security which was published in 2018.

UK investments in this vital area include:

- › Nationally accredited Academic Centres of Excellence for Cyber Research, part of a £1.9 billion UK investment in cyber security.
- › £180 million investment in CAV projects, including £2m for competitions focused on maintaining cyber security for vehicles, roadside infrastructure and supporting services.

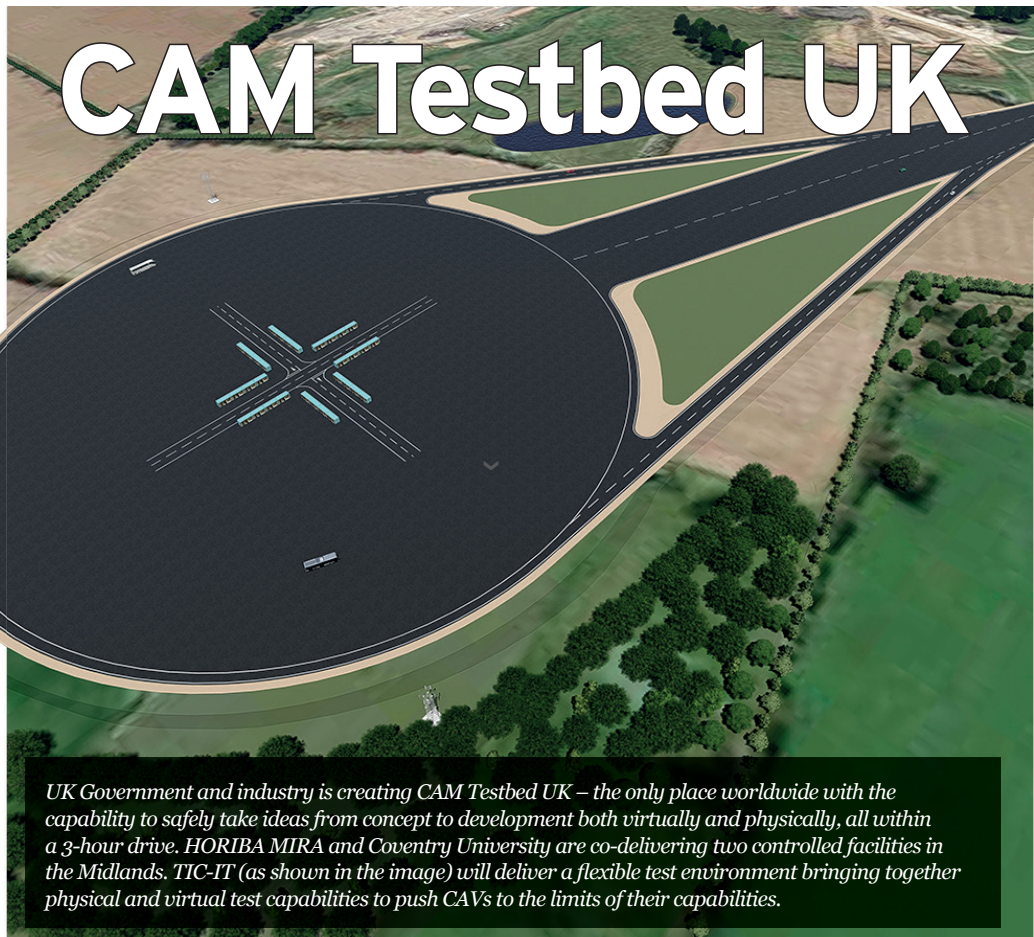
## Regulation

Government is developing a supportive regulatory framework to enable the safe development and deployment of CAV technology in the UK, and we are working to shape regulation at an international level.

The UK's first regulation for automated vehicles - the Automated and Electric Vehicles Act 2018 - sets out a framework for automated vehicle insurance and is the first of its kind. The Act is designed to extend existing insurance provisions to cover automated vehicles in order to support access to compensation in the event of a collision.

To support and inform any future regulation we have asked the Law Commission of England and Wales and the Scottish Law Commission to jointly undertake a three-year review of the UK's legal framework for automated vehicles. This wide-ranging review will consider issues of safety as well as the use of automated vehicles as part of public transport networks and on-demand passenger services.

The Law Commissions' extensive consultation on these complex issues is generating world-leading debate.



# CAM Testbed UK

*UK Government and industry is creating CAM Testbed UK – the only place worldwide with the capability to safely take ideas from concept to development both virtually and physically, all within a 3-hour drive. HORIBA MIRA and Coventry University are co-delivering two controlled facilities in the Midlands. TIC-IT (as shown in the image) will deliver a flexible test environment bringing together physical and virtual test capabilities to push CAVs to the limits of their capabilities.*

## Domain-specific validation and testing will be critical for safe and successful deployment of CAV technology.

To meet this challenge, UK Government and Industry partners are investing nearly £200m into CAM Testbed UK, building on world-class proving grounds and developing diverse public domain and virtual testing facilities, that range from rural to high density areas including Europe's only megacity, London.

With six core facilities, CAM Testbed UK offers a unique set of environments and capabilities for the testing and development of CAV technologies. It is the only place worldwide with the capability to take ideas from concept to development both virtually and physically, all within a 3-hour drive. The UK's comprehensive and integrated facilities are world-leading, with unique abilities to collaborate across organisational borders to share safety cases, data and learning.

Championing the CAV ecosystem is Zencic, a company created by

government and industry in 2018 to accelerate the CAV revolution in the UK. The company drives collaboration with partners across industry, government and academia to shape a world-class CAM Testbed in the UK, with the goal of ensuring a safer, more inclusive and productive mobile future.

## CAM Testbed UK

- › **ConVEx**
  - Data / Virtual
- › **HORIBA MIRA-Coventry University CAV Testbed**
  - Urban parking
  - Limit of controllability
  - Connected and configurable
- › **Midlands Future Mobility**
  - Highly connected real-world and digital environments
- › **Millbrook-Culham Urban Testbed**
  - Secure site
  - Controlled and semi controlled
- › **Smart Mobility Living Lab**
  - Public and Private London roads
  - Digital and real-world testing
- › **CAVWAY**
  - Fixed junctions / High speed testing
  - Slip road to motorway

Find out more about CAM Testbed UK at [www.zencic.io](http://www.zencic.io)

# UK CAV R&D projects

To date, the government, industry and academia have invested £240 million in a portfolio of more than 90 collaborative R&D projects that include Mobility as a Service (MaaS) public trials involving CAVs; through enabling technologies including automated control systems, sensors and microprocessors; to virtual validation and testing through simulation and modelling.



For a comprehensive overview of the range of CAV projects currently underway in the UK visit:

<http://tiny.cc/ccav-rd>

# Project highlights




**CAV FORTH** CONNECTED AUTONOMOUS VEHICLES

CAV FORTH will deliver a pioneering 12-month trial of automated buses on Scottish roads that will provide a world-leading demonstration of UK capability. The trial will see full-size, 12m, single-decker buses operating at a high level of autonomy along a 20km route that crosses the Forth Road Bridge, a UNESCO Heritage site. When fully operational the project could carry 10,000 passengers a day.

## MuCCA



Following a 30-month project MuCCA (Multi-Car Collision Avoidance) announced in March 2020 that it had developed a next generation driver aid that aims to avoid multi-car collisions on motorways.

If an accident cannot be avoided, the MuCCA system will attempt to minimise its consequences.

## AutopleX



Jaguar Land Rover is at the forefront of this project, developing CAV technology that can see around corners at blind junctions and through obstacles.

The aim of AutopleX is to combine connected, automated and live mapping technology to provide automated vehicles with information earlier.

## Venturer



Leveraging state-of-the-art technologies, industry expertise and world-class academic research, the £5million VENTURER research and development project has over the last three years established the West of England as a centre of excellence for the safe user-led trialling of CAV technology.

Drawing on its rich partnership of public, private and academic experts, VENTURER systematically assessed road users' responses to the introduction of driverless cars, using a series of increasingly complex scenarios, to understand the enablers and blockers to wide-scale adoption of CAV capability.

## 5StarS



5StarS addresses the increased threat from cyber attacks with the proliferation of connected and automated road vehicles.

The project developed an assurance methodology for CAV products to achieve cyber security robustness and resilience whilst achieving trust by manufacturers and consumers.

## Streetwise



Five led the 30-month £20 million Streetwise project to develop the technology to demonstrate how electric, automated vehicles could provide a commuter service between Croydon and Bromley in outer London.

## Lambda-V



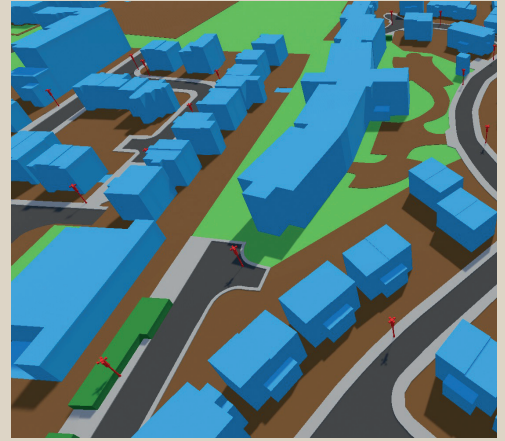
A one-year feasibility study that will take anonymized telematics data to help improve CAV technology, aiming to use human driver data to improve their performance and acceptability.

## Human Drive



A 30-month project, HumanDrive culminated in a successful 230 mile automated journey across the UK through live traffic and natural conditions in November 2019. The project is contributing to the development of a human-like self-driving capability.

# World-class simulation and modelling



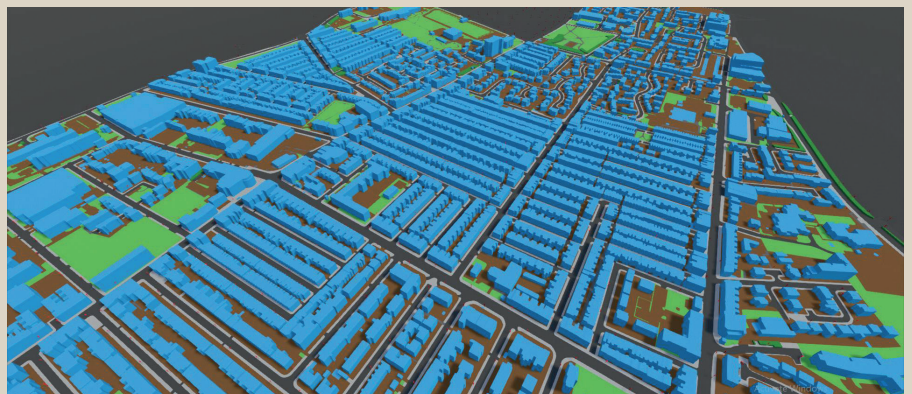
Smart Mobility Living Lab is one of the UK's most advanced urban testbed for CAVs, using public and private roads in London to safely develop and validate new mobility and transport technologies in a real-world connected environment.

**Our world-leading CAV research and development is underpinned by our equally acclaimed simulation and modelling capabilities.**

## Simulation and modelling

To assure the safety of Automated Driving Systems (ADS) we need to understand how the systems operate in a wide array of real world scenarios, however confidence in this area will not be achieved by physical driving alone:

- The large number of miles needed to ensure sufficient coverage of the scenarios will be prohibitive if done only in real time
- Controlling the large array of test parameters will be expensive



The solution is likely to involve more than one technology but will almost certainly include an element of simulation. Immense Simulation, Latent Logic and Humanising Autonomy are leading a global effort to ensure that ADS can be tested to their limits before they deploy in the real world.

MUSICC (Multi-User Scenario Catalogue for Connected and Autonomous Vehicles), a project led by our Department for Transport and Connected Places Catapult, is creating a system to store and share a library of scenarios against which an ADS will be expected to demonstrate its performance before release to market.



# Data and connectivity

^ Investment by the Millbrook-Culham Urban Testbed (pictured) in 5G, data storage, vehicles and simulation, together with unique access to a 2,000 person adult population in a secure site, is enabling testing to capture human aspects of real-world operation for CAVs, including Mobility-as-a-Service

## Data

The UK's world-leading expertise in data processing and analytics makes it one of the most attractive places to conduct CAV research and development. Connected and automated transport systems will use and generate vast amounts of data, creating a new value chain that takes in raw data and adds value. For this data to be used appropriately, safeguarding frameworks will have to be developed and UK companies are at the forefront of this development.

### ConVEx



The Government has invested collaborative R&D funding in the Connected Vehicle Data Exchange, or ConVEx. This project aims to create an open platform for the commercial exchange of data to help companies enhance and accelerate the development of connected and automated mobility capabilities, as well as helping local authorities to achieve their goals of safer, cleaner and more affordable transportation.

## World-class connectivity

The UK has first-class telecommunication infrastructure; in 2017 it was in the world's top five countries for both 4G coverage and fixed superfast broadband coverage. It is now leading investment in 5G, with six testbeds across the UK, which form part of a £1 billion commitment through the Digital Strategy to keep the UK at the forefront of connectivity. We are also working to deliver a modern infrastructure system which can adapt to future technology and advance the use of CAVs across our entire road network.

### AutoAir



AutoAir is making 5G technologies available for the test, development and validation of CAV technology at Millbrook Proving Ground. Connected vehicles will be tested to better understand how 5G can interact with our transport networks, as well as create an understanding of the potential business models and applications for the transport sector, driving opportunities for future efficiency, productivity and safety.

### UKCITE

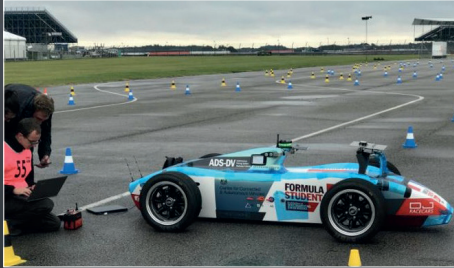


The UK Connected Intelligent Transport Environment (UKCITE) is a £5.5 million project to test connectivity technology in urban, highway and rural environments. It has involved equipping over 40 miles of urban roads and highways with a combination of multiple wireless technologies, enabling seamless connectivity across the corridor. The project has established wireless technologies across roads which can improve journeys, reduce traffic congestion and provide entertainment and safety services through better connectivity.

### A2/M2 Connected Corridor



This 'connected corridor' operates along a major road linking London to the port of Dover and beyond. It provides a great opportunity to pilot technology that will enable vehicles to communicate road safety information using roadside equipment and test connective technology on a variety of roads. The project aims to provide traffic updates to drivers' smartphones, giving the option to replace gantry-mounted variable messaging signs and reduce long-term costs. It also enables testing and development of systems that are interoperable both within and outside the UK.



Top: DevBot2.0, is Roborace's development vehicle, enabling human driver and ADS to compete in the same vehicle, DevBot2.0 holds the record for the fastest automated car at GoodWood's timed shootout

Above: teams competing in Formula Student Artificial Intelligence included some of the UK's top universities



Roborace's fully automated racecar, ROBOCAR

# UK motorsport and automotive excellence

**Since the modern era of Formula 1 began in 1967, only two teams from outside the UK have ever won the F1 Championship - and one of those used a British engine.**

- › Eight of the 10 current Formula One teams have R&D centres in what has become known internationally as Motorsport Valley®, the world's leading cluster for motorsport technology, with six of these teams headquartered here.
- › Motorsport teams' unique combination of world-leading technology and problem-solving ability makes them a hugely valuable resource for the global car industry.
- › As world leaders in electrification for Formula 1 and Formula E, Motorsport Valley is already a leading technology supplier to car manufacturers

**Get in touch:** [enquiries@ccav.gov.uk](mailto:enquiries@ccav.gov.uk)

looking to improve the performance of mainstream electric cars.

## UK CAV skills

- › Over the next decade, vehicle testing, validation and digital technology-based jobs are likely to enjoy significant growth, helping to offset changes elsewhere in traditional automotive manufacturing and production.
- › The Government is investing £400 million in 2020-21 for Further Education, recognising the vital role of developing and maintaining skills in this sector.
- › CCAV is working to quantify the skills gap in relevant disciplines and define appropriate skills development interventions.

› Motorsport Valley is home to the UK's new CAV Corridor, the unique alignment between these two innovation clusters creating the perfect environment for the next phase of automotive evolution. There is no other location worldwide that offers so much relevant automotive technology.

› In 2015, Roborace established itself as the champion of automated, electric motorsport, aiming to create the world's first automated race series, focusing on teams of engineers that programme cars rather than build them.

› Building on the success of Formula Student, IMechE and CCAV launched a new challenge during the 2018 season, an ADS Dedicated Vehicle (ADS-DV) designed to test and showcase the emerging talent in UK universities.

**AT  
A  
GLANCE**

# CAV development and deployment in the UK – a potential £62bn market

- Increasing productivity • Making journeys safer • Improving accessibility

*The UK Government is leading the development and deployment of CAV technology through...*

**Investing in R&D**

£440m invested to date by Government and industry into more than 90 projects involving over 200 organisations

**Delivering a clear regulatory pathway**

- > 2018 Automated and Electric Vehicle Act
- > Future of Transport Regulatory Review
- > CAV testing Code of Practice
- > Law Commission Legislative Review
- > CAVPASS

British climate allows testing in all weather conditions

**ZENZIC<sup>4</sup> CAM Testbed UK**

**BIRMINGHAM**

**LONDON**

**ALL WITHIN 3HRS**

**Creating a unique integrated testbed ecosystem**

£200m invested into CAM Testbed UK, the only place worldwide with the capability to safely take ideas from concept to development both virtually and physically, all within a 3-hour drive, covering:

Data | Parking | Rural | Highways  
Urban | Physical | Virtual



## UK Government, agencies and partners



Centre for Connected & Autonomous Vehicles



Department for Transport



Department for Business, Energy & Industrial Strategy



Department for International Trade

Innovate UK

Innovate UK  
Knowledge Transfer Network

ZENZIC<sup>2</sup>

CATAPULT  
Connected Places

SMMT  
DRIVING THE  
MOTOR INDUSTRY 

The **Centre for Connected and Autonomous Vehicles (CCAV)** was established to secure the UK's position at the forefront of the safe development, production and use of connected and automated vehicle (CAV) technology, working closely with industry, academia and regulators to continue to lead the safe development and deployment of CAV technologies.

**DfT** is assessing future roads infrastructure and management requirements and opportunities to prepare our roads for CAVs and innovative technologies, whilst ensuring best practice is disseminated in the here and now. This includes exploring the digital infrastructure requirements necessary to enable connected vehicles and support possibilities around transport data more generally.

**BEIS** is building an economy that works for everyone, so that there are great places in every part of the UK for people to work and for businesses to invest, innovate and grow.

**DIT** provides support to bring overseas investors to the UK and to help companies export from the UK, including in critical sectors for CAV development: automotive, technology, infrastructure.

**Innovate UK** is the UK's innovation agency, driving productivity and economic growth by supporting businesses to develop and realise the potential of new ideas.

**KTN** runs funding competitions, helping in the application process and giving feedback on proposals. We facilitate the consortium-building process, establishing relations and making introductions to other businesses.

**Zenzic** was created by Government and industry to accelerate the self-driving revolution in the UK. Zenzic is channelling £200 million of investment to unite industry, government and academia in the move to a safer, more inclusive and productive mobile future.

The new **Connected Places Catapult** accelerates smarter living and travelling in and between the places of tomorrow, focusing on growing businesses with innovations in mobility services and the built environment that enable new levels of physical, digital and social connectedness.

The **Society of Motor Manufacturers and Traders** is the voice of the UK motor industry, supporting and promoting its members' interests, at home and abroad, to government, stakeholders and the media, and is one of the largest and most influential trade associations in the UK.