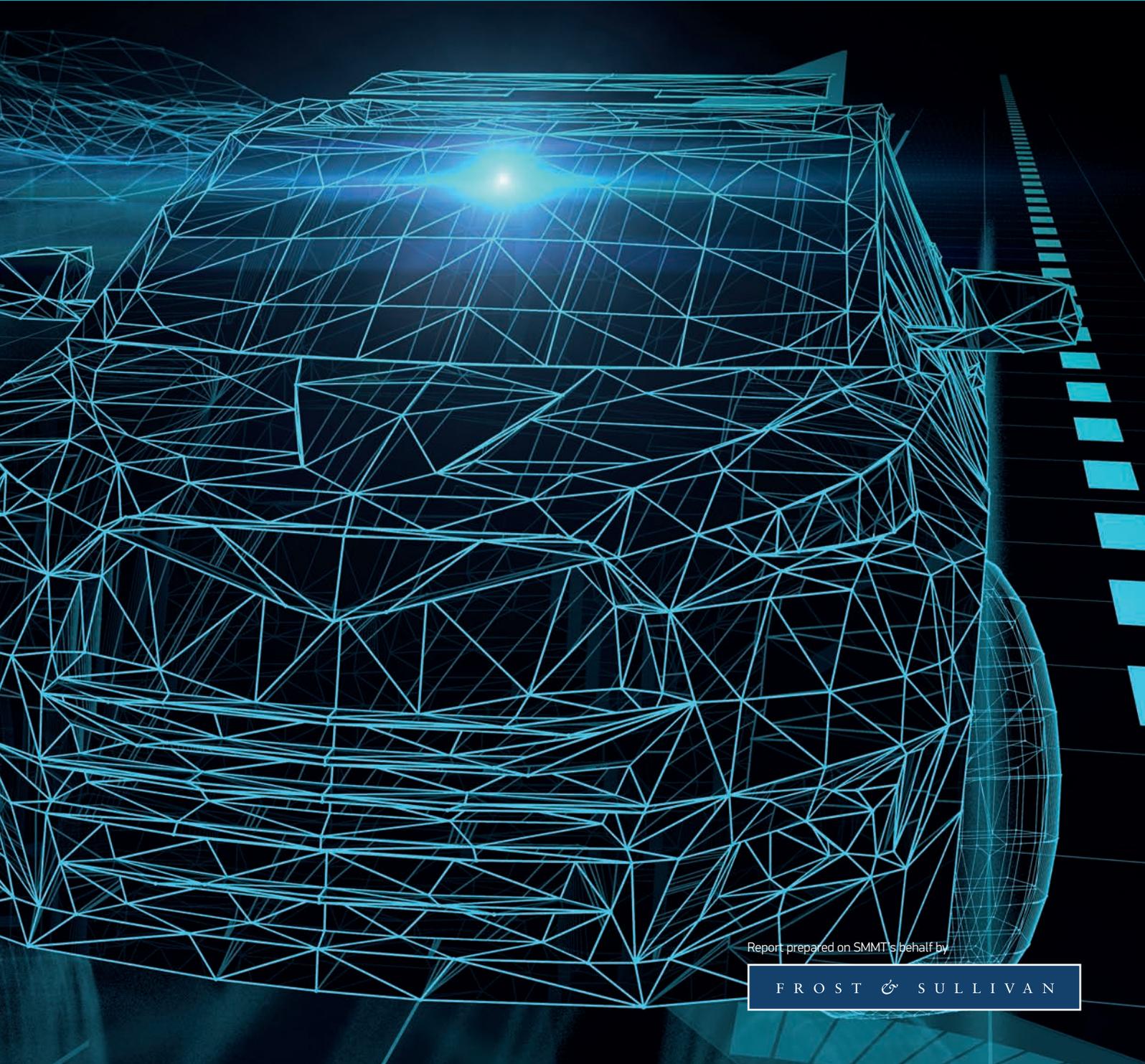


CONNECTED AND AUTONOMOUS VEHICLES

2019 REPORT / WINNING THE GLOBAL RACE TO MARKET



Report prepared on SMMT's behalf by

FROST & SULLIVAN

Page 3	FOREWORD
Page 4	CAV DEPLOYMENT INDEX CHAMPIONS
Page 5	EXECUTIVE SUMMARY
Page 6	THE CURRENT CAV MARKET LANDSCAPE
Page 9	GLOBAL OVERVIEW OF CAV DEVELOPMENT
Page 12	THE CAV DEPLOYMENT INDEX Benchmarking the UK's global competitiveness
Page 15	ECONOMIC IMPACT OF CAVS ON THE UK ECONOMY BY 2030
Page 18	FOUR KEY RECOMMENDATIONS AND CONCLUSION
Page 20	APPENDICES

THE START OF THE GREATEST TRANSPORT REVOLUTION

SINCE THE INVENTION OF THE MOTOR CAR

THE UK IS READY FOR THE JOURNEY



▶ A transport revolution stands before us as we shift to connected and autonomous vehicles (CAVs) – these technologies are no longer solely in the realm of science fiction and their adoption represents arguably the greatest change to how we travel since the invention of the motor car.

The major issue of our time – Brexit – is still unresolved. As this report shows, the UK is in a prime position to be a global leader in future mobility – but only if the conditions are right and crucially that we leave the EU in an orderly fashion. Clearly a 'no deal' Brexit would have a significant impact on the UK's competitiveness and ability to attract future investment and skilled labour to support CAV development and deployment with further negative effects due to regulatory divergence.

Despite Brexit, the UK and its automotive sector are open for business. Some people see automotive as yesterday's economy, but we don't agree. We're on the precipice of something more exciting and exhilarating than ever before – and the UK is ready for the journey. ■

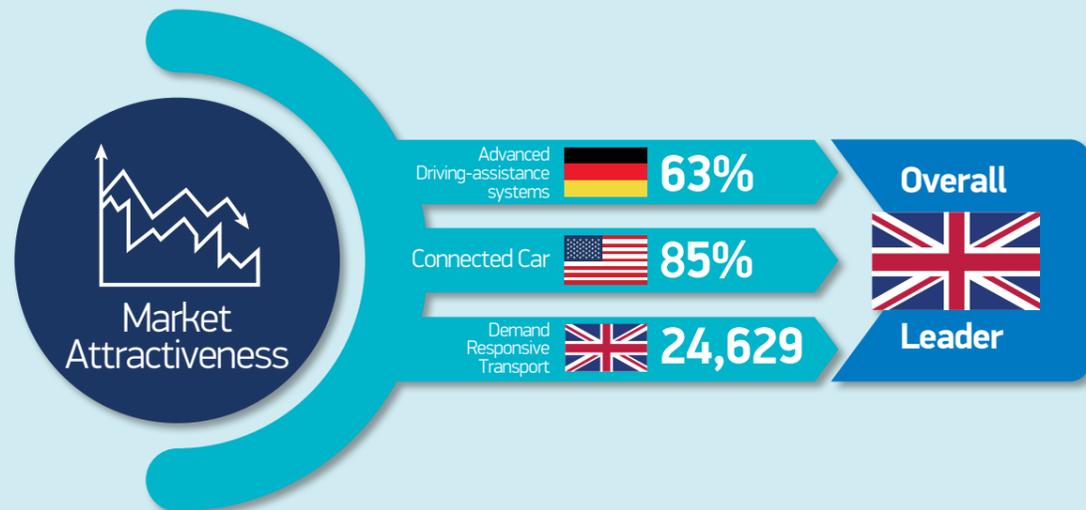
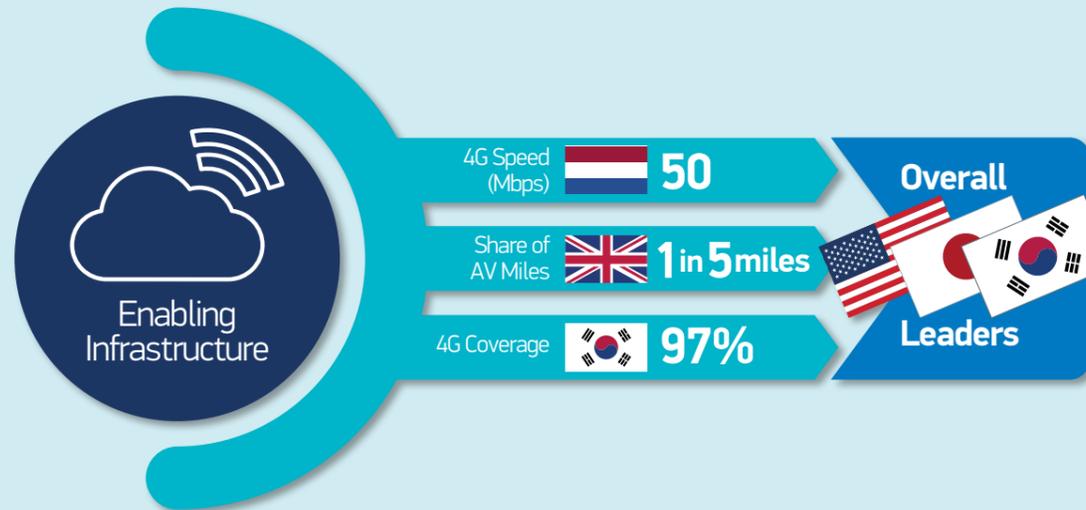
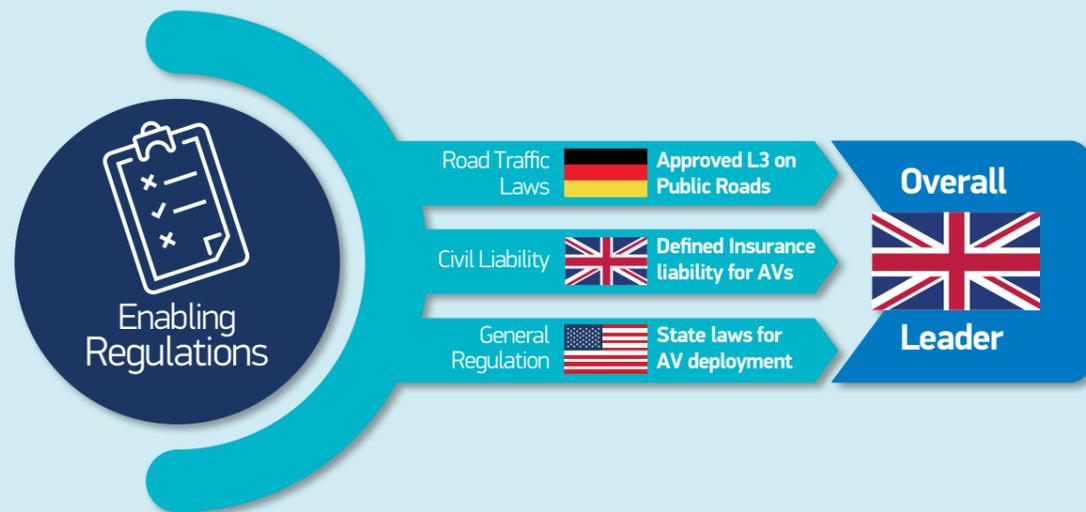
The automotive industry is leading the charge: investing significantly into new technologies; collaborating with government and policy makers; and with brands working closer together than ever before across different sectors. Global nations, meanwhile, are competing against each other to be the place to not only develop but to deploy CAVs in the real world. Make no mistake, the UK is among the front runners.

Autonomous driving trials are taking place in our major towns and cities, including London, Birmingham, Bristol and Milton Keynes. The UK has four major CAV test beds, more than 80 collaborative CAV R&D projects and a light touch approach to regulation, including insurance, with the world's biggest regulatory review to prepare for automated vehicles on public roads by 2021. We have a supportive government that is also investing billions to boost innovation in the sector.

Win the global race to widespread CAV adoption and the economic and social benefits are dramatic. Over the coming decade, today's driver assistance technology and the next generation of autonomous systems are set to save 3,900 lives and create 420,000 new jobs across automotive and adjacent sectors – with an overall annual £62 billion economic benefit to the UK by 2030.

Grasping this prize, however, will not come easy. To capitalise, innovation in Britain must continue. Favourable regulations, investment into infrastructure and ensuring public acceptance of new technologies are just three priorities.

Mike Hawes Chief Executive
The Society of Motor Manufacturers and Traders (SMMT)



► This report offers a detailed assessment of connected and autonomous vehicle (CAV) development, and crucially deployment, in the UK covering three key aspects:

- **Current market and technology trends, along with future roadmaps.**
- **The UK's progress in, and propensity for, CAV deployment relative to other major countries.**
- **The potential overall impact of CAV deployment on the UK's economy by 2030 and beyond.**

This report also relied on a custom economic model to forecast the economic benefit to the UK from the deployment of CAVs, which was estimated to be in the region of £62 billion per annum by 2030.

It concludes with an outlook to 2040, offering key recommendations to the UK government on how it can drive the unparalleled opportunities presented by widespread CAV adoption, including by providing supportive legislation and investment in infrastructure.

The economic modelling element of this report is based on current fiscal and political conditions in the UK – and these conditions staying broadly on the current path. Furthermore, the CAV Deployment Index does not cover factors such as economic attractiveness, government stability or availability of skilled labour.

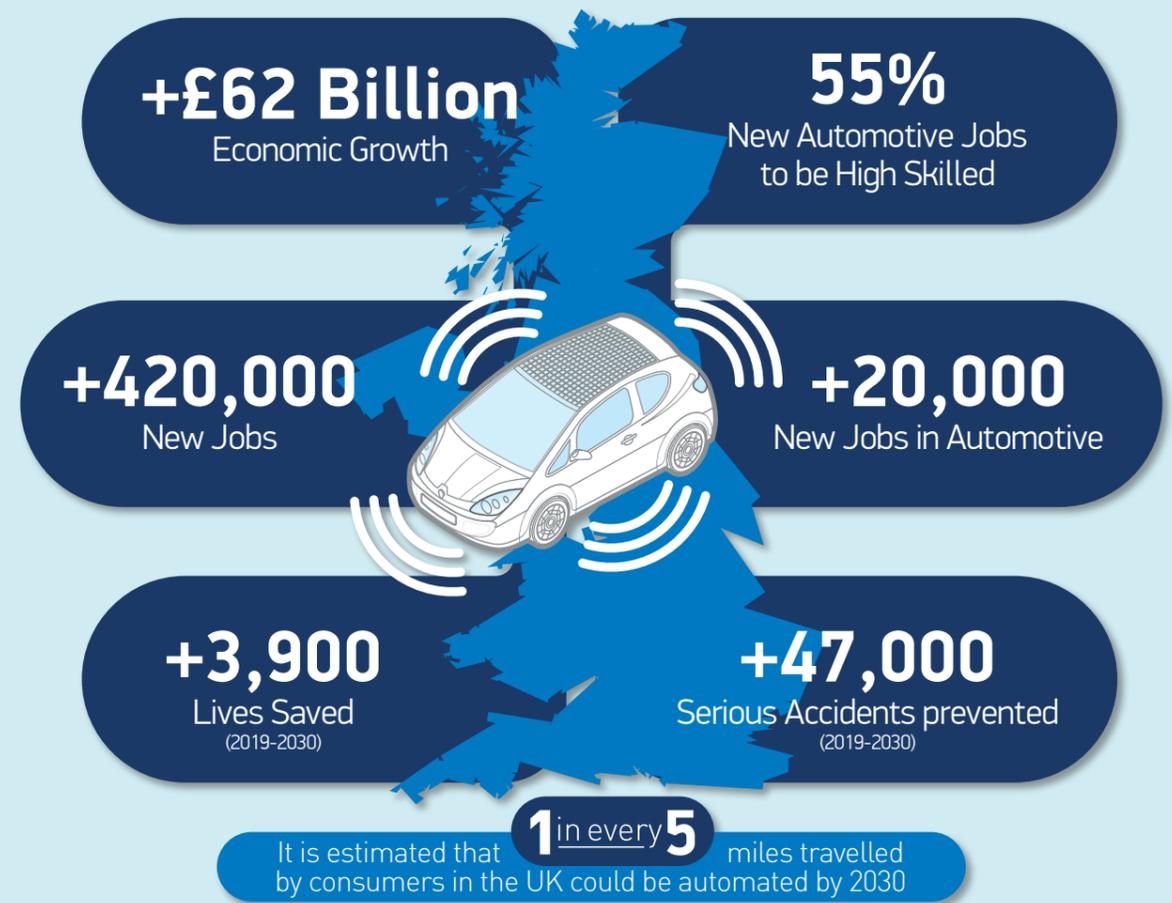
Central to this report is a new and bespoke CAV Deployment Index, which benchmarks the UK and other major countries in terms of their progress toward CAV rollout.

This comprehensive index is based on three macro parameters: **Enabling Regulations, Enabling Infrastructure** and **Market Attractiveness**.

Based on these three parameters, overall the UK comes out top, above rival nations, including the US, Germany and Japan.

For the purpose of this report, modelling and analysis assumes that the UK and EU will reach a favourable Brexit withdrawal agreement, ensuring the competitiveness and attractiveness of the UK as a destination for inward investment. ■

POTENTIAL OVERALL IMPACT OF CAVS ON THE UK ECONOMY BY 2030





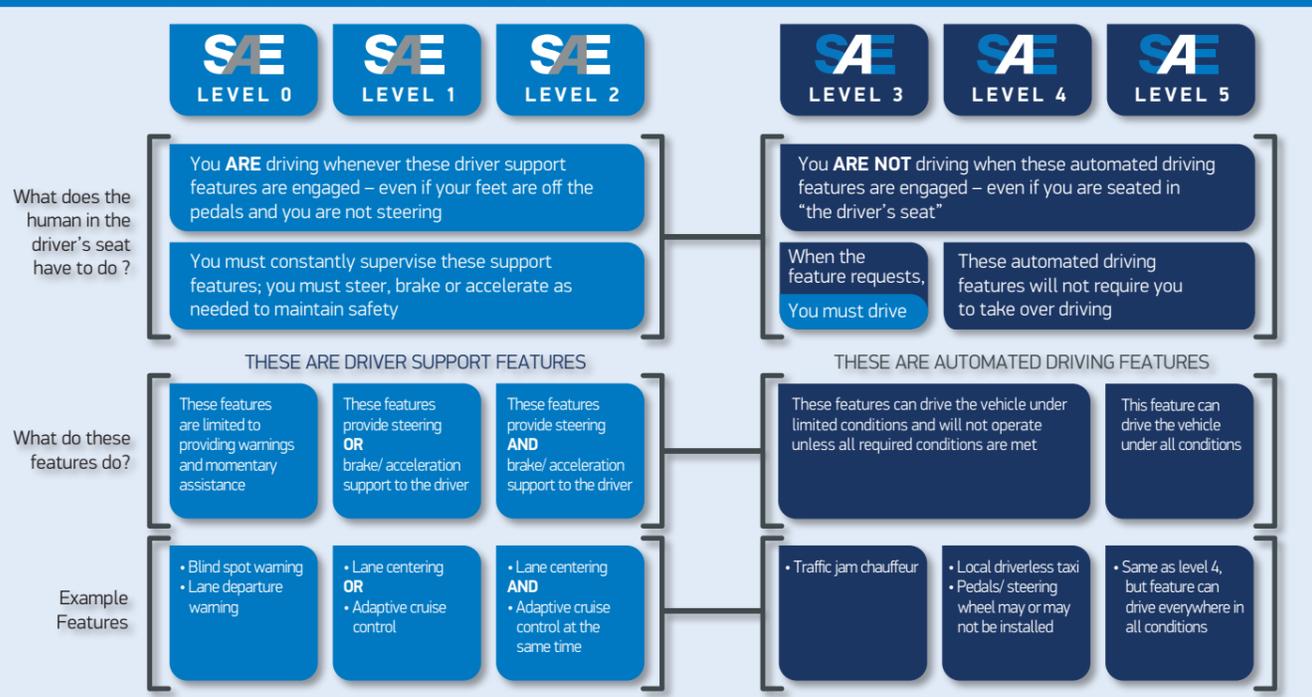
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THE CURRENT CAV MARKET LANDSCAPE

EVOLVING GLOBAL MARKET AND TECHNOLOGY TRENDS AND FUTURE ROADMAPS

► The emergence of CAVs will bring unprecedented change to the automotive industry worldwide. More than 18 million new automated vehicles¹ are expected to be added to the global motor parc by 2030, significantly changing the way people commute. Over the next decade, for instance, new mobility modes such as automated shuttles could address gaps in first and last mile mobility.

SAE J3016 LEVELS OF DRIVING AUTOMATION



SAE International (formerly the Society of Automotive Engineers) classifies automated driving features into five levels, from basic driver assistance (L1) to full automation (L5). These are considered the industry convention for categorising the driver assistance and automated features provided by Original Equipment Manufacturers (OEMs). The latest consumer-friendly version of these levels of automation, released by SAE

International in December 2018 and shown above, highlights the clear differences between Levels 1-5.

Currently, from the five levels defined, driver-in-the-loop assistance features, which are broadly categorised as Level 2 automation, are already available on the market. These include features such as lane centering with adaptive cruise

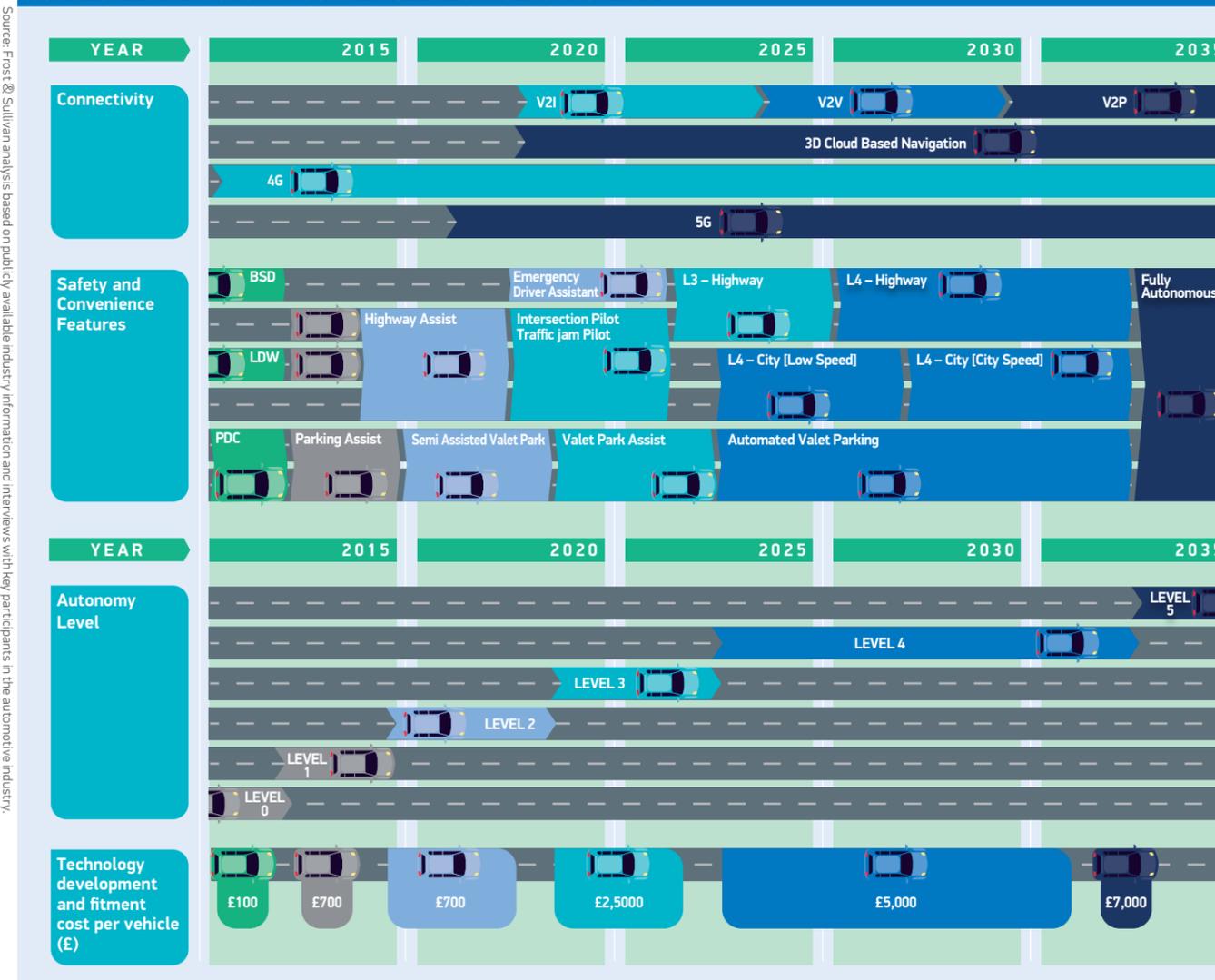
control. Regulation permitting, vehicles with higher levels of automation are set to roll out over the next decade. This will start with driver-out-of-the-loop traffic jam and highway pilot features, allowing drivers to disengage safely from dynamic driving tasks such as manoeuvring in traffic jams and driving on motorways. From 2021 onwards, some early generation Level 4 automation features may be introduced. These could include highly automated highway pilot, automated valet parking and automated vehicles such as taxis operating within virtually defined or 'geofenced' zones in urban areas.

Level 5 automated vehicles should have the capability to be fully self-driving, unconditionally, and with no operating domain or geographic restrictions. Based on current technology roadmaps and real world applications, however, the consensus is that full and unconditional automation, i.e. Level 5, is unlikely to be introduced before 2035. One of the primary reasons stated by

industry experts for this is the technology challenge involved in equipping AVs to tackle all possible unusual driving situations under all driving conditions and in all environments.

Instead, the road to Level 5 automated driving is likely to be reached gradually as more advanced driver assistance features come to market. This strategy, while incremental in its approach, is nonetheless expected to have a significant impact on the safety, convenience and cost aspects associated with current modes of transport. As this happens, disruption is likely to occur across traditional, ownership focused vehicles as well as shared mobility services such as taxis and shuttles. For example, it is estimated that there will be a 15% reduction² in all collisions across major markets, including in Europe and North America, within a span of 10 years of Automated Emergency Braking (AEB) being mandated in Europe (expected between 2021 and 2025).

CONNECTED AND AUTONOMOUS VEHICLE TECHNOLOGY ROADMAP



The above infographic highlights the estimated cost of technology development and fitment per vehicle required to achieve each of the five levels of automation. Between 2018 and 2030, based on global OEM rollout for the various levels of automation, an estimated £176.5 billion³ is likely to be invested by OEMs worldwide in the global deployment of Level 3 and Level 4 automated features. This unprecedented level of investment will drive the need for new business models and revenue streams to generate returns.

1: THE CURRENT CAV MARKET LANDSCAPE

EVOLVING MARKET AND TECHNOLOGY TRENDS & FUTURE ROADMAPS IN THE UK

Leading OEMs, including Audi, BMW, Ford, Jaguar Land Rover, Mercedes-Benz, Nissan, Tesla and Volvo, already provide Level 2 driver assistance features in the UK. These include systems that provide steering, acceleration and braking assistance when driving on motorways and dual carriageways. While availability is currently restricted to a few variants and models, more than 30%⁴ of all vehicles sold in the UK by 2030 are expected to be fitted with Level 2 driver assistance features..

Both the roadmap for CAV deployment and real world applications for these technologies outlined in SAE J3016 indicate that the first 'driver-out-of-the-loop' Level 3 features such as Traffic Jam Pilot and Highway Pilot could be deployed in the UK as early as 2021, regulation permitting.

By 2022, automated shuttle services are likely to be launched in some British cities. The shuttles will be capable of operating autonomously at low to moderate speeds of up to 40mph and are anticipated to improve the safety and convenience of getting around in cities.

The successful deployment of automated vehicles (AVs) in real world situations will be complemented by the penetration of connected services in vehicles. Among the important connected in-car services that will complement AV growth are navigation services such as connected maps and app-based ones such as music streaming. While e-call systems (emergency assist calling) that are now mandated in all new vehicles in the UK and Europe are a very useful feature, the technology is very basic and relies on 2G connectivity. It will not be sufficient to provide connected vehicle services that complement vehicle automation.



GLOBAL OVERVIEW OF CAV DEVELOPMENT

GLOBAL OVERVIEW OF CAV DEVELOPMENT

Several countries are currently exploring the impact of AVs on their cities and highways. Crucial to building this understanding is real world testing. Accordingly, many test beds have been set up to help collect vital data on how AVs interact with their surroundings, with a series of major milestones reached in nations around the globe in 2018.

EUROPE

- AV testing on public roads was legalised in several countries, including France, Germany, the Netherlands, Norway, Sweden and the UK.
- A legal framework for AVs, including driving licence equivalents for self-driving vehicles, was reviewed in the UK, the Netherlands, and Germany. The UK Parliament approved further clarity on liability in self-driving mode, introducing the world's first insurance legislation for AVs.
- Oxbotica, a UK start-up focused on AV software stack and related services, began on-road testing for Level 4 automated grocery delivery vehicles, taxis and shuttles at locations across the UK.

NORTH AMERICA

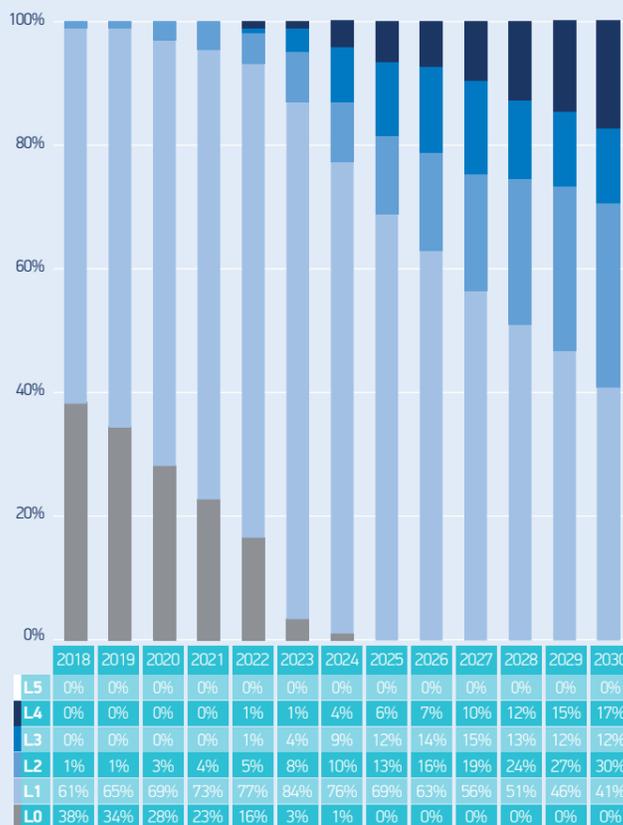
- California passes state level approval for driverless vehicle testing with no safety driver present.
- The US Department of Transportation issued guidance for automated driving pilot programmes.
- GM and Ford set up new automated driving divisions to accelerate AV deployment. Tesla rollout Level 2 and Level2+ features with Level 3 and Level 4 features planned for 2020.
- Waymo, a spinoff from technology giant Google, starts first AV commercial business model in Arizona.

ASIA PACIFIC

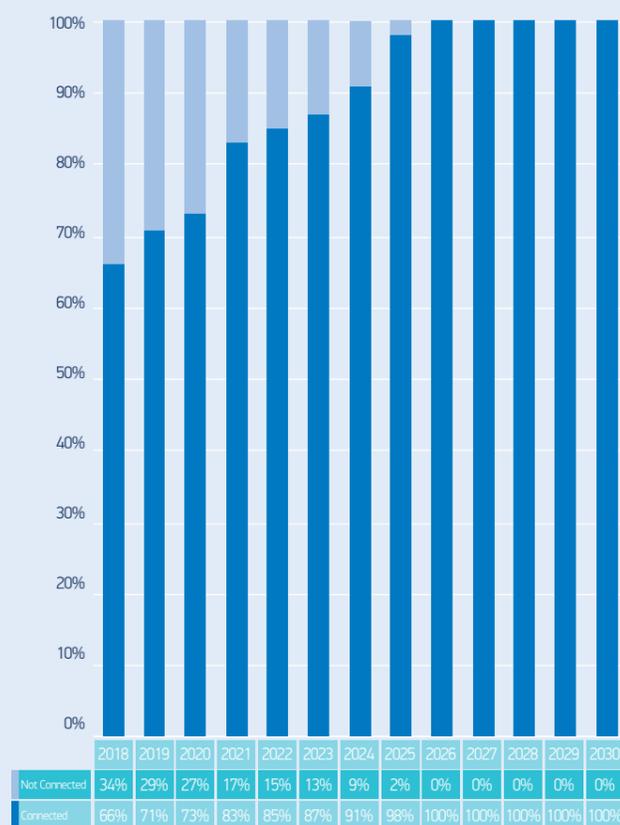
- Japan considered policies related to liabilities, driving licenses and cybersecurity laws.
- In China, 11 roads were added to the existing 33 roads in Beijing designated for autonomous driving tests. AVs were required to complete 5,000 km of daily driving in designated closed test fields before being allowed to apply for public road testing permits.
- China granted permission to Audi, BMW and Daimler to test AVs in Beijing and Shanghai.



FORECAST OF NEW AUTOMATED VEHICLES REGISTERED ON UK ROADS AS A PROPORTION OF ALL REGISTRATIONS



FORECAST OF NEW CONNECTED VEHICLES REGISTERED ON UK ROADS AS A PROPORTION OF ALL REGISTRATIONS



Source: Frost & Sullivan



UNITED KINGDOM

Test Beds: Four major CAV test beds and 3 additional test sites for highways, rural and parking.
Self-Driving Road Testing Approval: ✓
Potential Automated Road Miles: 1 in 5 miles

NETHERLANDS

Test Beds: None
Self-Driving Road Testing Approval: ✓
Potential Automated Road Miles: 1 in 10 miles

FRANCE

Test Beds: Multiple OEM test beds
Self-Driving Road Testing Approval: ✓
AD testing is permitted on the autoroutes.
Potential Automated Road Miles: 1 in 12 miles

GERMANY

Test Beds: Multiple OEM test beds
Self-Driving Road Testing Approval: ✓
AD testing is permitted on the autobahns.
Potential Automated Road Miles: 1 in 10 miles

USA

Test Beds: 10 government authorised test beds
Self-Driving Road Testing Approval: ✓
Potential Automated Road Miles: 1 in 8 miles

CHINA

Test Beds: 3 city based restricted AD test trials with testing permitted on specific public roads.
Self-Driving Road Testing Approval: ✗
Potential Automated Road Miles: 1 in 12 miles

SOUTH KOREA

Test Beds: 1 dedicated test bed for AD testing.
Self-Driving Road Testing Approval: ✗
Potential Automated Road Miles: 1 in 20 miles



3 THE CAV DEPLOYMENT INDEX Benchmarking the UK's global competitiveness

► The widespread development and testing of automated vehicles (AVs) in various countries is a good indicator of individual countries' overall readiness for CAVs. However, while there has been much discussion about the development of CAV related technologies and their major influencing factors, there has not been as much debate about the attractiveness of each of these regions from a strictly deployment perspective. Countries compete on a relatively more equal footing in deployment as compared to development, where countries that are home to a significant number of vehicle manufacturers and CAV system developers have a strong advantage.

Our report sets out to fill this gap by evaluating these regions as target markets for CAV investors. To this end, it uses three key macro parameters to benchmark leading countries in CAV deployment: regulations, infrastructure and market attractiveness.

These parameters are essential to understanding how ready a market is for consumers to use/adopt CAVs and for mobility companies/OEMs to deploy them.

■ **ENABLING REGULATIONS:** A clear strategy to modify existing motor insurance requirements is one of the fundamental pillars to support widespread AV rollout, and the UK Parliament introduced the world's first insurance legislation for AVs in 2018. This, combined with strong policy intent on transport-related data aggregation and sharing, gathered by operators at a national level, authorised by the government, has helped position the UK in first place under this parameter. Germany also ranks highly, thanks to its forward thinking amendments to road traffic law that allow the driver to perform secondary tasks while the automated driving system is safely engaged.

The Netherlands and Japan have favourable policies from an AV development and testing perspective, but work is needed in commercialisation-focused areas to improve their regulatory attractiveness as CAV deployable markets.

While the current state of legislative policies in the countries assessed in the report were diverse, all the countries including the UK will need to take definitive steps in establishing type approval and deployment related frameworks in order to capitalise on the potential benefits AVs stand to offer to consumers and the overall economy. Lack of direction from a legislative standpoint can cause delays in deployment for certain features and unsafe deployment for others.

Our assessment highlights that defining a civil liability framework is a critical first step to ensuring safe deployment and also winning consumer confidence and the UK has taken an early advancement on that front. A similar proactive and forward looking nature should be followed in other areas of legislative reforms such as road traffic laws and more widespread testing and validation frameworks for the UK to consolidate its position as a global benchmark on AV related regulatory reforms.

THE TOP FOUR COUNTRIES IN THE ENABLING REGULATIONS BENCHMARKING INDEX ARE UK, UNITED STATES, GERMANY / SOUTH KOREA

■ **ENABLING INFRASTRUCTURE:** The deployment of connected vehicles, as well as V2X services that complement automated driving, over the next 10 years will rely heavily on the availability of communications infrastructure (4G mobile connectivity), especially across road networks. Countries such as South Korea and the Netherlands have the highest ratings in terms of overall availability and download speeds of their 4G networks, although availability beyond urban areas still requires expansion.

In the UK, the balance between overall 4G connectivity on roads and urban areas is equally distributed, with 90% coverage across motorways. However, with current coverage levels of only 58%, A and B roads⁵ require further improvement in network availability.

The expected deployment and coverage of next generation 5G networks can potentially spawn new connected vehicle services and V2X applications that complement automated driving, leading to enhanced road safety, travel efficiency, productivity and convenience. The expected aggressive rollout of 5G coverage in the United States and South Korea, underpinned by the relatively greater 5G-readiness of their mobile network operators and their partnerships with OEMs, explains the strong performance of these two countries in this area.

Another key consideration within this parameter⁶ is the proportion of consumer miles – covering urban, motorway and rural driving – that could be automated in a given country. Consumer miles are not the same as the total length of a country's entire road network. The proportion of consumer miles travelled on each road type also differs from country to country. Different road types present different challenges in performing HD mapping and installing communications equipment such as roadside units, fibre optics and smart gantries.

With a balanced split in the types of roads used and a clear technology focus in enabling automation through HD mapping on all three road types, and modernising the Strategic Road Network, the UK leads this sub-index. While the United States and China have a wider overall road network, the reduced availability of HD mapping across the road network in China and the focus on automation in selected motorways and cities in the United States are likely to limit proportion of consumer miles travelled that can potentially be done by AVs. Likewise, the focus of AV deployment in Germany is predominantly on the autobahn and a few selected cities despite the widespread availability of HD mapping.

It is estimated that one in every five miles travelled by consumers in the UK could be automated by 2030.

THE TOP THREE COUNTRIES IN THE ENABLING INFRASTRUCTURE BENCHMARKING INDEX UNITED STATES, SOUTH KOREA, JAPAN

■ **MARKET ATTRACTIVENESS:** The market attractiveness benchmarking index comprises four important proxy technologies and services – Advanced Driver Assistance Systems (ADAS), connected cars, Mobility as a Service (MaaS), and Demand Responsive Transport (DRT) – that indicate the potential for CAV adoption. While connected car uptake is self-explanatory, ADAS uptake is an indicator of a market's appetite for automation and, by extension, future adoption of AVs. Current MaaS uptake and DRT fleet size indicate future market potential for automated shuttles operating as mobility services in geofenced areas within cities.

DRT business models are likely to be the first transit modes to adopt automation for consumers and for that reason, a strong DRT fleet service is a key indicator for assessing the propensity of adoption for future AV services. These early AV services are likely to compliment current transport solutions available in a region and for this to be realised, the availability of integrated transport data on a consolidated platform would be essential. This integrated data is what

is used by current journey planning and payment solutions such as MaaS and so this too is a good indicator to assess AV deployment potential of a market.

With the largest DRT fleet in the world and two unique MaaS integration solutions, i.e. the Transport for London platform and MaaS Global's West Midlands-based Whim platform, reinforced by high ADAS and connected car uptake, the UK scores highly on this index. Germany, with its initiatives in mobility integration and the highest penetration of ADAS, also indicate potential to be an early adopter of AVs.

The Netherlands, with its unified payment portal for mobility services, and France with the launch of the Ubeqo MaaS platform, are also key markets that score highly.

THE TOP THREE COUNTRIES IN THE MARKET ATTRACTIVENESS BENCHMARKING INDEX UK, UNITED STATES, GERMANY

DEPLOYABLE AV CUSTOMER MILES AS A PROPORTION OF TOTAL CONSUMER MILES TRAVELLED



Country	Enabling Regulation	Enabling Infrastructure	Market Attractiveness	CAV Deployment Index			
				Enabling Regulations (/3.5)	Enabling Infrastructure (/3.0)	Market Attractiveness (/3.5)	CAV Index/Benchmarking (/10.0)
United Kingdom	2.9	2.2	3.3	8.4			
United States	2.6	2.3	3.0	8.0			
Germany	2.6	1.9	2.8	7.2			
Netherlands	2.2	2.1	2.2	6.4			
South Korea	2.4	2.3	1.5	6.2			
Japan	2.1	2.3	1.8	6.2			
France	1.9	1.7	2.5	6.1			
China	1.4	2.0	1.9	5.2			

UK ON TRACK TO EMERGE AS A LEADING MARKET FOR AV DEPLOYMENT

While each of these three macro parameters indicates the essential elements required for the successful deployment of CAVs in a country, the value of having a leading position in all three reinforces a strong and positive outlook for effective CAV deployment.

However, an analysis of each of the macro parameters and their sub-indices indicates that there is no one country that dominates in all three areas. Nevertheless, among the major countries that were analysed, the UK emerged as a leading market for CAV deployment over the next decade.

This projection is based on the UK government's forward looking regulations, such as insurance legislation for AVs, strong connected car uptake, and its significant potential for AV deployment on urban, rural and motorway operating domains.

While the macro and micro parameters assessed in the

benchmarking report provide a holistic perspective on assessing the deployment attractiveness of the various markets, parameters such as economic attractiveness, labour skill set, implementation costs and others will also effect the deployment of CAVs in any market.

The UK, although highly attractive as a market for deploying CAVs, will still potentially rely on foreign players to realise its CAV deployment potential. Although many global OEMs such as Nissan Jaguar Land Rover and Volvo have established a roadmap for CAV development, the UK is still dependent on a few local technology players to develop CAVs specific for the UK market. To ensure seamless AV deployment in future improvements to infrastructure and a robust legislative framework will be required, predicated on the UK leaving the EU in an orderly fashion and with a deal favourable to the automotive sector in this country.

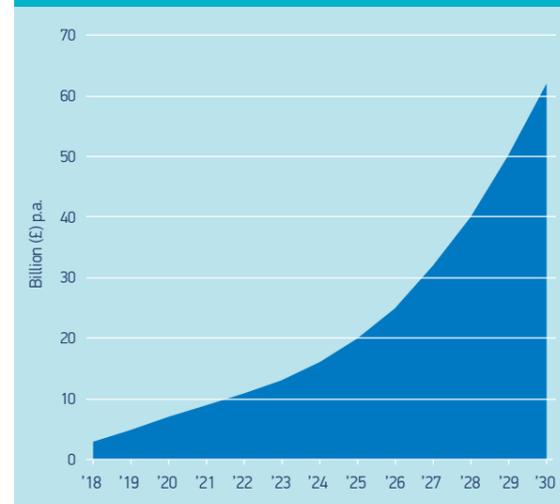


4 ECONOMIC IMPACT OF CAVS ON THE UK ECONOMY BY 2030

ECONOMIC IMPACT: THE £62 BILLION PRIZE

► This report forecasts a total of £62 billion in annual economic benefits for the UK from CAV deployment by 2030, with the impact on consumers worth some £46 billion delivering the bulk of the prize. This is due to enhanced consumer productivity enabled by better in-car connectivity, improved travel efficiency and reduced mobility related expenses. For instance, current estimates based on our CAV roadmap indicate that CAV deployment can save every driving commuter nearly 42 hours in travel time, annually. Moreover, commuters stand to benefit from a 20% increase in average speeds per journey due to reduced congestion and smoother traffic flows.

ECONOMIC BENEFITS ACCELERATE OVER TIME TO OVER £62 BILLION P.A. IN 2030



The wider impact of connectivity and automation on the economy in terms of new revenue streams emerging both from within and outside the automotive value chain is anticipated to contribute another £18 billion, of which nearly 15% would be generated by new revenue from within the digital services market.

The automotive value chain is estimated to have a net positive impact on the economy, with downstream and peripheral services (mobility services, aftersales and vehicle insurance, among them) contributing new revenue

sources for companies in this space. On the upstream technology side, licencing hardware and software for automated driving and connected services are expected to be major revenue generators, with new technology entering the market, along with traditional OEMs and suppliers likely diversifying into this business.

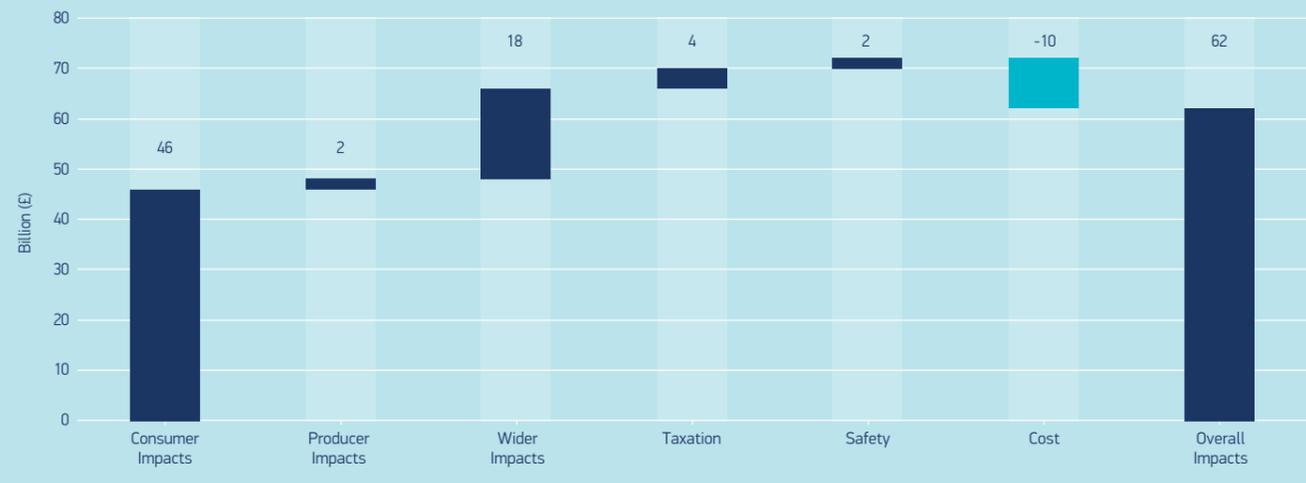
The above analysis is calculated based on the assumption that, the UK government would need to incur a net expenditure of around £10 billion on infrastructure development which will be needed to sustain this growth scenario. This spend will need to focus primarily on providing the requisite digital infrastructure to support new modes of transport for consumers. This investment, especially in establishing the required infrastructure, will need to be made upfront to deliver the positive economic impacts indicated in the report.

CAV RELATED SAFETY TECHNOLOGIES HOLD POTENTIAL TO SAVE 3,900 LIVES BY 2030

While the reduction in overall mobility costs and improvements in mobility convenience are two of the key benefits of CAVs, their biggest impact on consumers is likely to be felt in the sphere of increased safety on the UK's road networks.

Wider adoption of even basic driver assistance features such as automated emergency braking (AEB) and blind spot detection (BSD), are expected to considerably mitigate the incidence of road accidents. By 2030, the overall benefits accrued from crash avoidance is estimated at more than £2 billion, with

ECONOMIC IMPACT OF CAVS ON THE UK ECONOMY BY 2030



a reduction of over 47,000 in serious collisions and a further 3,900 lives saved. According to current projections, a total of almost 56,000 crashes of all kinds can be eliminated via AV related technologies by 2030 alone.⁷ These are expected to be further augmented in years to come when V2X applications, such as intersection collision warning and road hazard warning, complement the safety benefits that automation will bring.

CREATION OF MORE THAN 420,000 JOBS ACROSS THE ECONOMY

Digitisation of the automotive value chain is forecast to help create more than 20,000 new jobs in the automotive sector alone. Of these, 11,000 (55%) are expected to be highly skilled across both upstream and downstream services. Rewarding new job opportunities are expected to emerge in software and hardware development for automated and connected technologies in the upstream,

and in vehicle fleet and network management in the downstream along the value chain.

Over the next decade, testing, validation and digital technology-based jobs are likely to enjoy significant growth, helping to offset changes elsewhere in traditional manufacturing and production. Current CAV development trends indicate that market-specific validation and testing will be critical for successful deployment of CAVs and this will lead to emergence of a new set of automotive jobs in vehicle system testing in the UK that does not exist currently.

The wider impact on the UK job sector within adjacent industries, including in telecommunications, content creation, logistics and others, is likely to be even more pronounced; more than 400,000 new jobs are expected to be created. These assessments are predicated on the UK leaving the EU with a favourable Brexit deal that maintains

POTENTIAL OVERALL IMPACT OF CAVS ON THE UK ECONOMY BY 2030

+£62 Billion Economic Growth	55% New Automotive Jobs to be High Skilled
+420,000 New Jobs	+20,000 New Jobs in Automotive
+3,900 Lives Saved (2019-2030)	+47,000 Serious Accidents prevented (2019-2030)

the UK's competitiveness and attractiveness as an investment and sales destination.

OUTLOOK TO 2040: BEYOND THE HORIZON

While the widespread rollout of Level 3 and 4 automation will likely create a significant impact on the UK economy by 2030, it is in the decade following 2030 that the most momentous changes will occur. The introduction of highly, and potentially fully, automated vehicles, the ubiquity of connected vehicles and the emergence of seamless MaaS business models will result in a complete overhaul of the way people commute, triggering a stronger impact on the overall economy.

One of the major influencing factors to consider while assessing the prospective impact on the UK economy is the overall growth in per-mile business models rather than per-car business models. The expansion of urban boundaries will make MaaS accessible to more people in the UK. All major OEMs are likely to have MaaS divisions focusing on revenue generation from new mobility modes and in-car data related services.

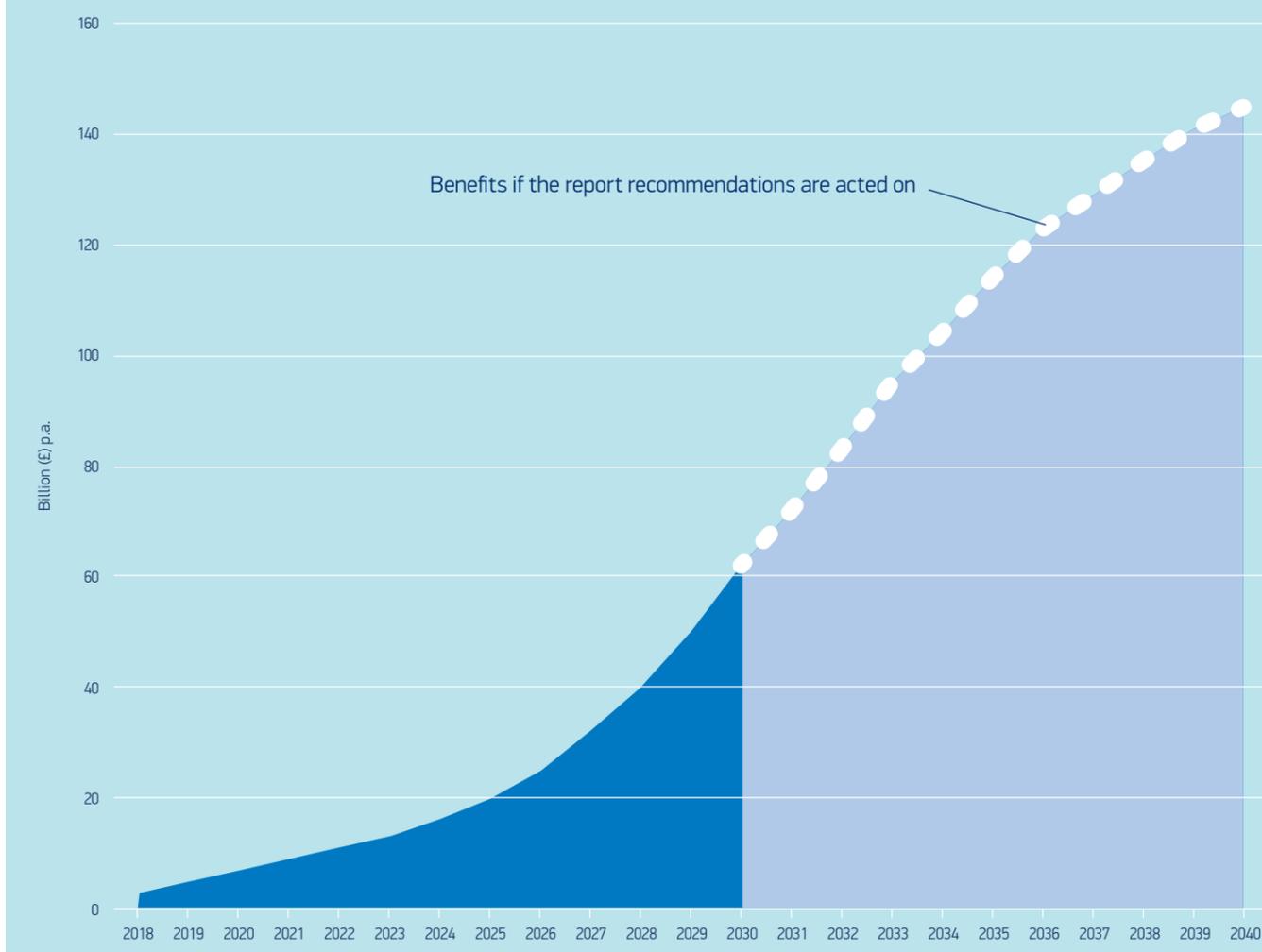
Moreover, the market for premium vehicles in the UK is likely to grow further, with higher customisation leading to higher margins on vehicle sales.

Considering all of the important shifts in mobility, social and employment patterns, the overall impact on the UK economy due to CAV technologies could potentially be more than £145 billion by 2040. But, as referenced previously, the UK's exit from the EU must happen in a way that maintains the status quo as far as possible.

Similar to the previous decade, the economic benefits driven by CAV deployment are expected to accrue to end consumers, who will be able to better integrate their work and personal needs through seamless mobility modes and connected digital services.

Beyond the improvement in productivity, the adoption of CAVs is also likely to improve the overall convenience and quality of life for UK commuters as mobility will be more readily available to all and will provide a more stress-free commuting experience. This added convenience is likely to be the strongest driver to increase CAV adoption by consumers.

ECONOMIC BENEFITS ACCELERATE OVER TIME TO OVER £145 BILLION P.A. IN 2040



5

FOUR KEY RECOMMENDATIONS

► While the overall economic impact assessed in the report shows significant growth potential if the UK continues on its current trajectory of developing and deploying AVs, the benchmarking exercise nonetheless indicates areas where the UK can further improve in order to capitalise on the opportunities presented by the CAV market.

The report identifies four key areas where the UK government can support the industry and accelerate its growth:

- 1. AMENDING CURRENT ROAD TRAFFIC LAWS:** The first step the government should take to pave the way for the safe deployment of AVs would be to amend road traffic laws to enable the deployment of Level 3 AVs. This report's estimate of 12% penetration of Level 3 by 2025 is based on the assumption that changes to international regulation are forthcoming by 2021 and amendments to current UK road traffic laws could be implemented by 2022. The UK is already one step behind Germany in this regard.
- 2. IMPROVING ROAD COVERAGE OF 4G ACROSS ROAD NETWORKS:** 4G coverage on the entire UK road network is an essential pillar for successful connected vehicles deployment. As highlighted in the country benchmarking section, the current coverage of 4G on the UK's A and B road networks is limited to about 54%. Improving this coverage is another important step that the government will need to take to ensure a conducive technology landscape for deploying connected vehicles in the first instance and V2X applications that complement AVs later on the UK's urban, rural and motorway road networks.
- 3. ENABLING SAFE DEPLOYMENT OF CONSUMER ORIENTED URBAN MOBILITY SERVICES:** The roadmap for AV deployment clearly highlights that the area of highest positive impact is likely to be in urban environments. Here, the government can assist with AV deployment by encouraging local authorities to work in collaboration with industry to implement consumer oriented urban mobility services, with safety as the central tenet of such initiatives. This is in line with the government's recently published **Future of Mobility: Urban Strategy**⁸
- 4. EXPEDITING INTERNATIONAL HARMONISATION OF REGULATIONS:** While deployment readiness and attractiveness differ from country to country as our Benchmarking Index has shown, it is important for regulators to work towards an internationally harmonised set of regulations that define the testing, validation and type approval of AVs. This will enable the industry to work towards a unified technology standard and focus on providing maximum value through AV related mobility services across diverse markets. The establishment of such harmonised regulations and international standards will be critical to defining a future where various industry players can access global markets.

CONCLUSION

The deployment of CAVs over the next decade is set to have a dramatic impact on both industry and the economy in the UK. Our research indicates that the biggest direct impact will be on consumers. For instance, current estimates based on the roadmap of AVs in the UK indicate that AV deployment can save every commuter nearly 42 hours in travel time, annually. Moreover, commuters stand to benefit from a 20% increase in average commuting speeds per journey due to reduced congestion and smoother traffic flows.

As a result, workforce productivity is set to surge. In addition, CAV implementation will generate revenues across the automotive value chain. New jobs will be created in automotive software and hardware as well as in adjacent industries such as digital and telecom services.

These and many more positive impacts will be realised even earlier than anticipated should the government immediately act upon the recommendations mentioned in this report. It could mean the difference between the UK economy achieving

the £145 billion economic impact by 2035, instead of the currently forecast 2040.

The UK has the potential to emerge as a global centre of CAV development and deployment over the next decade and establish itself as one of the most attractive markets for CAV related investments. The advantages of this for the UK's economic future cannot be overstated. However, all of this will only be possible with active and sustained support from the government, especially in terms of investment in infrastructure and regulatory support.

It is also critical that the UK leaves the EU in an orderly fashion with a Brexit deal favourable to the automotive industry. Should the country leave Europe in a no deal scenario, significant damage will be done to the UK's long-standing reputation as a politically stable destination for inward investment and the potential benefits outlined in this report are at risk of being realised.



UK CAN EMERGE AS THE FULCRUM OF CAV DEPLOYMENT BY 2030

by Sarwant Singh, Senior Partner and Board Member, Frost & Sullivan

“The UK has a near perfect blend of attributes that will help it capitalise on CAV deployment. These include a forward thinking approach to legislation, advanced technology infrastructure, highly skilled labour force and technology savvy customer base. Collectively, they will position the UK as a strong market for AVs from which the industry can benefit.

While the realisation of fully driverless vehicles is unlikely in the next decade, the Frost & Sullivan report highlights the substantial value to be gained in taking incremental steps towards CAV deployment over the coming years.

The UK provides excellent testing, developing and deployment opportunity for AVs with well structured cities like London and highly sophisticated and controlled areas like Heathrow airport which would be ideal early adoption zones for AV solutions such as automated shuttles and kerb side delivery bots

Along with a fine array of premium OEMs and mobility players, the UK also hosts a very advanced aviation and defence industry which has pioneered technology development in automation. This, combined with state-of-the-art AV test bed facilities, MIRA and Millbrook, underlines the fact that the UK has every essential building block needed to benefit from CAV development and deployment.

With a potential £62 billion to capitalise on by 2030 and a further £145 billion at stake in the following decade, the value created by CAVs for the UK is not to be taken lightly. The opportunities and the road ahead, while challenging, are clear. The onus is not just on industry stakeholders but, equally, on key decision makers in the UK Government to leverage the country's strong position and spearhead a future of mobility defined by safe, convenient and accessible mobility for all. ”

6 APPENDICES

GLOSSARY OF KEY ABBREVIATIONS

BSD
Blind Spot Detection
Warns the driver when the system detects other vehicles located to the driver's blind spot such side and rear.

LDW
Lane Departure Warning
Warns the driver when the vehicle detects an unintentional drift from its travel lane.

AEB
Automated Emergency Braking
System detects vehicles and pedestrians in front and brings the vehicle to standstill during emergency.

LKA
Lane Keeping Assist
System centers the vehicle to the middle of the lane when the vehicle detects an unintentional drift from its travel lane.

PDC
Park Distance Control
Ultrasonic sensor based feature helping the driver in parking by providing audio warnings.

V2I
Vehicle-to-Infrastructure
Technology which allows vehicle to communicate with infrastructures like parking lots, traffic signals etc.

V2V
Vehicle-to-Vehicle
Technology which allows vehicle to communicate with other vehicles like traffic data etc.

V2P
Vehicle-to-Pedestrian
Technology which allows vehicle to communicate with pedestrians like slowing down the vehicle if pedestrian is detected etc.

V2X
Vehicle-to-Everything
Technology that allows vehicles to communicate with moving parts of the traffic system around them.

Parking Assist
Automated steering assistance to vehicle parking feature. Driver needs to engage automated parking mode.

Semi Assisted Valet Park
Steering and braking/acceleration feature automated in parking feature. Driver needs to engage automated parking mode.

Valet Park Assist
Fully automated parking with driver monitoring the parking execution. Driver may / may not need to engage automated parking mode.

Automated Valet Parking
Fully automated parking and summoning feature with no monitoring required. Can be executed with no passenger in the vehicle.

Highway Assist
Steering and braking / acceleration function automated during motorway / A road driving with driver required to monitor the operation.

Emergency Driver Assistant
Automated assistance to steering and or braking/ acceleration functionality once the vehicle detects a delay in driver input for the driving situation.

Intersection Pilot
Automated lane merger and intersection driving during motorway and A road driving with no monitoring from the driver required.

Traffic Jam Pilot
Automated low speed and stop and go driving with driver not needing to monitor the operation

CAV DEPLOYMENT INDEX – DETAILED BREAKDOWN

Countries/ Weights	CAV Index/ Bench- marking	Enabling Regulations			Enabling Infrastructure				Market Readiness				Total Score (Out of 3.5)		
		General	Civil Liability/ Insurance	Road Traffic Laws	Total Score (Out of 3.5)	Digital	Digital	5G Pilots/ Tests	Deployable Road Miles	Total Score (Out of 3)	ADAS uptake	Connected Car Uptake		MaaS Uptake	DRT Fleet Size
United Kingdom	8.4	8	8	9	2.9	4	7.7	6	9	2.2	9	9	10	10	3.3
France	6.1	6	4	6	1.9	4.5	6.8	4	6	1.7	8	9	8	3	2.5
Germany	7.2	8	4	10	2.6	3.9	6.6	6	7	1.9	10	9	10	2	2.8
Netherlands	6.4	8	4	7	2.2	8.2	9	2	7	2.1	8	6	8	2	2.2
United States	8	10	4	9	2.6	2.5	9	10	8	2.3	8	10	8	8	3
Japan	6.2	6	6	6	2.1	4.5	9.5	6	8	2.3	9	4	6	1	1.8
China	5.2	4	2	6	1.4	3.7	8.7	6	6	2	6	5	6	4	1.9
South Korea	6.2	8	6	7	2.4	7.9	9.7	8	5	2.3	7	3	6	1	1.5

FOOTNOTES

- ¹ Frost & Sullivan Report, Global Autonomous Driving Outlook, 2018
- ² Frost & Sullivan Report, Rear End Collision Analysis, North America, 2017
- ³ Computed based on sum of average technology development cost for 2.5 million level 3 and 15.4 million level 4 vehicles across all major global OEMs.
- ⁴ Frost and Sullivan analysis based on JATO and SMMT data
- ⁵ Ofcom, Connected Nations Report 2017
- ⁶ See appendices
- ⁷ See appendices
- ⁸ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786654/future-of-mobility-strategy.pdf

ECONOMIC IMPACT – DETAILED BREAKDOWN

THE £62 BILLION PRIZE

ECONOMIC IMPACT – DETAILED BREAKDOWN

CONSUMER IMPACT	£46 BN
<ul style="list-style-type: none"> An estimate of the value of time where consumers can make more use of the time spent in their vehicles through increased connectivity £25 Bn More efficient journeys lead to greater productivity and labour market flexibility £15 Bn Other savings for consumers including reduced costs in insurance, running costs and parking £6 Bn 	
PRODUCER IMPACT	£2 BN
<ul style="list-style-type: none"> Producer impact is based on expected growth in profit from increased sales due to demand for connected and autonomous vehicles and increased local content. 	
WIDER IMPACTS	£18 BN
<ul style="list-style-type: none"> Revenue growth in upstream automotive value chain from retail, after sales and digital services Revenue growth for peripheral service industries –IT, technology, electronics Revenue growth from digital services generated from in-car data, across the value chain (OEM, technology players, network providers) 	
TAXATION	£4 BN
<ul style="list-style-type: none"> An increase in tax revenues is assumed from direct taxation such as revenue from income tax due to the increased number of jobs and increased revenue from corporation tax Increased revenue from indirect taxes 	
SAFETY	£2 BN
<ul style="list-style-type: none"> Estimated based on total lives saved, serious and slight accidents eliminated through ADAS and AV technology 	
COST	(£10 BN)
<ul style="list-style-type: none"> Infrastructure investments and road maintenance costs will rise 	

ENABLING INFRASTRUCTURE – SUB INDICES (QUANTITATIVE PARAMETERS)

Countries	Digital Infrastructure- 4G Speed (Mbps)	Digital Infrastructure- 4G Coverage (%)	Deployable AV consumer over total consumer miles (2030)
United Kingdom	23.1	77	1 in 5 miles
France	25.1	68	1 in 12 miles
Germany	22.7	66	1 in 10 miles
Netherlands	42.1	90	1 in 10 miles
United States	16.3	90	1 in 8 miles
Japan	25.4	95	1 in 7 miles
China	21.7	87	1 in 12 miles
South Korea	40.4	97	1 in 20 miles

MARKET READINESS – SUB INDICES (QUANTITATIVE PARAMETERS)

Countries	ADAS uptake (2018)	Connected Car Uptake (2018)	DRT Fleet Size
United Kingdom	41%	>80%	24,629
France	36%	>80%	7,250
Germany	50%	>80%	2,993
Netherlands	31%	<60%	1,659
United States	39%	>85%	19,137
Japan	48%	<45%	100
China	19%	<55%	7,077
South Korea	26%	<30%	100

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