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MOTOR INDUSTRY



# Connected and Autonomous Vehicles – The UK Economic Opportunity

March 2015

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# ABOUT THE STUDY

The UK's automotive industry has been growing strongly in recent years, bucking the trend seen in other EU countries with production up to 1.6 million vehicles in 2014 and forecast to rise to 2.0 million vehicles in 2018.

The UK has a proud history of automotive innovation with significant research centres and R&D investment of £1.7 billion in 2013. Today in the UK, connected and autonomous vehicles are being developed and tested on UK roads in Bristol, Coventry, Greenwich and Milton Keynes. Other EU countries need legislative changes to conduct such tests.

There are many adjacent sectors which will be impacted by connected and autonomous vehicles including insurance, telecommunications, electronics, technology, IT, transportation, logistics, advertising, digital and retail. In many of these sectors the UK has a leading position.

The purpose of this study is to assess the impact of connected and autonomous vehicles on the UK economy. The study was commissioned by the Society of Motor Manufacturers and Traders (SMMT) and prepared by KPMG LLP.

Our study comprised the following:

- Desktop research and analysis of publicly available information, academic and industry studies and forecasts (including publications available to purchase). Specific sources have been listed in the body of the report.

- Interviews with key participants in the automotive industry such as academics, researchers and senior members of the OEM management teams.
- Interviews with participants in adjacent industry sectors.
- Use of the 'green book' economics model (an appraisal framework recommended by HM Treasury and supported by the Department for Transport's webTAG framework).

The study considered both connected and autonomous vehicles which are being developed by OEMs. Vehicles are becoming connected through mobile data networks and other dedicated communications protocols that facilitate connections with vehicles (V2V), other devices or machines (V2D) or with infrastructure (V2I).

We have classified autonomous vehicles into different levels of autonomy. These are summarised in the graphic on the next page.



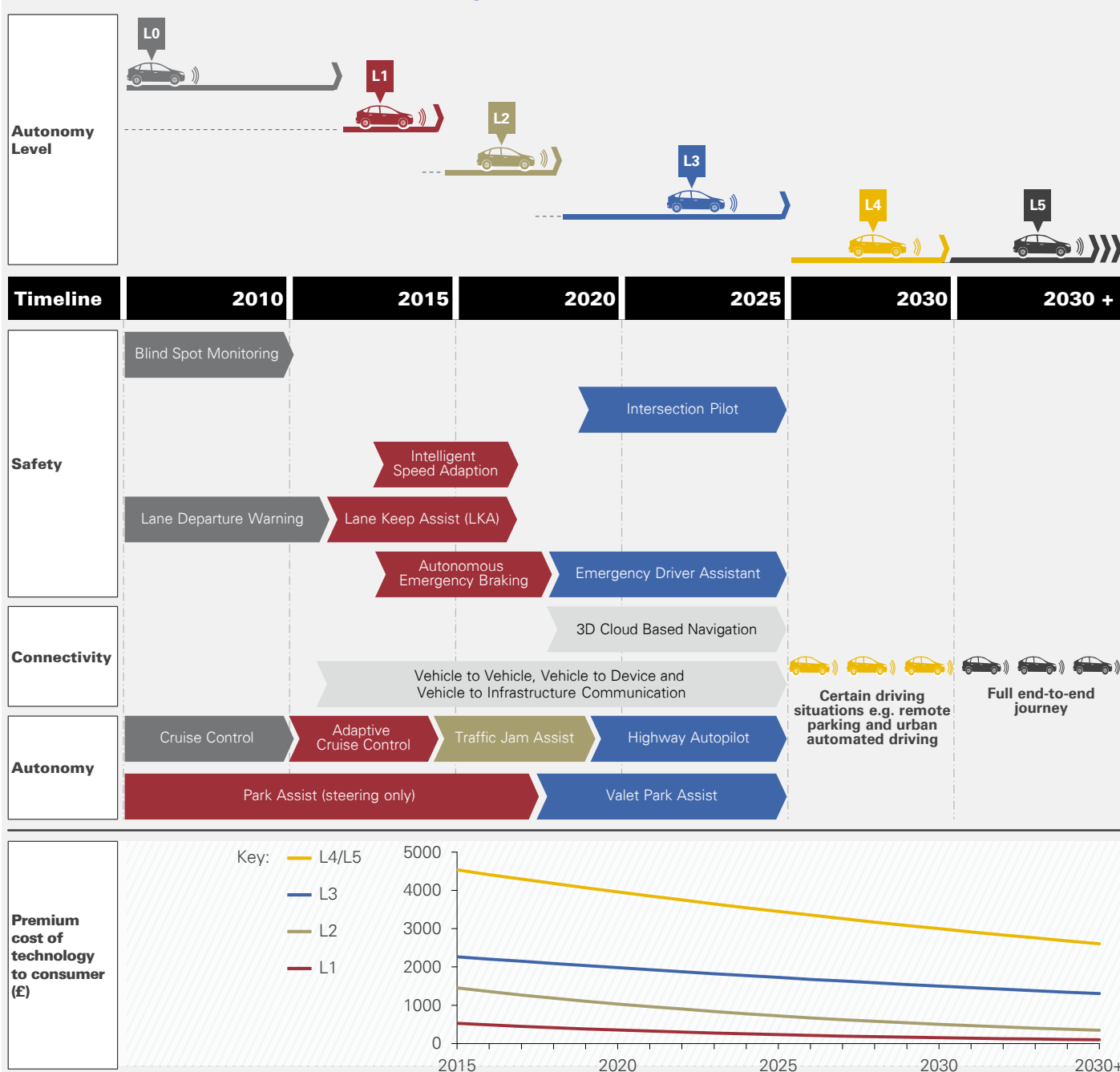
## Defined levels of automation

Level	L0	L1	L2	L3	L4	L5
Driver	Driver only	Assisted	Partial automation	Conditional automation	High automation	Full automation
Automation <sup>(1)</sup>	Driver continuously in control of speed <b>and</b> direction	Driver continuously performs the longitudinal <b>or</b> lateral dynamic driving task	Driver <b>must</b> monitor the dynamic driving task and the driving environment <b>at all times</b>	Driver <b>does not</b> need to monitor the dynamic driving task nor the driving environment at all times; must always be in a position to resume control	Driver is not required during <b>defined use case</b>	System performs the lateral <b>and</b> longitudinal dynamic driving task in all situations encountered during the <b>entire journey</b> . No driver required
				System performs longitudinal <b>and</b> lateral driving task in a defined use case. Recognises its performance limits and requests driver to resume the dynamic driving task with sufficient time margin	System performs the lateral <b>and</b> longitudinal dynamic driving task in all situations in a <b>defined use case</b>	
Example	No intervening vehicle system active	The other driving task is performed by the system	System performs longitudinal <b>and</b> lateral driving task in a defined use case			
	N/A	Park Assist	Traffic Jam Assist	Highway Patrol	Urban Automated Driving	Full end-to-end journey

Note: (1) In performing our study we have found there to be different and significant economic benefits arising from connected, Level 3, 4 and 5 autonomous vehicles. In this report, all types of autonomous vehicles have been considered including cars, trucks and pods.  
Source: Level of automation terms from SAE J3016.

# INTO THE FUTURE: TECHNOLOGY ROADMAP

## Connected and autonomous vehicle technology road map



Source: KPMG analysis based on publicly available industry information and interviews with key participants in the automotive industry.

Vehicle manufacturers, Tier 1 suppliers and new entrants are developing this technology now

**Customers value the better use of their time that this technology will enable**

Scott Le Vine, Centre for Transport Studies, Imperial College London

#### Electric vehicles

Some expect that autonomous vehicles will be adopted more readily in urban settings where there is greater potential for vehicle sharing and these vehicles are likely to be electric powered to save on operating costs and meet EU CO<sub>2</sub> legislation.

All large vehicle manufacturers and many Tier 1 suppliers are making substantial investments in connected and autonomous vehicle technology.

Our interviews evidenced that premium brands are likely to lead the way in introducing connectivity and autonomous technologies with mass-market and commercial vehicles following as cost reduces.

Major economic benefits come with higher levels of connectivity and autonomy. Traffic Jam Assist is being introduced by Audi, BMW, Daimler and Volvo in 2015. Traffic Jam Assist sees the car take control of steering and speed in heavy traffic at speeds of up to 40mph. This technology is a combination of adaptive cruise control and lane departure monitoring systems first introduced in 2012.

Later this decade Intersection Assistant technology will see the vehicle drive itself at junctions controlled by traffic lights and Highway Autopilot will automatically control speed, steering (including overtaking) and will exit the motorway at the junction pre-determined by the driver.

High automation where the driver does not need to be in control of the vehicle will start with simple applications such as the Remote Parking Assistant where the vehicle searches for a vacant parking space and then parks itself through commands from a smart watch. Urban automated driving will not be seen until the next decade.

#### Fully autonomous technology remains some way ahead

The majority of automotive OEMs we interviewed expect fully autonomous technology to become available after 2025. Considerable hurdles remain to be overcome, such as refinement of prediction and decision-making algorithms and cyber security. All saw L3 technology as a stepping stone to fully autonomous vehicles, but a few companies are working on a fully autonomous solution today, such as Google.

**Fully autonomous driving is a goal that OEMs are pursuing incrementally**

Egil Juliussen, Director Research, Infotainment & ADAS, IHS Automotive

**The randomness of the environment such as children or wildlife cannot be dealt with by today's technology**

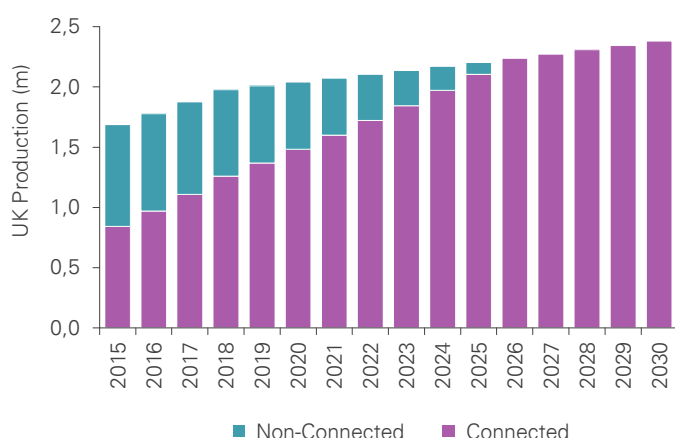
Markus Rothoff, Director of Autonomous Driving, Volvo

#### Connectivity continues to develop

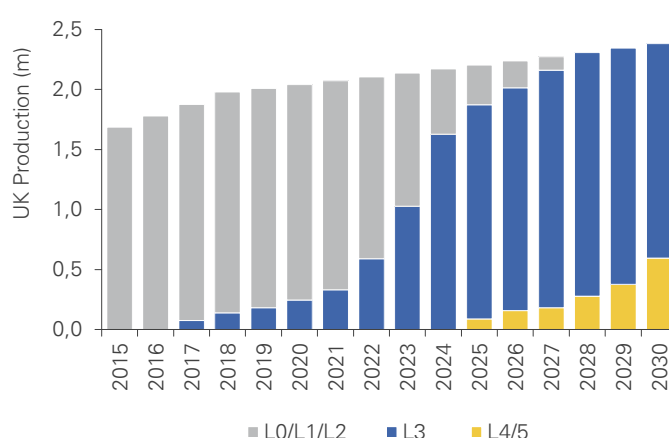
Connectivity is also on a journey of technological progression. Limited connectivity in the form of aftermarket telematics black boxes has provided insurers with valuable data which can lead to reduced insurance premiums for some drivers. Many cars on sale now offer connectivity over mobile networks to the internet either through the driver's smartphone or through a SIM embedded in the vehicle, particularly premium cars and cars designed for younger buyers. In the coming years, connecting vehicles to other vehicles, devices and infrastructure will drive substantial benefits such as shorter journey times, more valuable use of time during journeys, and fewer accidents when combined with autonomous emergency braking and adaptive cruise control.

# CONNECTED AND AUTONOMOUS VEHICLE MARKET OUTLOOK

Forecast of UK Production of Connected Cars



Forecast of UK Production of Autonomous Vehicles



Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Connected Car Penetration	50%	55%	59%	64%	68%	73%	77%	82%	86%	91%	95%	100%	100%	100%	100%	100%
L3 Production Penetration	0%	0%	4%	7%	8%	12%	16%	25%	48%	75%	81%	83%	87%	88%	84%	75%
L4/5 Production Penetration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	7%	8%	12%	16%	25%

Charts and table source: KPMG analysis based on IHS (2015) estimates and publicly available information from GSMA (2014), Ofgem, MobileSquared and RAC Foundation (2008).

## UK production of autonomous cars is expected to grow significantly by 2030

Based on current trends, it is expected that all vehicles produced in the UK by 2027 will have at least L3 technologies embedded in them and that there will be a 25% penetration of fully autonomous vehicles by 2030.

This presents an opportunity for OEMs and suppliers with production facilities in the UK as a technological hub.

We believe the UK will become a centre of excellence for connected and autonomous driving and highlight the following factors:

- Jaguar Land Rover and our other premium brands will be early adopters of this technology.
- The UK government announced a £200 million fund to develop connected and autonomous vehicle technology in March 2015.

- Fully autonomous vehicle pilots in Bristol, Coventry, Greenwich and Milton Keynes are taking place in 2015.
- One of Europe's premier connected car testing facilities is at MIRA.
- The UK has leading positions in telecommunications, technology and insurance.

Overall, we expect local content of vehicles to rise from a third today to over 40% in 2030 and component exports to rise by 3% per annum.

# WIDER MARKET IMPACT

## Many sectors will benefit from connected and autonomous vehicle technology

### Integrated transport

Connectivity has enabled a number of service providers to offer journeys comprising integrated train, bus and vehicle transportation and this is set to develop further in major cities, notably London, and in the freight operating sector. This will allow for a more efficient arrangement of transportation that improves road capacity and reduces the cost of transportation overall.

### Vehicles as a service

Connectivity is already allowing companies such as BMW, Uber and car clubs to provide access to cars as a service but fully autonomous vehicles will allow the potential for mass vehicle transportation to be provided as a service. This is especially relevant for urban traffic, particularly the daily commute. Vehicles provided as a service will be more heavily utilised and we expect the number of journeys to increase as the 'impedance to travel' diminishes.

### Telecommunications industry will benefit from dramatically increasing data traffic

Connected vehicles will increasingly communicate over mobile networks, and will generate substantial growth in data transmissions that will benefit the telecommunications industry. We forecast growth of approximately 12% annually to 2030.

### Service provision

Connectivity already allows for the provision of services to the driver in-car. We expect a regulatory model to develop whereby consumers can elect to share their data when they choose which will allow for improved service provision from a range of service providers such as vehicle maintenance, advertising, infotainment streaming and retailers.

### Insurance

The motor insurance industry will be disrupted as safety improves and driver behaviour and accident event data become more widely available. Premiums will fall, monoline motor insurers will consolidate and liability will shift from drivers to manufacturers.

### Planning

Automated vehicles will be able to park themselves out of the city centre allowing for better use of urban spaces. Emergency services may be able to respond more quickly by alerting oncoming vehicles.

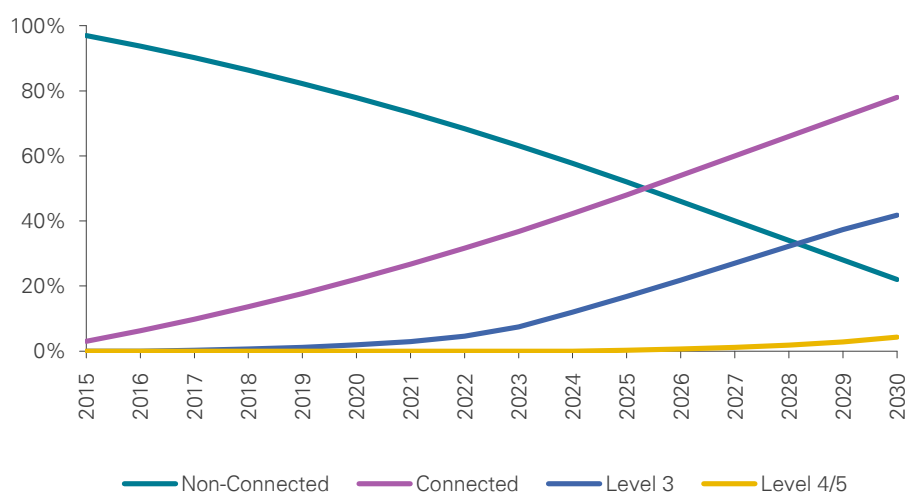
### Public benefits

However the single largest area of benefit will be to the public and society as a whole. Connectivity will allow for reduced congestion which will save time, increasing productivity and labour market flexibility. Connectivity will allow vehicle occupants to better use their time whilst in the vehicle. Improved safety and reduced emissions of CO<sub>2</sub>, particulates and noise will have wide ranging health benefits.

### Timing of benefits realisation

The realisation of the changes highlighted on this page depends on the speed of technology take-up. Government and insurers are expected to incentivise the adoption of these technologies but given that there are over 30 million cars on the UK roads and on average 2.4 million cars are sold it will take many years for the technology to roll out absent a widespread scrappage scheme. Many benefits require a substantial penetration of the fleet to be realised but some are realised gradually.

### Technology take-up as a percentage of total UK vehicle fleet, based on KPMG analysis of IHS (2015) estimates



Source: KPMG analysis based on IHS (2015) estimates and publicly available information from GSMA (2014), Ofgem, MobileSquared and RAC Foundation (2008).



# THE £51 BILLION PRIZE

## Economic impacts: Headline findings

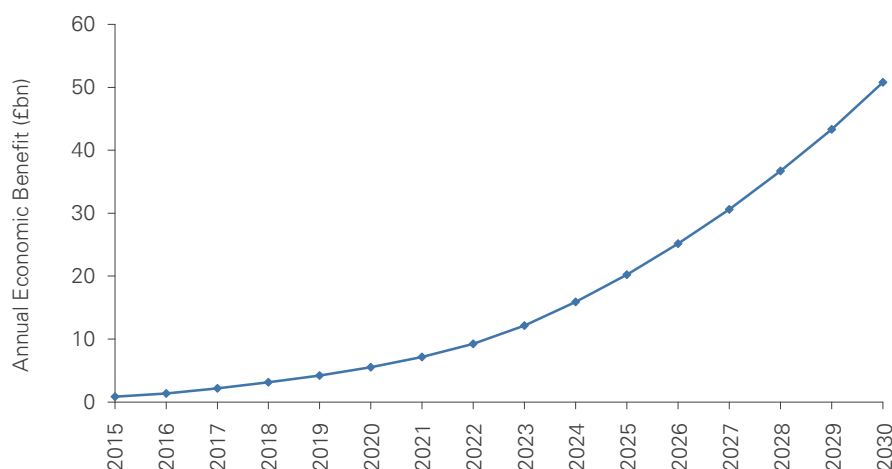
Our forecast is that the annual economic benefit of connected and autonomous vehicles will grow to £51 billion by 2030. Most of the benefits accrue to consumers who experience a transformation in the ease at which they can travel, which in turn generates wider economic benefits, such as fewer accidents, improved productivity and increased trade.

These benefits are unlocked both by connectivity and increasingly autonomous vehicles. For example, the development of vehicle to vehicle communication with adaptive cruise control and autonomous emergency braking can substantially reduce motorway bunching which reduces travel time and accidents.

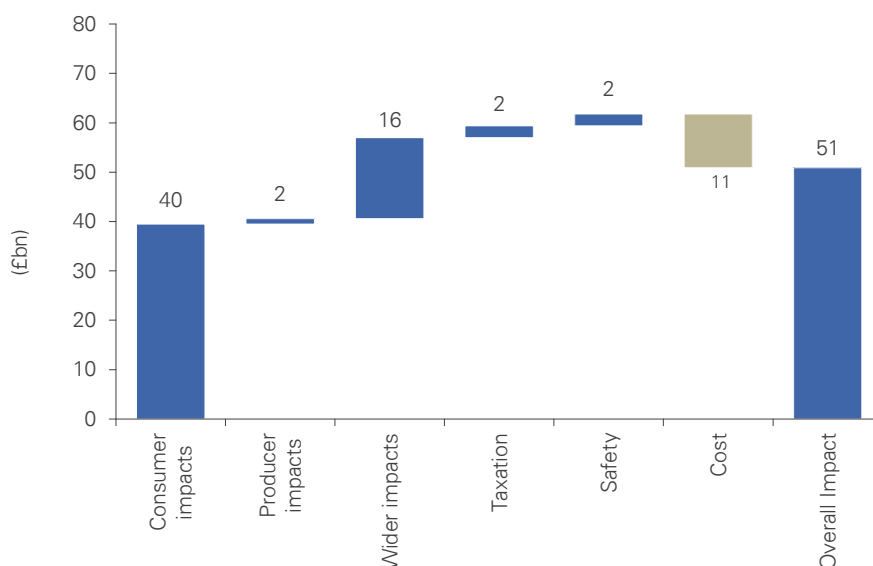
We also forecast the development of the UK as a centre of excellence in connected and automated vehicle technologies, increasing production to 2.4 million vehicles in 2030. There are modest improvements to the profitability of the telecoms, logistics, insurance, retail, and media sectors.

We forecast an increase in the level of government expenditure on roads but this is offset in part by an increase in indirect and corporation taxes.

## Economic benefits accelerate over time to over £51 billion in 2030



## Impact of Connected and Autonomous Vehicles in 2030



# GENERATING OVER 300,000 JOBS

## Output and jobs

The additional vehicle production and increased local content as the UK becomes a centre of excellence for connected and autonomous vehicles will lead to a further 25,000 jobs being created within the automotive industry. However, more substantial job creation occurs across the economy because of improvements to productivity and greater mobility of workers. Adjacent sectors such as telecoms and creative industries such as digital and media will also generate additional jobs as they serve new markets created by connected and autonomous vehicles.

These benefits will be reflected in GDP growth which we forecast to be an additional, cumulative 1% by 2030.

We forecast that connected and autonomous vehicles are increasingly likely to be electric, shared use vehicles which will have environmental benefits, and substantially reducing noise particulate pollution in urban areas.

## Impact of Connected and Autonomous Vehicles in 2030

**+£51bn**



Value added annually by 2030 (at 2014 prices)



**+1%**

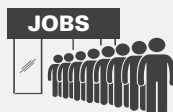
Impact on GDP (2030)

**+320,000**



Additional jobs impact

**+25,000**



Jobs in automotive manufacturing created

**+25,000**



Serious accidents prevented (2014-2030)

**+2,500**



Lives saved (2014-2030)

# THE ROAD AHEAD – OPPORTUNITIES AND CHALLENGES

## Areas for attention

Regulators should focus on removing barriers to the development, testing and adoption of connected and autonomous vehicles by creating a framework that provides clear standards for manufacturers and consumers in important areas such as liability, data and privacy, cyber security and connectivity across borders.

By not ratifying the Vienna Convention on Road Traffic and allowing the piloting of fully autonomous vehicles on public roads without need for primary legislation, the UK has a supportive environment for the development of connected and autonomous vehicle technologies.

However, many countries are now accelerating their regulatory framework reviews in this area and the UK government needs to pursue its actions set out in the “Pathway to Driverless Cars” with vigour if it is to maintain a lead.

Moving forward, standards are needed that give OEMs and developers of connected and autonomous technologies boundaries that can be worked to without restricting the innovation and development of the industry. Standards and clarification around the following key areas need to be considered:

- Testing – The testing of autonomous vehicles on public roads throughout the UK is already allowed and the government will shortly publish its Code of Practice to clarify the standards which testers are expected to follow. This puts the UK at the forefront of international testing.
- Liability – Existing laws concerning manufacturer defects are substantially sufficient for determining liability in an accident involving a car with some level of autonomy. However, a framework for determining liability on the transition of control from the vehicle to the driver of semi-automated technology would provide clarity including the application of current civil and criminal law.
- Privacy and Data – Current data protection laws again are substantially sufficient to deal with personal locational data collected by vehicles and consumers already have some experience of ‘opting in’ to data sharing on their smartphones. However to unlock the societal benefits of data sharing it may be that some limited level of mandatory data sharing is desirable such as that being achieved through the EU’s e-call initiative expected to be implemented in 2018.
- Digital Infrastructure – Development of digital infrastructure is necessary to maximise the benefits of connectivity in vehicles. The March 2015 announcement of funding to support private sector investment is a welcome start in this regard.
- Cyber Security Standards – Standards will need to be created to define the minimum security embedded in the hardware; as well as what the boundaries are for software and connectivity. This may be included within the current Type Approvals and ISO frameworks.
- Telecoms Standards – Global telecommunications standards will need to be defined by regulators to ensure interoperability and connectivity of systems. This will require the necessary dedication of radio frequency bandwidth/spectrum, and clear standards with regard to IoT (Internet of Things) and M2M (Machine to Machine) connectivity to allow vehicles to communicate with devices being developed by other industries.

As a member of the EU which has leverage to shape global regulation and standards, the UK is well placed to help drive the regulatory framework – further strengthening the UK’s position in the global automotive industry.

## **Developing standards at EU-level is where most of the regulatory effort is required**

Stuart Young, Partner  
Wragge Lawrence Graham & Co



Businesses will also need to evolve and invest to ensure they can grow and benefit from the industry

Connected and autonomous vehicles will open up a wide array of opportunities not just for automotive businesses but a range of adjacent sectors as well. Some key areas include:

**Decision-making software –**

Advanced software and algorithms will be required to make sense of the complexity of data received from the vehicles' sensors and how to choose between least-worst options in the event of a potential crash. This is an area which will need substantial work due to the reputational risks faced by vehicle manufacturers.



**Vehicle cyber security –** There is an opportunity for players within the industry to support cyber security from a hardware and software point of view. ECUs and MCUs will need to be developed which have sufficient levels of resistance to cyber attacks and likewise with software and networks.



**Data opportunities –** Connected and autonomous vehicles will generate vast amounts of data if consumers choose to share it. This has the potential to open up a range of opportunities for consumer engagement and indeed monetisation for the data owner. This will become a source of competitive advantage for OEMs, technology companies and insurers as well as supporting automated traffic flow management.





# APPENDICES

THE DETAILS OF  
THE FORECAST





# AN ANALYSIS OF OUR FINDINGS

## Assumption area

## Impact



### Consumer Impacts



£40bn

An estimate of the value of time where consumers can make more use of the time spent in their vehicles through increased connectivity £20bn

More efficient journeys lead to greater productivity and labour market flexibility £15bn

Other savings for consumers including reduced costs in insurance, running costs and parking £5bn



### Producer Impacts



£2bn

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



£16bn

- Travel and freight costs reduce across the economy
- Trade and exports increase across the economy
- Telecommunications data traffic increases by 12% CAGR
- Consolidation of monoline motor insurers
- Revenue growth for creative industries including digital, advertising, media
- Revenue growth for digital retailers
- Revenue growth for service industries – IT, technology, electronics
- Better use of space in cities, energy management and impact on property values



### Taxation



£2bn

- 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



£2bn

- It is assumed that 94% of accidents occur due to human error as estimated by the DfT. This is forecast to halve by 2030.



### Cost



(£11bn)

- Infrastructure investments and road maintenance costs will rise

**Total**

**£51bn**

Numbers are subject to rounding errors

# METHODOLOGY

## Approach and methodology

The economic impact of connected and autonomous vehicles is estimated as the difference in value of the UK economy between a Do-Nothing Scenario in which vehicle connectivity remains as it is today and a Do-Something Scenario in which connected and autonomous vehicles evolve as forecast in the technology road map.

The estimated economic benefits are clearly attributable to connected and autonomous vehicles and are ‘additional’ rather than simply arising from a redistribution of resources.

Our analysis is based on the assumption that connected and autonomous vehicles will lead to a reduction in the impedance to travel, defined as the combination of travel time, travel costs and journey experience. This reduction in the impedance to travel stimulates demand and generates economic benefits to the consumer.

In turn, the added value created by the take-up of new technology leads to an increase in output, a reduction in unit costs, and an improvement in the commercial performance of the sector.

Additional wider economic benefits are stimulated through enhanced highway network performance and improved safety, production-related benefits arising from adjacent sectors, and changes in government expenditure and taxation.

### ‘Do-Nothing’ Scenario



#### Consumers

Future demand and cost of motoring is based on current DfT projections, i.e. it assumes no additional impact on cost and demand from increased connectivity and automation.



#### Producers

Under this scenario UK export production is linked to global growth rates in demand for cars and the home market is linked to the domestic market growth rate for cars, while the value of vehicles is based on current levels of connectivity and automation.

### ‘Do-Something’ Scenario



#### Consumers

Estimates the impact of increased connectivity and automation on motoring costs, and from this calculates the impact on demand for road travel using demand elasticities published by RAND and supply elasticities from the RAC Foundation.



#### Producers

Under this scenario UK exports and home markets are the same as in Do-Nothing except they receive a boost based on increased demand for connected and automated vehicles. The value of produce is increased based on the value of connectivity, and autonomous level.

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