Impacts and benefits

1. What are the potential applications for autonomous vehicles?
Autonomous Vehicles are set to bring transformational change into the urban environment. Increasingly automated driving benefits:

- Safety
- Convenience and comfort
- Accessibility
- Efficiency and co-ordination of traffic
- Environmental Impact

The major gains to be made in these areas are primarily via the reduction of vehicles in tandem with a move to full automation across all vehicles, regardless of mode, and the introduction of low or zero emission vehicles. This is a major ambition, therefore to ease the transition specific areas can be targeted to aid the public acceptance. The introduction in various public areas such as university campuses, tourist areas and shopping centres will aid public acceptance and build confidence – this is key to enabling the uptake of this technology. Public Sector transport services, for example adult day care transport, healthcare delivery, etc. can be some of the first vehicle transport to transition as confidence grows. Integration into the mass transit system is vital within city region areas, identifying areas that have low levels of public transport connectivity acts as both a social need requiring a solution, plus the ideal test areas to determine the business models that will support the move to autonomous vehicles, especially when monitoring the impact their introduction will have.

The full benefits will be realised at Level 4, full autonomy, according to an MIT study published in 2014 *Road Vehicle Automation*, Frazzoli and colleagues studying Singapore estimated that 300,000 driverless taxis, in theory, could do the work of the 780,000 privately owned cars currently operating today in Singapore, while keeping waiting times below 15 minutes. A 60 percent reduction in the number of vehicles operating in Singapore.

Effective taxi fleet management, reduction in personal car ownership and access to electric and hybrid vehicles without the worry of charging them could produce up to 94 percent less greenhouse gas emission per mile worldwide by 2030 when compared to conventional taxis according to a 2015 study published in *Nature Climate Change*.

2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?
As outlined above in the answer to question 1 the user benefits are:

- Safety
- Convenience and comfort
• Accessibility
• Efficiency and co-ordination of traffic
• Environmental Impact

When deployed as part of an integrated transport approach, regardless of urban or rural environment, the public will effectively have access to a demand responsive transport system. Providing user specific vehicles (for example catering for users with limited mobility) on demand, whilst maximising the use of such vehicles will provide an efficient, effective service to users.

The disbenefits are very much centred on the ability to balance transport on demand with the numbers of people travelling, therefore it is imperative to integrate with mass transit transport modes to aid the efficiency and reduce environmental impact. There is the potential of increasing user inactivity leading to wider societal problems, therefore where possible keeping the use of vehicles to sector specific needs and ensuring where people are being transported it is not necessarily a full end to end service.

3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?
Research is being undertaken to understand the full impact of this technology. The West Midlands is already at the forefront of design, manufacture and testing of the vehicles. This incorporates:

Digital Simulation: Warwick Manufacturing Group has built and utilises a full digital test simulator (https://www.youtube.com/watch?v=XqJlfK3Hjq0&feature=youtu.be&noredirect=1). Utilising virtual simulation to lower the cost of prototyping, analysing human computer interaction and provide as real an environment as possible, the area is leveraging the digital incubator environment and creative skills that use data and design.

Within the Midlands area there is advanced transport modelling focussing on autonomous vehicle impact being undertaken at Horiba Mira Ltd. in Nuneaton. This is allied to the research strengths of the 12 universities and the science parks in Coventry, Birmingham and Wolverhampton all of which have intelligent mobility, cyber security, alternative fuel cell and human machine interaction specialisms. The Advanced Propulsion Centre at Warwick Manufacturing Group is a centre of excellence for low carbon propulsion and fuels positioning the region at the centre of this global industry.

There is the ability to take advantage of the local creative digital sector too. Harnessing user experience, games development technologies and agile processes to enhance automotive manufacture with an additional sector that the region shows strength in. This can enhance not only the virtual prototyping but also the human computer interaction with the vehicles. Visteon, lead partner on UK CITE, will provide the ‘infotainment’ aspect, unlocking the potential for a whole new economy within connected vehicles. The iVMS project is working with Serious Games International Ltd (SGIL) based on the Coventry University Technology Park. Birmingham, Warwick and Stratford upon Avon are one of the 12 games cluster hub
for computer games development enabling the use of digital technologies to facilitate
behaviour change through gamification and incentivisation.

**Controlled Environment:**

The stage following digital simulation takes place on the off road test track, enabling further
research and understanding to take place – again the West Midlands can call on a wealth of
experience. Communication infrastructure, realistic test track conditions, safety critical
feedback and technical expertise are all available in close proximity and in a collaborative
environment catering for large OEMs through to SME sizes precision engineered car
manufacturers.

**HORIBA MIRA Ltd :**

One of the UK largest transport systems R&D companies. It has a technical team of >500
staff, including dedicated teams focused on Intelligent Vehicles and Mobility, controls and
electronics and safety. Specialist laboratories ranging from electro-magnetic compatibility
laboratories, components and structures test laboratories, simulation and modelling
facilities to climatic wind tunnels. Host Europe’s first purpose built Intelligent Transport
Systems (ITS) facility for developing and determining the system performance of mobility
products and services. To date the main focus has been in the fields of:

- Connected and Intelligent Vehicles: Autonomous control systems; Co-operative
  control systems; Active safety systems; ECO driving solutions; Human Machine
  Interfaces
- Intelligent Infrastructure: V2V - V2I and mesh communications interface; Data
  management, trustworthiness security; Off-board control systems and cloud based
  modelling tools for transport management
- System Performance: Safety, system reliability, cyber security, performance and
  verification.

**Gaydon test track:**

The Jaguar Land Rover Gaydon Centre is one of the principal engineering centres of Jaguar
Land Rover and the location of the headquarters of Land Rover. The site houses a design,
research and development centre and extensive test track facilities and is used for the
design and development of Jaguar and Land Rover vehicles.

**Jaguar Land Rover Fen End:**

The development is home to around 300 staff in its Vehicle Operations, a specialist group of
automotive engineers which prepares and refines a range of vehicles for global events and
product launches. 200-acre testing facility.

**BCU campus (Project Insight):**

Leading on the developments within the Knowledge Hub, Eastern Side (Enterprise Zone)
laying out a vision for 7 new public spaces connected with a fleet of autonomous vehicles.
Providing a test bed to trial CAV, provide a tailored digital infrastructure and align with
investments in infrastructure.
The key aspects include renewing Corporation Plaza, Aston Square, Jennens Park, Cinema Square (in Millennium Point), Typhoo Wharf, Eastside Locks and Curzon Street with an extension to Eastside City Park.

4. How much is known about public attitudes to autonomous vehicles?
Public attitude is the subject of most debate related to CAV. The impact of introduction is the subject of pure speculation during this testing and research period. The core CCAV and Innovate UK funded projects are all studying the impact of these vehicles on public attitudes, the studies are key deliverables and due to be shared publicly.

A major difficulty in understanding public attitude is due to the fact that the deployment and use of this technology is not well understood, therefore speculation is framed by our current understanding of cars and how they integrate with society. A great deal of written work and research is taking place from the likes of Elon Musk estimating the impact of Tesla autonomous vehicles, through to academic research studies in many high profile universities (MIT, Cambridge, etc.). In the West Midlands we believe that identifying our areas of mobility challenges, providing this intelligence to the pod manufacturers and companies that will provide services we can set up valid tests that meet real world problems and then determine the public attitude as this is likely to be a different response to the more basic question of replacing current driving with autonomous driving that operates within the same pattern of life.

Introducing autonomous features within vehicles will start to move the mind-set steadily. The introduction of certain vehicles in controlled environments again will build trust. The final act of moving to fully autonomous vehicles almost everywhere will take a major step as, unlike autopilot on flights, many people are already drivers and therefore understand the mental steps undertaken to drive a vehicle. Replicating this in a machine has understandably been met with some scepticism.

5. What is the scale of the market opportunity for autonomous vehicles?
KPMG 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.

The global value of entertainment and wellbeing services in non-commercial vehicles is forecast to grow at 25% Compound Annual Growth Rate to $18bn by 2020. Greater connectivity is an opportunity for mobile network (LTE) and WiFi network operators to increase the productivity of their asset base with a new customer segment. AXA (2015) estimated the 10 year benefits to the UK haulage industry for Intelligent Transport Services
and safety services at >£20bn, quantifying the opportunity is part of the UK CITE deliverables.

Creating an enabling environment

Research and development

6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?
Work undertaken in and around the West Midlands is moving towards developing the best multi-level test environment for connected and autonomous vehicles. The access to digital simulation at Warwick Manufacturing Group, the controlled test environments at Gaydon and Nuneaton and finally the inter-urban area between Coventry, Solihull and Birmingham will provide a mixture of motorway and local roads to test the vehicles. The ambition is to tap into the existing skill base across many industry sectors and scales of firms, from tier 1 manufacturers through to the SME supply chain and innovation incubators.

This work requires national and international recognition, to enable it to be a focal point, in the case of the West Midlands there is political and institutional recognition that should now, with additional investment, go further. This should go beyond demonstrating the movement of the vehicles in real-life conditions, it should reflect all the proposed benefits and economic possibilities. The demonstration area should have the ability to trial and test business models that are aimed at connected vehicles; develop connected vehicle infrastructure; work in many mobility sectors such as freight; identify health benefits; have access to a professional services sector to recognise the financial and legal implications and whole host of additional testing and research.

7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?
Primarily the UK Government can offer support and promotion, understand and recognise that the devolved powers to the West Midlands Combined Authority can help to deliver this facility. Recognise that the Midlands Engine with its Transport Innovation ask can build on this area outwards from the West Midlands and further afield within the UK where there are pockets of automotive and research specialities. It should facilitate bringing together people for developing standards to allow information exchange, ensure that different vehicles can use the infrastructure and ensure that driver, passenger, information and cyber safety and security are paramount. Internationally through the Britain is Great brand promote the facility as a centre for testing, development and learning.

In terms of key coordination the cyber-security aspect is critical, it is the only body that can take a central coordinating role. The issuing of security certificates to vehicles requires a national, if not international body, that has to be closely monitored and validated. The implications of implementing poor security can take on a national significance from a Defence perspective. The ability of vehicles to cross borders to facilitate movement also opens up a new area of cyber warfare. The UK Government is key to this and the decisions cannot be left to the industry, EU and international standards coordination or the devolved
local highway authorities alone. This presents a massive opportunity to grow the economy by developing expertise, business and skills to take a lead on this.

8. How effective are Innovate UK and the CCAV in this area?
Innovate UK and CCAV are providing a key focal point for the research and development of CAV. They have brought together industry, academia and the public sector. The next steps taken are vital to taking the sector forward and ultimately scaling it. Innovate UK can distribute more funding to build a research and development area that acts as the focal point for the industry in the UK, if not Europe. The West Midlands is well placed to be that area, due to the previous investment and existing assets, combined with a political will to make this the region for CAV.

CCAV can act as the international liaison body, promoting the UK automotive industry and facilitate the advertising of the UK research and development area to manufacturers, businesses and academia. Working with bodies such as Drive Midlands, CCAV should be in a position to bring a massive slice of the international market to the UK.

9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?
The opportunity for SMEs supporting many different facets of the connected and autonomous vehicles industry is huge. Harnessing the supply chain of agile SMEs, who can develop and refine the techniques to build parts, components, digital technology, products and services aided by incubators and business support programmes will build on the existing and growing skill base, much of which is already based in the West Midlands. The University R&D hubs are at the heart of utilising new manufacturing techniques, such as 3D printing, to develop the technology and equipment to rapidly build quality materials and components, putting the region at the heart of the new manufacturing techniques that will need to be flexible and sustainable.

The concentration of large scale business and associated SME supply chain is a key facet of the Midlands Engine, covering the whole Midlands area, not just the West Midlands. This region has already attracted 880 Foreign Direct Investment projects creating over 48,000 new jobs and safeguarding a further 23,000. Evidence from Midlands Connect shows that improved highway reliability and regular average speeds across the Midlands along integrated transport can provide an economic benefit to the wider Midlands of up to £800m per annum by 2036 with 143,000 additional jobs when a 10% reduction in general travel times are achieved.

The key enabling activity for the multi-sector industries that are required to support autonomous vehicles is the UK and global recognition of an area being at the heart of the environment. An area, such as the West Midlands, acting as a focal point has the compound effect of utilising many existing skills and also growing the sector to attract new entrants.

*Real world operation*
10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?
The extent of the infrastructure upgrades required is the primary research goal of the UK CITE project. This will provide understanding in a mixture of technologies that are easy to deploy whilst ensuring safety and security through the collaborative work of Jaguar Land Rover, Vodafone, Siemens, Highways England and host of other companies.

The car, infrastructure, data and connectivity factors all require harnessing efficiently to ease the deployment of this technology and aid the scaling up of the industry. Therefore changes will need to be made along the major routes, the key is matching the appropriate technology to the appropriate use of the vehicles. This demonstrates that greater research is required to identify viable business models that allows the deployment of CAV to meet specific needs in a cost effective way. During this research the opportunity to exploit new data sources, interactions between vehicles and service providers has to be harnessed to release further capital in order to improve the physical and digital infrastructure.

11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?
This is a key aspect of the research needed to fully understand deployment. Trialling the vehicles with a view to understanding the public attitude, the integration with existing transport, the ability to solve mobility challenges and ultimately identify viable business models is key to enabling wider deployment. It is estimated that the major benefits will accrue once there is fuller automation, combined with improved fuel cell technology, the ability to get there is mostly dependent upon the behaviours people show when moving. Is there widespread agreement on car sharing and demand responsive transport? What is the appetite for uptake? How to incentivise travel behaviour change to create a more efficient network? The management strategy required will only be possible to develop once the implications have been tested. The proposal to identify a plethora of challenges across the West Midlands will aid this understanding. This is the key milestone to enable fuller deployment within the existing transport infrastructure.

12. Does the Government have an effective approach on data and cybersecurity in this sector?
In terms of key coordination the cyber-security aspect is critical, it is the only body that can take a central coordinating role. The issuing of security certificates to vehicles requires a national, if not international body, that has to be closely monitored and validated. The implications of implementing poor security can take on a national significance from a Defence perspective. The ability of vehicles to cross borders to facilitate movement also opens up a new area of cyber warfare. The UK Government is key to this and the decisions cannot be left to the industry, EU and international standards coordination or the devolved local highway authorities alone. This presents a massive opportunity to grow the economy by developing expertise, business and skills to take a lead on this. The UK Government currently requires more work in this area, bringing together experts in various fields to capture the best possible approach, building a central body that takes responsibility and can be held accountable.
The approach to data is currently lacking and if left to the automotive manufacturers alone the full exploitation may not be recognised and therefore more costly further down the line.

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?
The professional support services are already actively engaged in the research work around connected and autonomous vehicles. The financial, legal and insurance models are being defined and evaluated. They will need to be flexible to adapt as the market grows in maturity. Risk and responsibility is perhaps the largest and most difficult question, this is where the UK Government has to lead the way based on the existing research and working closely with industry bodies. The trial deployment is already challenging the responsibilities of the automotive manufacturers, infrastructure providers and the public highway authorities. The technology to capture and understand problems and ultimately assign responsibility is developing along the lines of the aeronautical sector, with black boxes recording conditions and helping to determine faults. This alone has implications in terms of both cost and time, but ultimately it is a challenge that paves the way for further economic growth. The country and companies that understand the methods needed to unpick this and work with the legislative authorities will undoubtedly stand to gain financially from this expertise.

The potential economic cost of mitigating risk, accepting liability or defending actions has to work in a way that does not deter the deployment of these vehicles. The UK will face a risk of being behind the international development opportunities if it is not at the forefront of this sector. The focal point of research and development form the manufacturing perspective and can also act as a focal point for the professional support services, again the West Midlands is well placed for accountancy, legal and insurance professionals.

14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?
The deployment approach is again a huge influence on the ethical issues to be addressed. The level of complexity of deployment will invariably affect the complexity of the ethics. This requires research of practical infrastructure based deployment, public acceptance and professional service guidance around liability. The West Midlands does not believe there will be a one size fits all approach to the ethics and judgement issues. Deployment of vehicles in a sectioned off infrastructure will invariably lead to different judgment and liability decisions, perhaps akin to the current rail industry.

The judgment criteria is a major factor in public acceptance, therefore a simple framework of understanding based on deployment environment and intended use will aid the uptake. The level of complexity around deployment will be a major learning form deployment across a research and development area when it comes to the crucial aspect of sustainable business models. Therefore we would repeat the call that further research is required that is built upon the excellent work undertaken so far.

Wider governance

15. What does the proposed Modern Transport Bill need to deliver?
The key to unlocking the benefits of autonomous vehicles is via the integration with existing transport infrastructure. Developing demand responsive travel in line with mobility as a service utilising market-led initiatives that incorporate public policy is key to the effective deployment of this technology. The Modern Transport Bill needs to deliver the environment in which to legitimately test the market in public with autonomous vehicles. Leadership from central government on the approach to cyber-security acting as a trusted broker to monitor security but respectful of personal privacy. The UK government should facilitate integrating payment and back office market places to create incentivisation for car share, multiple modes and active travel ensuring a seamless experience of ticketing for the customer, providing correctly tracked payments for the service provider and providing the information for effective transport planning. The data standards and financial monitoring to allow this should be led by government to ensure an open and competitive marketplace. The UK Government can guide the market using open standards and enforcing adherence, this will provide a more open market for new entrants, ensure greater competition and create specific marketplace solutions to ensure mobility options in areas where existing transport is seen to be uneconomic.

16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?
The autonomous vehicle industry covers a wide array of skills and sectors, encompassing engineering, digital skills, business development, management, financial, legal and a whole host more. The advantage of this sector is that it can act as a catalyst to inspire career choices to work in a technology area, no matter a person’s background. The advantage of the multi-disciplined requirements is such that connected and autonomous vehicles can act as the focal point in an area to upskill the workforce, however the sectors are so varied that it will maintain diversity should there be unexpected turbulence in the marketplace, ensuring sustainable skills and continued employment to the people trained for this industry.

The West Midlands has suffered as a result of its focus on manufacturing once this sector declined. The history and association with the automotive industry is renowned, the autonomous vehicle industry provides an opportunity to build for the future whilst reflecting the past. There are already educational schemes at schools, colleges and university level that are aligned to the HS2 scheme. The same approach could be undertaken for autonomous vehicles. Identifying dedicated courses, apprenticeships and research projects for this sector could be achieved in a similar manner. As with HS2, this action has to take place now. Aligning this educational support to the proximity to a dedicated research and development environment will serve to catalyse and enhance further the offering in the region, enabling the economic goals of the West Midlands Combined Authority to be achieved and act as a tremendous demonstration of how devolution can work in practice to support not only the local but also the national economy.

17. Is the Government’s strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?
The investment that the government has taken so far is welcomed. The UK is now catching up some of the leading countries in Europe, notably Germany and France. The connected
vehicle trials around Coventry will in fact be leading the way in creating a large real world test environment, many other countries have focussed purely on the ability of a car to drive itself. The UK does however have some way to go in catching both the US, Japan and Singapore. These leading countries are looking at commercial deployment of the vehicles, they are consolidating tech companies, purchasing software and integrating rideshare and mobility as a service models. The deployment, peripheral businesses concerned with legalities and insurance can be further developed. Connected vehicles offer a whole new market that is currently untapped and can be further explored. The infrastructure, manufacture and deployment is a sector that could also flourish, developing low cost, low power, easily deployable components that can work globally in retrofitting infrastructure in developed cities through to low cost installation in the developing countries. The West Midlands would encourage greater investment in the infrastructure, public attitude, in-vehicle connectivity and professional services to take advantage of the existing research in this region to ensure that the UK is at the forefront of this sector.

18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?
Automotive production is a truly global industry, Brexit poses a challenge for the existing sector let alone the future research and development. Connected and autonomous vehicles require a collaborative approach to standards to ensure that the full benefits can be achieved. The EU has lead the ETSI standards working with the Car to Car consortium to help design a European approach to connectivity and autonomous functions that unites the member states and also acts as a counter point to the US led standards. The nature of transport is cross-border, it is expected that vehicles will move from country to country and there will be an expectation that the connected and autonomous or driver assist functionality will also work. This presents challenges to infrastructure, cyber security and personal data. In a post Brexit environment the UK Government is urged to continue to keep and attract further autonomous research and development to support the existing market and to grow it for the future. The incentives to retain the key tier 1 manufacturers are vital, additionally the funding to participate in collaborative efforts to develop a standard approach to connectivity, data exchange, privacy laws and crucially cyber-security is also vital. In the short term the UK commitment has to be demonstrated in order to ensure that the Brexit negotiations are favourable to the industry and that the right skills and funding are retained here. We would recommend the following specific actions:

- Favourable conditions to retain the Tier 1 manufacturers (and therefore the dependant supply chain)
- Commitment to EU standards for connectivity and autonomous features
- Cyber-security leadership that works in partnership with the EU to ensure freedom of vehicle movement across border whilst ensuring a robust defence mechanism should cyber-attacks be conducted via vehicle based technology
- Creation of a world leading test environment to encourage the international motor manufacturers to the UK to test all aspects of the autonomous vehicle industry, including mass-transit, business model opportunities, car to car communication, car to infrastructure trials, professional services and skills. A truly world class test
environment would keep the UK at the forefront of the sector irrespective of the Brexit implications

26 October 2016