Introduction

1. The Government welcomes the opportunity to contribute to this Inquiry.

2. Connected and autonomous vehicles have the potential to affect many aspects of our lives. The Government is keen to ensure we make the most of the opportunities they offer, and has established the Centre for Connected and Autonomous Vehicles (CCAV) to keep the UK at the forefront of the development and deployment of this technology.

3. The Government’s approach to the regulation, research, development, and demonstration of connected and autonomous vehicles is differentiated by operating in a more collaborative and transparent fashion than almost any other country. We are taking forward measures, including through the forthcoming Modern Transport Bill to enable their safe development and introduction.

Impacts and benefits

1. What are the potential applications for autonomous vehicles?

4. The Government’s focus to date has been on road vehicles, where automating the driving task could improve safety and open up new mobility options. In this sector “connected and autonomous vehicles” is an umbrella term for a number of distinct technologies; all enabled by developments in underpinning capability in computing power, sensing technology and data analytics.

5. Key aims of this technology are to automate the driving task (either to support or allow the driver to disengage from the driving task entirely) and to connect vehicles to other vehicles or to infrastructure (either to provide services to the driver, or to allow vehicles and roads to operate as a network to improve safety and efficiency). Many commentators believe these technologies will converge over time, though predictions for when and how this will happen differ.

6. Those developing automation technology are following two parallel tracks of development. Some are seeking to add automation to existing vehicles incrementally over time, building on existing Advanced Driver Assistance Systems (ADAS) such as Automated Emergency Braking (AEB). Others are seeking to leapfrog this approach and focus on fully automated vehicles that do not need a driver, with activity focused on urban or motorway driving.

7. Similarly, in connectivity, there are different tracks of development. Some manufacturers are focused on introducing new features for drivers such as navigation information and infotainment (in-vehicle information and entertainment not related to
the driving task), using existing networks. These features are already available in vehicles for sale, with some estimates suggesting there are one million vehicles with this type of connectivity on UK roads. Other manufacturers are keen to introduce new technology to allow vehicles to speak to each other and to infrastructure. Much of the potential safety benefit from connectivity could come from networking in this way, either over the cellular network or via other technologies.

8. In addition to road vehicles, there are also a significant range of wider potential applications of automated vehicle technology, such as in ports and warehouses, hazardous environments (removing people from operating in dangerous conditions such as nuclear decommissioning, natural disasters), as well as a range of security and military use cases. More information can be found in the UK’s 2020 Robotics and Autonomous Systems (RAS) Strategy published in 2014 on behalf of the industry-led, RAS Special Interest Group⁴.

9. Connected and automated vehicles are also expected to form part of the smart city ecosystem; both in transforming urban mobility and generating new sources of data that can help city authorities plan and manage infrastructure and service delivery in a more effective and integrated way.

10. Exactly what development path these technologies will take is still unclear. By adopting an outcomes-focused approach to the R&D and policy development, the Government intends to keep the UK at the forefront of the latest developments and well-positioned to secure sustainable, long-term economic value from their deployment.

2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

11. Connected and autonomous vehicle technologies provide the opportunity for the UK to unlock and secure significant social and economic benefits and to demonstrate how it will use innovation to thrive in the world. Some early areas of focus are listed below. The Government plans further research to understand the benefits and disadvantages.

12. Safety – In the UK we have some of the safest roads in the world. Nevertheless over 1700 people are killed on UK roads every year, with many more being seriously injured. Human error is a factor in up to 94% per cent of all recorded road injury collisions in Great Britain (Department for Transport, 2015); automating the driving task has the potential to deliver significant improvements.

13. Mobility – Automating the driving task could improve mobility options for those currently unable to drive, whether due to financial, physical, sensory, or cognitive reasons. Extending inclusion will have social and economic benefits.

14. Network efficiency – Connecting vehicles to each other and to infrastructure could enable more efficient use of our roads by creating networks of vehicles that can interact with traffic signals and network operators. INRIX research has found that in 2014, 

English drivers spent on average 30 hours a year stuck in congestion, rising to 96 hours a year in the London commuting belt, in addition to regular commuting times\(^2\).

15. **Productivity** – In England, drivers currently spend on average over three working weeks each year driving. If drivers are safely freed from the driving task it may be possible in future for journeys to become more productive.

16. **Jobs and growth** – Industry estimates that these technologies could provide up to £51 billion benefit annually to the UK economy, creating over 300,000 jobs by 2030\(^3\).

17. Consolidating our early leadership in connected and autonomous vehicle technologies could spearhead our innovation-led industrial strategy, supporting regional growth and new job creation by combining our world class research base and global, cross-sectoral centres of excellence with our resurgent automotive industry and one of Europe’s most productive workforces.

18. The Government believes these potential benefits are a strong justification for pursuing a leading role for the UK in the development of these technologies. At the same time there will be important risks to manage:

   a. Connecting vehicles to networks and to each other will mean they will require a high degree of network security. It will therefore be important for the technologies to be safe and secure by design, and handle data appropriately.

   b. Connected and autonomous vehicles could have an impact on the way our wider transport system operates, and on those who are employed within it. While some international studies suggest that certain jobs may be reduced by robotics and automation others maintain that many more jobs will also be created. For instance, it is estimated that, in the UK, connected and autonomous vehicles will create up to 320,000 jobs in the wider supply chain by 2030\(^4\). We need to understand these risks and act to shape the way the technology emerges to ensure that it delivers benefits for the widest group of people.

   c. To make progress, part of the development of the technology will need to take place in the real world. It is essential for the technology to be developed in a transparent and safe way, to allow members of the public to engage and shape the way it emerges, and to feel comfortable with it.

3. **How much is known about the potential impact of deploying autonomous vehicles in different sectors?**


19. Connected and autonomous vehicles have the potential to radically transform current mobility paradigms. In the long term this could mean transformative impacts on the nature, patterns and volume of travel, with wider impacts on spatial planning and other areas of policy. However, there is significant uncertainty over how the market will develop and what these impacts will be.

20. Overall, the need remains to continue to address the historic backlog of investment to keep the country moving and get our networks ready for the future. The background increases in transport demand will continue to be driven by population increases, urbanisation, and ageing.

21. Government is continuing to develop the evidence base around the complex and wide ranging potential impacts of CAV technology, to inform long-term infrastructure and policy decisions to ensure we are planning ahead and preparing for a range of alternative futures, and to ensure we can maximise the social and economic benefits of these technologies along the way.

22. Cars, rail, and public transport all serve different needs. For example, our cities have limited road space and public transport is essential to keep people and businesses moving. The speed and convenience of city-to-city rail travel is unlikely to change. If we see transport as a tool of economic policy, as well as personal mobility, then the power of rail to support sectors such as business services and finance is clear. More generally, new, high-quality transport assets have the power to reshape our economic geography.

23. We plan further research to help us understand the impact of connected and autonomous vehicle technology - including projects funded through the £100 million Intelligent Mobility R&D Fund, academic research, as well as modelling and scenario development.

4. How much is known about public attitudes to autonomous vehicles?

24. Engaging the public in the development and demonstration of connected and autonomous vehicle technologies and maintaining their trust in its safety and security is vital. It is important for those developing the technology to engage with the public about the benefits and costs of these technologies openly and honestly.

25. The Four Cities Driverless Car Trials will involve testing of automated vehicles in real-world environments in Bristol, Greenwich, and Coventry and Milton Keynes. This will enable the public to see the vehicles up close, and build understanding of how the vehicles will fit into everyday life. Each of the trials has a discrete public engagement workstream to gather data on public attitudes to connected and autonomous vehicles, through surveys, workshops, and interaction with the vehicles. This will help to inform the focus of future research competitions and future policy development.

26. To increase our understanding of these issues, the Department for Transport will be launching a three year social and behavioural research programme to build our understanding of the attitudes, behaviours and wider acceptability of connected and autonomous vehicles for drivers, road users, transport stakeholders and wider society.
This will build on other work, such as an HGV platooning trial, currently being commissioned by the Department for Transport and Highways England. Part of this work will consider the behaviour and attitudes of platoon drivers and other road users.

27. In addition, in the Traveller Needs and Capability Study (jointly funded by BEIS, DfT and Innovate UK), the Transport Systems Catapult surveyed over 10,000 people and from this have identified the key drivers for travellers, and how the development of connected and autonomous vehicle technologies can assist in meeting their future needs across an increasingly connected and autonomous transport system. It also addresses how the key “pain points” experienced during an everyday journey can be ameliorated or solved.

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

28. Connected and autonomous vehicle technologies are still at a relatively early stage of development. There is great uncertainty around deployment and market penetration rates. However, many leading figures in the automotive industry believe the impact is likely to be as great as anything that the sector has ever experienced. General Motors’ CEO, Mary Barra, has suggested that the sector will, over the next ten years, experience greater disruption than over the past fifty years. Significant investment in these technologies is taking place among vehicle manufacturers, automotive industry suppliers, and new entrants to the market.

29. Early estimates from industry suggest that if the UK can consolidate its early leadership position, success could be worth up to £51bn annually in socio-economic benefits to the UK by 2030. The Transport Systems Catapult believes the (more broadly defined) global “intelligent mobility” could be worth up to £900bn by 2025.

30. The Government plans to take forward further research on the connected and autonomous vehicle supply and value chains with the Transport Systems Catapult and Innovate UK to determine where the UK should best focus its resources to achieve sustainable, long-term economic growth and high quality job creation. The Traveller Needs and Capability Study (referenced above) produced the initial assessment of where the UK strengths lie (below).

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Creating an enabling environment

Research and development

6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

31. The UK has a world class research base and global centres of excellence in automotive, software development, as well as world centres of law, insurance, finance, computer games, and telecoms. Two of the world’s best vehicle test tracks – Horiba MIRA and Millbrook – are located in the UK.

32. In addition, we have one of the most open regulatory frameworks for testing of connected and autonomous vehicles in the world, set out in July 2015 in the guidance document “A Pathway to Driverless Cars: A Code of Practice for Testing”. A key feature of this framework is that trials are possible on any road in the UK.

33. These strengths enabled the current UK trials of automated vehicle technology, each interdisciplinary project involving many collaborators such as global corporates, telecoms, insurers, local authorities, universities, and SMEs. They have also prompted the establishment of new testing environments in Coventry, Milton Keynes, Greenwich, Culham Science Park, Cranfield University and elsewhere.

34. While these facilities are world class, competition for global leadership in this field is fierce, and the Government believes that we will need to do more in future to continue to be able to compete.

35. Over the summer the Government issued a call for evidence to industry to identify how to improve the UK’s test environment for connected and autonomous vehicles. In particular, it asked whether there is a case for a new flagship test bed to provide a focus...
for this activity. Responses to this consultation are now being considered and a response will be issued in due course.

36. In addition, the Government is investing significant funds into R&D which we believe will create a pipeline of high quality UK R&D projects to lock in and maximise the value to the economy. This is discussed in more detail below.

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?

37. Government has acted quickly to secure an early leadership position in the research, development, and demonstration of connected and autonomous vehicle technologies. We have done this by establishing a world-leading regulatory environment and by investing significant funds in R&D.

38. Building on the £19 million four cities driverless car trial announced in 2014, the then Chancellor announced a further £100 million at Budget 2015 for an Intelligent Mobility Fund for research in this area, to be match-funded by industry.

39. The winners of the first, £20 million, competition were announced in February 2016, with eight collaborative R&D projects and 13 feasibility studies receiving funding. This has resulted in total project costs of around £30 million with an additional £10 million being injected into the UK’s research base. A second, £35 million, competition is currently open. This competition includes a ground-breaking challenge prize of up to £15 million to demonstrate a highly automated vehicle in a range of environments. There is currently no other challenge quite like this.

40. The Centre for Connected and Autonomous Vehicles is working with Innovate UK, industry and the research community to better align UK research and development efforts and ensure that investment in supporting the development of connected and autonomous vehicles technologies is effective, targeted and derives maximum value. As part of this, we will work with key groups such as the Automotive Council to enable development of suitable roadmaps and ensuring that government funded research activity is effectively disseminated and helps to inform wider research efforts in industry and academia.

8. How effective are Innovate UK and the CCAV in this area?

41. The Government believes it has the right plans in place to succeed in this area.

9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?

42. In such a fast moving field it is important to make it as easy as possible for UK SMEs to get involved in the development of the technology.

43. UK SMEs have seen some success and are involved in many of the R&D projects taking place across the UK. Oxbotica, a spin out from the University of Oxford, has publicly
launched Selenium – an autonomous control system. FiveAI – a Cambridge/Bristol based Artificial Intelligence startup is now working on an autonomous vehicle control system.

44. However, more needs to be done for SMEs to gain access to the facilities and kit they need for testing. Government will continue to discuss and engage with SMEs to understand how best to support their involvement in this sector, removing barriers to entry, enabling testing at various scales and in different environments, and providing routes to market. These were persistent themes in the Call for Evidence on the UK testing environment mentioned above.

Real world operation

10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?

45. As connected and autonomous vehicle technology is still in an early stage of development it is not possible to identify precisely what infrastructure changes will be necessary to enable them. Views in industry differ about what will be needed to operate their systems. Some operators have said, for example, that clearly defined white road markings are integral, other operators have said that wide spread connectivity is more important to allow for the automated vehicles to download road information as they are travelling.

46. To help us determine the appropriate policy response we will continue to engage with industry and with international partners to understand the implications of different scenarios. Projects such as the UK’s A2-M2 Connected Vehicle Corridor will be testing different communication requirements, and the associated infrastructure, for broadcasting traffic information into road vehicles. Alongside this work we will continue to build our evidence base and business case for future deployment.

47. As the technology is still in its infancy it is important we remain flexible and consider how the technology will develop to avoid locking in to systems which become obsolete in the long run.

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?

48. The move to automated vehicle technology will require close working between government, industry and academia to create the right regulatory and insurance frameworks and to provide the public with assurance that the technology is being developed safely and will improve their lives.

49. In 2015 the Government published “The Pathway to Driverless Cars”, a regulatory review of what will be necessary to enable the testing and development of automated vehicle technology. The publication of the “Code of Practice for the Testing of Automated Vehicle Technologies” later that year was a key milestone on the pathway. It provided guidance on organising tests for automated vehicle technologies on public roads and in public places whilst maintaining safety.
50. Consultation with industry since the publication of these documents has identified insurance as a priority area for reform to enable the development of the technology. Our current motor vehicle system requires that the driver is insured, and when drivers disengage from the driving task entirely, and hand control and responsibility to their vehicle it is possible that gaps will start to emerge. These gaps, such as no clear route to compensation in the event of a collision involving an automated vehicle, could hinder innocent victims from getting compensation quickly and easily – a cornerstone of our insurance practices. For that reason, the Government has consulted on the issue over the summer, and will bring forward measures in the Modern Transport Bill to update our motor insurance framework so that it is ready for the introduction of automated vehicle technology.

51. We will continue to engage widely as the technology develops to ensure our framework remains appropriate to safely enable people to enjoy the benefits of the technology. Given the uncertainties in how the technology will develop, it is important for Government to create as open as possible a framework to avoid stifling any particular technological pathway.

12. Does the Government have an effective approach on data and cybersecurity in this sector?

52. We believe that these technologies must be secure by design and handle data appropriately. We are working closely with the security community and the UK’s leading cyber-security sector (which is in the top three worldwide), together with industry, other countries and international standard-setting bodies to promote a vision for a secure connected and autonomous vehicle ecosystem that articulates the social, economic and commercial case for security by design and appropriate data protection.

53. We are developing guidance on cyber security which we intend to publish. We are also pressing for international coordination and investigating other options for government intervention including standards, regulation and consumer information.

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?

54. As referenced above “The Pathway to Driverless Cars” regulatory review set out key changes that will be needed to enable the development of automated vehicle technology. The Government has taken forward many of the actions identified in that review, including issuing guidance for automated vehicle testing, and plans to continue to work with the automotive and the insurance industry to address others.

55. This is a sector which is developing at pace but we are still at an early stage in the development of the technology, and there are still some tough technical challenges to overcome. As the focus of industry is likely to adapt to developments in their research

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programmes, it will be important for Government to remain flexible and we will need to adjust our approach to focus on the current state of play at any given time.

56. In addition, some aspects of road vehicle regulation are handled internationally to facilitate the export for sale and cross border use of vehicles. We expect, for example, that the sale of automated vehicles will be underpinned by technical standards set in Geneva by the UN Economic Commission for Europe. The UK wields significant influence in this forum, and chairs the global experts committee designing the standards for automated functions in road vehicles.

57. Given this, we have necessarily had to choose where to focus our efforts and design a rolling programme, with waves of reform. In doing so we have been guided by the following principles:

a. **Ensure safety is at the heart of the approach.** When the technology is perfected it will save many lives, but people in the UK will also expect the development process to be safe and secure too.

b. **Keep the UK in the lead.** If another country has found a freedom that does not exist here then we look for ways to address that.

c. **Focus on the problems that are most pressing.** We have been led by intelligence from the UNECE process on which technologies are closest to market and our assessment of which elements of the regulatory framework need to change to ensure we provide the right testing landscape for industry to make progress.

58. As referenced above, over the summer the Government consulted on the first wave of reform, some of which will be taken forward as part of the Modern Transport Bill.

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?**

59. Connected and autonomous vehicle technologies offer significant social and economic benefits but there are a number of potential ethical, legal, and wider social issues linked with some uses. Government has a role to play in managing and mitigating any risks that might arise.

60. It is important to strike a balance within the regulatory framework to ensure that laws are in place to prevent harm to humans, while at the same time ensuring that innovation is not stifled and any barriers to the development of these technologies are removed where possible. For example, Government has undertaken a regulatory review (explained elsewhere in this submission) for connected and autonomous vehicle applications in order to inform future regulation and research.

**Wider governance**

15. **What does the proposed Modern Transport Bill need to deliver?**
61. The Government plans to take forward measures to update our legal framework for motor insurance to prepare for automated vehicle technology (as set out above). The Government consulted over the summer on these measures and will respond to the consultation in due course. The insurance industry will need time to prepare for the changes that the introduction of automated vehicles will bring, and by making changes to the way that motor vehicle insurance legislation now, we will provide the insurance industry with that time.

62. It is important to remember that much of the technology which will require regulatory change to use safely is still being developed. And, until the technology is more mature, it is not sensible to change regulations now. So, we will use our rolling programme of regulatory reviews and, where necessary, reform, to make the required changes to primary and secondary legislation, and guidance, when we have a better understanding of how the technology works. That way, we can make sure that our regulations, and guidance, will help people and businesses to safely use, and thus, benefit from connected and autonomous vehicles.

16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?

63. The UK is operating from a position of some strength but the rapid growth of the sector presents a challenge now and in the future with increasing competition for vital – but readily transferable – talent from across sectors i.e. the financial technology sector and from other parts of the world, i.e. Silicon Valley.

64. In October 2016, the Transport Systems Catapult published a “Intelligent mobility skills strategy: Growing new markets in smarter transport”. That report concluded that, in the wider Intelligent Mobility sector which encompasses connected and autonomous vehicle technologies, the UK faces a potential skills gap of 742,000 people by 2025. Using a wider skills approach they identified that around 1.159 million individuals will be needed against an estimated supply of 417,000.

65. The Science and Technology Committee Report on Robotics and Artificial Intelligence published in October 2016 echoed the findings of the Transport Systems Catapult but suggested that there has been a shift in graduate career choices.

66. The Government will be considering this alongside other work to identify the skills we need to succeed in future.

67. Alongside this, the DfT has launched its Transport Infrastructure Skills Strategy, which makes a commitment to 30 000 apprenticeships by the end of the parliament – this is across roads and rail sectors and down supply chain. CEOs (or equivalent) of Network Rail, Highways England, Crossrail, HS2 Ltd. TfL, all signed up to this commitment. The Strategic Transport Apprenticeship Taskforce (STAT), is the primary delivery vehicle for the strategy and was launched in April this year. The STAT will report on progress annually. The first report is due in the spring of 2017.
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?

68. Connected and autonomous vehicles are seen as the first robots that the general public will encounter day-to-day but, as referenced above, there are a significant range of other applications.

69. British-Australian mining company, Rio Tinto, is currently running 69 driverless trucks in its Australian iron ore mines in Pilbara and operated from Perth, 1,200 kilometres away. The trucks run 24 hours a day and remove the human driver from a dangerous occupation. The trucks move about 20 million tonnes of material a month and have travelled more than 3.9 million kilometres since they were deployed in 2012.

70. As part of the UK Atomic Energy Authority, the RACE (Remote Applications in Challenging Environments) facility in Culham, Oxfordshire, is conducting R&D and commercial activities in the field of Robotics and Autonomous Systems (RAS), again exploring how to remove people from dangerous environments, such as nuclear decommissioning. (Automated vehicle testing is also taking place in Culham as Oxbotica has recently made the facility its testing site.)

71. In Agriculture

   a. Ordnance Survey recently announced a partnership with American agricultural machinery manufacturer, CNH Industrial, to test driverless tractors near OS’s headquarters in Southampton.

   b. The 2013 Agritech strategy set out the establishment of four Centres for Agricultural Innovation with £68m funding from the Department for Business, Energy and Industrial Strategy (BEIS), (matched by industry). The first of these centres, Agrimetrics, a world class big data centre was launched by ministers in October 2015; the other three will be launched this autumn. One, the Agricultural Engineering Precision Innovation Centre (Agri-EPI; £18 million over four years) will help the UKs agri-food sector develop advanced technologies that will increase productivity and sustainability in UK agriculture. It will explore, among other things, research projects examining robotics for planting, monitoring and harvesting crops.

72. The UK is recognised as a world leader in robotics, autonomous systems and artificial intelligence. BEIS will work with industry and academia to explore the full range of opportunities presented by Robotics and Autonomous systems and considering its potential within the wider industrial strategy

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?
73. We understand the concerns of industry and it will be a priority of our negotiations to support UK car manufacturers and ensure that their ability to export to and from the EU is not adversely affected by the UK’s future relationship with the EU. However our automotive sector is strong. Car production hit a 10-year high in 2015, increasing nearly 4% from the year before. 163,000 people are directly employed by the sector and another 330,000 in the supply chain.

74. The UK is a world-leading location and welcoming partner for the research and development of new automotive technologies required in all global markets in the coming decades, from zero emissions to connected and autonomous technologies. We are also a leading market for the testing and deployment of those technologies.

75. Securing our world-leading position in the research and development of these technologies, along with our rolling programme of reform to keep our regulations up to date, will help the UK continue to support regional growth, high value job creation, and our resurgent automotive sector.

76. There is a real opportunity for this to become a success story, demonstrating how the UK can and will retain global influence and thrive post-Brexit. For research, development, and demonstration of these technologies, the funding and most of the regulations are within our control.

77. The UK programme is differentiated by operating in a more collaborative and transparent fashion than almost any other country. This approach is already having an impact. Recently both Volvo and Jaguar Land Rover have separately announced high profile research programmes of around 100 highly automated vehicles in the UK. The former demonstrates that the UK is attractive for globally mobile investment; the latter that we are growing world-leading capability in the sector.

28 October 2016