



Department
for Transport

The Pathway to Driverless Cars

Summary report and action plan



February 2015



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Foreword



Driverless vehicle technology has the potential to be a real game changer on the UK's roads, altering the face of motoring in the most fundamental of ways and delivering major benefits for road safety, social inclusion, emissions and congestion.

The UK is already a world leading centre for vehicle research and technology. We have some of the best innovators, engineers, facilities and opportunities for automotive investment in the world.

This review concludes that our legal and regulatory framework is not a barrier to the testing of automated vehicles on public roads. This creates a tremendous opportunity for the whole country to share in shaping the future of these exciting developments and the Government, working with the devolved administrations, wants to play its part in making that happen. I believe we have one of the most welcoming regulatory environments for development of this technology anywhere in the world.

This document lays out the Government's plans to facilitate the testing and production of vehicles in which the driver can choose to use their travel time in ways that have never previously been possible. When you consider that the average driver spends the equivalent of six working weeks driving a year, this represents a real opportunity. In addition, automated vehicles that never get tired or distracted could hold the key to substantially improving road safety.

We are setting out the best possible framework to support the testing of automated vehicles, to encourage the largest global businesses to come to the UK to develop and test their technologies.

I would like to thank those individuals and organisations that contributed so positively to the development of this review. Their knowledge and experience has brought huge benefit and will help to take the technology from the test track to the urban laboratory. Supported by the right investment we can create the right industrial and regulatory conditions in the UK for building the automotive technologies of the future.

A handwritten signature in black ink, appearing to read 'C Perry', with a long horizontal stroke extending to the right.

Claire Perry, MP
Parliamentary Under Secretary
Department for Transport

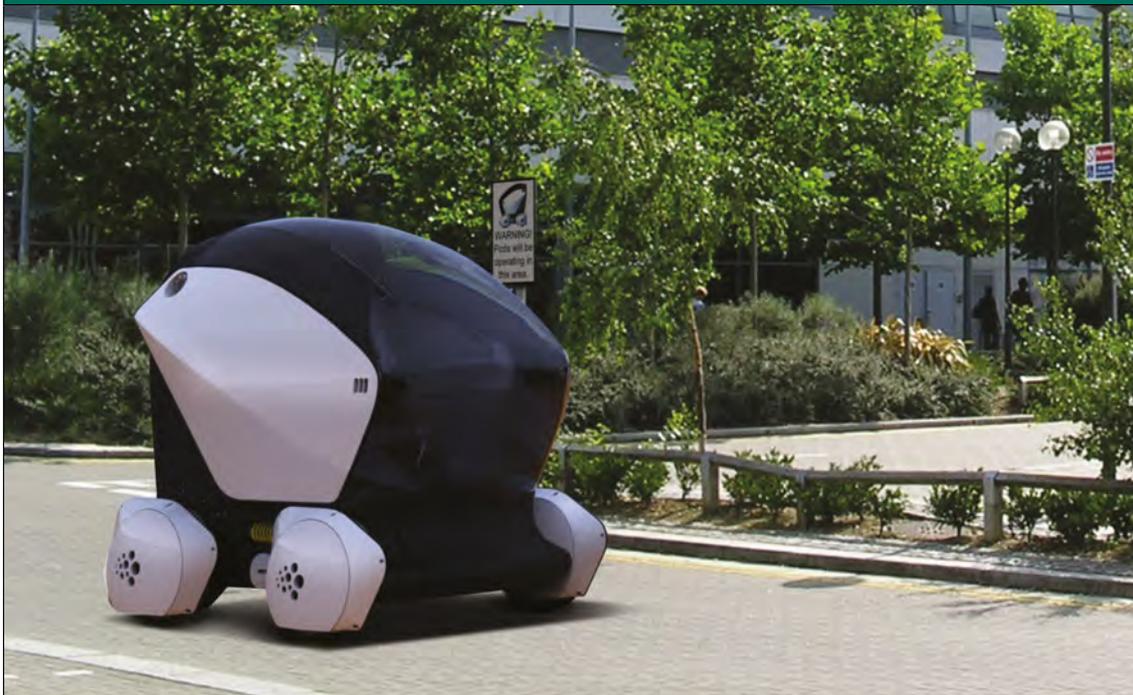
Executive summary

Background

Driverless cars and other automated vehicles offer major potential benefits and could profoundly change our lives for the better.

- 1.** They will make driving easier, allow people to be more productive and offer greater mobility to a wider range of people than ever before. They will also help improve road safety, reduce emissions, and ease congestion. As a result they could provide significant economic, environmental and social benefits, including improving social inclusion. This review marks the UK Government's initial stage in analysing, understanding and developing a strategy to ensure we capture these potential benefits while maintaining our excellent road safety record.
- 2.** The simultaneous development of a combination of technologies has brought about this opportunity. For example, some current production vehicles now feature adaptive cruise control and lane keeping technologies which allow the automated control of acceleration, braking and steering for periods of time on motorways, major A-roads and in congested traffic. Advanced emergency braking systems automatically apply the brakes to help drivers avoid a collision. Self-parking systems allow a vehicle to parallel or reverse park completely hands free. Developments in vehicle automation technology in the short and medium term will move us closer to the ultimate scenario of a vehicle which is completely "driverless".
- 3.** The next step is the introduction of vehicles in which the driver can choose whether they want to drive or not. If they select an autonomous mode, they can allow the vehicle to take care of driving while they make use of the journey time in other ways.
- 4.** While the term "driverless" is often used to describe these technologies, the reality is that entirely removing the need for a driver (and therefore automating steering and other controls) is a longer term goal for most vehicle types. Certainly for the testing phase there will always need to be a suitably qualified 'test driver' who will be supervising the vehicle and be ready and able to take over active control if necessary.

Figure 1 – An early design concept of the self-driving pods that are due to be tested in Milton Keynes in 2015



Approach

The focus of this review is to ensure the UK is at the forefront of the testing and development of the technologies that will ultimately realise the goal of driverless vehicles.

5. We have learnt from existing international experience and the views of stakeholders. This has been combined with our own internal expertise to inform the actions detailed in this report which will ensure the UK retains its significant competitive edge in this area.
6. Our review has examined the approaches being taken in North America, Europe, Japan and China. The views of stakeholders were also gathered and analysed in a 'call for evidence'. 38 responses were received from a wide range of stakeholders, including the key representative bodies for the automotive and insurance industries, the legal profession, technical institutions, and groups representing a wide range of road users, from children and disabled people to drivers, motorcyclists and cyclists.
7. The responses from stakeholders to the 'call for evidence' have been considered throughout the review. Individual analysis of the key themes discussed and how the stakeholders responded to each question can be found within the full supporting document: *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies.*

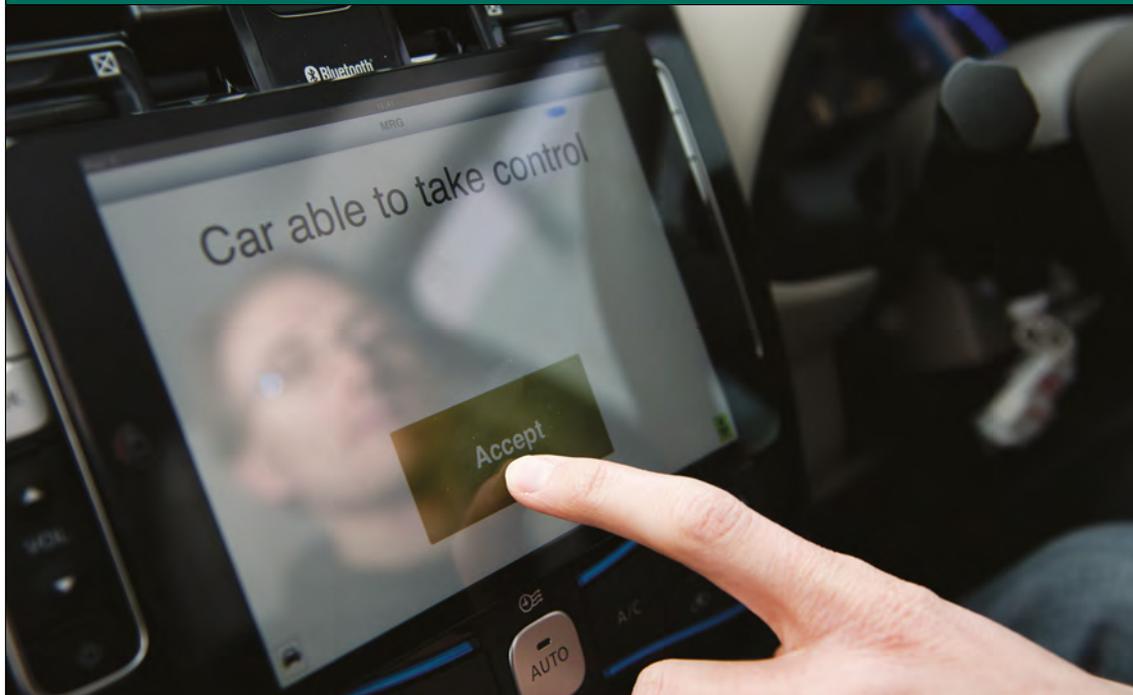
8. Our approach also included a review of existing UK regulations and legislation to examine their compatibility with automated vehicle technologies.

Findings

Driverless vehicles can legally be tested on public roads in the UK today. The UK is uniquely positioned to become a premium global location for the development of these technologies.

9. Our review of existing legislation found that our legal and regulatory framework is not a barrier to the testing of automated vehicles on public roads. Real-world testing of automated technologies is possible in the UK today, providing a test driver is present and takes responsibility for the safe operation of the vehicle; and that the vehicle can be used compatibly with road traffic law.
10. North America has been the first country to introduce legislation to permit testing of automated vehicles, but only four states have done this. Fifteen states have rejected bills related to automated driving and the National Highway Traffic Safety Administration (NHTSA) has issued a preliminary statement of policy which advises states against authorising members of the public to use self-driving vehicle technology at this time.
11. In Europe, only Germany and Sweden are known to have completed a review of their legislation in this area, with a further three countries currently progressing one.
12. Those wishing to conduct tests in the UK are not limited to the test track or certain geographical areas, do not need to obtain certificates or permits, and are not required to provide a surety bond (provided they have insurance arranged).

Figure 2 – The human control interface from the Oxford Mobile Robotics Group’s automated Nissan Leaf vehicle



13. We believe the UK is therefore uniquely positioned to become a premium location globally for the development of these technologies.

Next steps and action plan

The Government will publish a Code of Practice in spring 2015 for those wishing to test driverless vehicles on UK roads.

14. The primary action from this review is for the Government, working with the devolved administrations, to publish a Code of Practice, to promote safety and set clear guidance to be followed in responsible testing. The Code of Practice will be developed in collaboration with key stakeholders before being published in spring 2015.
15. A Code of Practice will be quicker to establish, more flexible and less onerous for those wishing to engage in testing than the regulatory approach being followed in other countries, notably in the US. This will help to maintain the UK’s position at the forefront of developments in this important technology, while maintaining safety.
16. Failure to follow guidance in a Code of Practice would be a clear indicator of negligence. A Code of Practice that reflects good and responsible practice with regard to the safety of other road users would carry considerable weight on any issue of liability. By involving industry stakeholders in developing the code we expect them to act in accordance with it. Those involved in the three trials jointly funded by Government will be required to comply with the Code.

17. The Code of Practice will be subject to periodic review to ensure that it keeps pace with best practice and takes into account experience from testing.

The Government, working with the devolved administrations, will review and amend domestic regulations by summer 2017 to accommodate driverless vehicle technology.

18. Looking ahead to the everyday use of vehicles designed to allow the driver to disengage from the task of driving, it is clear that the legal and regulatory framework needs to be reviewed and amended in a number of areas:
- **Clarification of liabilities** – There needs to be greater certainty around criminal and civil liability in the event of an automated vehicle being in a collision. Under the current legal framework these issues would be dealt with on a case by case basis by the Courts. We will aim to provide additional clarity and certainty in legislation, to provide a sound basis upon which to allocate criminal and civil liability.
 - **Amending regulations on vehicle use** – Existing regulations governing how vehicles are used and maintained will need to be revised to allow the use of automation technology without a test driver and to ensure that the technology is maintained correctly. This may involve changes, for example, to the MOT test to check roadworthiness. It may also be appropriate to revise *The Highway Code* to include a section on automated vehicle technologies.
 - **Promoting safety** – Safety is of paramount importance. The Government will consider whether a higher standard of “driving” should be demanded of vehicles operating in an automated mode than would be expected of a conventional driver. Government will also consider how the existing regulatory framework may be developed to ensure automated vehicle technologies are protected from possible cyber threats.

19. We expect that this review will stimulate a range of further independent testing of automation on UK roads. We will also be taking the opportunity to learn from real-world experience on these issues from the joint government and industry-funded trials taking place in four UK cities, which were announced in the Autumn Statement 2014.

The Government will liaise at an international level with an aim to amend international regulations by the end of 2018.

20. There will also need to be changes made to the European standards (known as type approval) with which mass production vehicles are required to comply prior to sale, as well as to ISO standards such as that on symbols and driver warnings. Developing these standards is likely to take several years.

21. It therefore makes sense to encourage testing on a national level to gain first-hand experience of these technologies, which can inform our negotiations on international standards.
22. The Government will continue its existing engagement with our international partners in the area of vehicle standards with a particular focus on ensuring that the necessary amendments can be put in place before vehicle manufacturers are ready to bring these technologies to market.

Summary

23. In summary the UK is uniquely positioned to help develop automated vehicle technologies and bring these to market:
 - The Government is developing a light touch/non-regulatory approach to the testing and development of these technologies – as set out in this review.
 - The Government can facilitate long distance and large area public road testing now – our Code of Practice approach can be applied across the UK, unlike many other countries which offer only selected roads or small, restricted geographical areas.
 - The UK has some of the most challenging and diverse traffic, road and weather conditions in Europe and London is Europe's only 'Megacity'. This makes the UK the ideal centre for testing and developing these technologies.

In this review the Government has set out clear next steps showing how we will continue to ensure the regulatory and legislative framework is there to support the further development and mass production of automated vehicle technologies.

1. Introduction

- 1.1** The advent of driverless and automated vehicle technologies offers enormous opportunities. It will make driving easier, improve road safety, reduce emissions, and ease congestion. It will also enable drivers to choose to do other things than driving during the journey. Ultimately access to fully automated vehicles will also improve mobility for those unable or unwilling to take the wheel, enhancing their quality of life. As a result driverless vehicles could provide significant economic, environmental and social benefits.

Creating more free time

- 1.2** The average driver in England spends 235 hours driving every year. That is the equivalent of six working weeks. Despite the increasing sophistication of modern vehicles, and greater application of driver assistance technologies, the driver must still concentrate on driving 100% of the time. Highly and fully automated vehicles will change this. For the first time since the invention of motor vehicles, the 'driver' will be able to choose whether they want to be in control, or to hand the task of driving over to the vehicle itself. This represents a major opportunity – allowing drivers to safely use the journey time however they wish, from reading a book, to surfing the web, watching a film or just chatting face to face with other passengers.

The average driver in England can save up to **6 working weeks** a year driving time



Improving safety

1.3 Fewer deaths and injuries



Human error is a factor in over 90% of collisions. Failing to look properly, misjudging other road users' movements, being distracted, careless or in too much of a hurry are the most common causes of collisions on our roads. Automated vehicles will not make these mistakes. They use a range of sensors which will constantly monitor their surroundings. We have come to rely on many technologies that assist the driver of a vehicle, for example

Anti-lock Braking Systems (ABS), cruise control or parking sensors. As these technologies evolve, they are reaching the point where a vehicle is capable of operating for periods of time with reduced, or in some instances without, driver input. Evidence from automated technologies available today already demonstrates significant safety benefits.¹ For example automatic emergency braking, lane departure warning and electronic stability control have all been assessed to have improved safety based on existing evidence.

- 1.4** The insurance industry recognises the potential benefits of increased use of automated vehicle technologies. They are already working to encourage the fitment of automatic emergency braking systems to all new vehicles, and a reduction in insurance claims could lead to lower premiums.
- 1.5** Highly and fully automated vehicles are a natural progression from today's automated safety technologies. They will be required to obey all road traffic laws and *The Highway Code* and are expected to substantially reduce collisions, deaths and injuries.

Reducing emissions and easing congestion

- 1.6** By communicating with their environment and other vehicles, automated and driverless vehicles offer the promise of better use of road space, reducing congestion and providing more consistent journey times, through the use of "connected vehicle" technologies. "Connected vehicles" would communicate with each other and their surroundings to identify the optimum route, helping to spread demand for scarce road space. Vehicles could also communicate with roadside infrastructure such as traffic lights and use this information to minimise fuel consumption and emissions.

¹ AAA Foundation, "Evaluating Technologies Relevant to the Enhancement of Driver Safety", 2014

Increasing access to vehicles for everyone

1.7 Most people take driving for granted and could not imagine life without their car. However there are still many people who do not have a driving licence, or access to a vehicle. Disabled people may be unable to drive. Elderly people may be judged unfit to drive. Others may simply not want to drive or be concerned about their ability to do so.

1.8 When automated vehicle technologies develop to the extent that vehicles which can undertake door to door journeys without the need of a driver at all, they could improve mobility for all these people, enhancing their quality of life.



Opens up access to cars for **everyone** increasing social inclusion



31% **women** do not hold a full driving licence



14% **men** do not hold a full driving licence



46% **17-30 year olds** do not hold a full driving licence

Government policy on automated vehicles

1.9 The Government recognises the significant benefits that driverless and automated vehicles will bring. As a result it is working to support their development and introduction.

1.10 As part of the 2013 National Infrastructure Plan, the Government pledged a review of the legislative and regulatory framework to enable the trialling of driverless cars on UK roads. These plans were also announced in the 2013 Autumn Statement.

Background to the driverless cars competition in the UK

On 30 July 2014, the Government launched a “driverless cars” competition inviting UK cities to join together with businesses and research organisations to host vehicle trials locally.

The results were announced in December 2014 with Greenwich, Milton Keynes, Coventry and Bristol being selected, and £19 million being provided by the Government to allow testing of automated vehicle technology.

This review provides the legal clarity to support the trialling of automated vehicles on UK roads.

- 1.11** Automated technology represents a significant area of interest and investment in the global automotive industry. Manufacturers recognise the potential benefits the technology offers, and are carrying out extensive testing on private test tracks. The next step is to carry out carefully controlled testing on public roads.
- 1.12** This summary document highlights the key findings presented in the Department for Transport's (DfT) detailed review, entitled *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies*. This reviews the legislation and regulations to ensure that there is a clear and appropriate regime to enable highly and fully automated vehicles to be tested on UK roads.
- 1.13** In our review, most of the legislative provision relevant to testing is reserved and applies throughout the UK, and where not reserved the provisions in different parts of the UK are closely aligned if not necessarily identical. Substantial parts of Road Traffic law also give effect to European law obligations which apply throughout the EU.
- 1.14** The government will work with the devolved administrations to revise and amend legislation to support the introduction of automated vehicle technologies. Where legislative change is proposed for the future it is necessary to recognise that this may mean changes in different parts of the UK.

Figure 1.1 – Driverless Nissan Leaf developed with University of Oxford



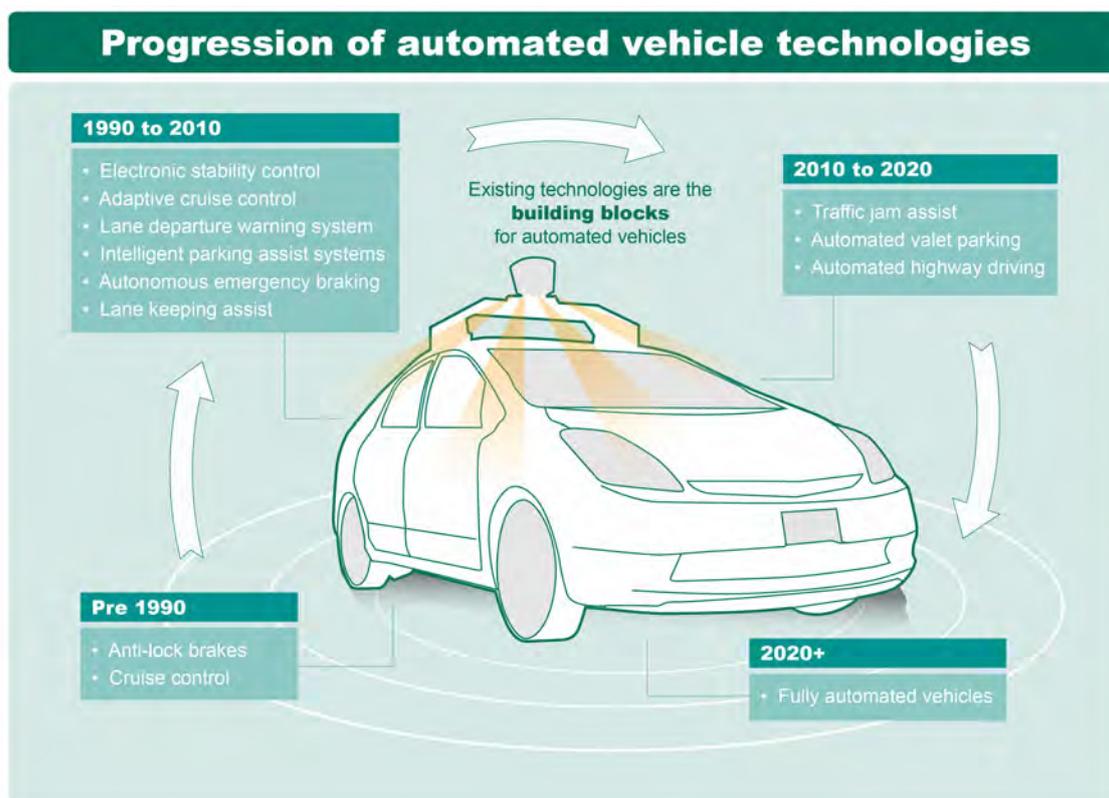
2. Definitions

Introduction

- 2.1** It is important to be clear about terminology as the phrase “driverless car” can be interpreted in different ways. Truly driverless, or “fully autonomous”, vehicles would mean that a driver does not need to be present. However most commentators do not expect vehicles capable of fully autonomous operation on public roads in all circumstances to become available until at least the 2020s.
- 2.2** Before the technology reaches this stage, vehicles will become available which can undertake increasingly large proportions of journeys autonomously while still requiring that a driver takes manual control some of the time.
- 2.3** The simultaneous development of a combination of technologies has brought about this opportunity. For example, some current production vehicles now feature adaptive cruise control and lane keeping technologies which allow the automated control of acceleration, braking and steering for periods of time on motorways, major A-roads and in congested traffic. Self-parking systems allow a vehicle to parallel or reverse park completely hands free. Developments in vehicle automation technology in the short and medium term will move us closer to the ultimate scenario of a vehicle which is completely “driverless”.

Driver assistance versus higher levels of automation

- 2.4** The defining difference between existing “driver assistance” systems and the higher levels of automation discussed in this report is that when using any existing driver assistance systems on the market today, the driver should be “engaged” or “in the loop” at all times. This means the driver should constantly monitor road, traffic and weather conditions, remain ready to resume manual control and be responsible for the overall safe operation of the vehicle.
- 2.5** In the higher levels of automation discussed in this report, the systems are designed to allow the driver to completely ‘disengage’ from the driving task and undertake other tasks. This is sometimes known as the driver coming “out of the loop”.



Levels of automation

2.6 For the purposes of this review we use the term 'automation' as a general term to describe the technologies used in driverless vehicles:

2.7 This report uses two definitions to describe different levels of automated or driverless vehicles:

- High Automation
- Full Automation

High automation

2.8 This means a vehicle in which a driver is required to be present and may need to take manual control for some parts of the journey. Under certain traffic, road or weather conditions, the vehicle's automation systems may request the driver to take control.

2.9 Early highly automated vehicles may only offer an automated mode under certain very specific driving conditions such as highway cruising or in low speed conditions. As the technology develops, the vehicle will be able to undertake driving duties autonomously for a greater and greater proportion of the time.

Full automation

- 2.10** This means a vehicle in which a driver is not necessary. The vehicle is designed to be capable of safely completing journeys without the need for a driver in all normally encountered traffic, road and weather conditions.² This can be seen as the most advanced form of such technology.
- 2.11** Occupants of fully automated vehicles will be able to engage in tasks other than driving for the entire journey. Fully automated vehicles may still offer a full set of controls to allow a driver to resume manual control if they so wish, but this would be entirely optional.

Defining the driver and other vehicle occupants

- 2.12** A further potential source of confusion when discussing automated vehicles is the term 'driver'. Conventionally a vehicle will always have a human driver sitting in a driver's seat and controlling the movement of the vehicle through a combination of controls such as a steering wheel and pedals.
- 2.13** When fully automated vehicles become available for use on the public highway they may not even have a driver's seat. The "driverless shuttle" vehicles already available for sale have no manual controls or driver's seat, although they are not currently approved for use on public roads.³
- 2.14** For the purposes of this review we will use the following definitions:
- **Test driver:** During testing of automated vehicle technologies, our expectation is that a suitably qualified 'test driver' will be supervising testing of the vehicle and be ready and able to take control if necessary. The test driver will be responsible for ensuring the safe operation of the vehicle at all times whether it is in 'manual' or 'automated' mode.
 - **Driver:** Once highly and fully automated vehicles come to market, the term 'driver' will become less clearly defined. Highly automated vehicles will allow a person who is seated at the manual controls of the vehicle to completely disengage from the task of driving for certain periods of the journey. Nevertheless the expectation is that the person seated in this position will continue to be commonly referred to as the 'driver', even if the vehicle is in an automated mode.

2 In highly adverse conditions in which even an expert human driver might consider it unsafe to proceed, a fully autonomous vehicle may also determine it is not appropriate to continue.

3 "Driverless shuttle" is an emerging class of vehicles which do not have a driving seat or manual controls and typically have a maximum speed below 25 km/h

- **Vehicle user:** In the case of fully automated vehicles and driverless shuttles that do not have a driver's seat, it no longer makes sense to refer to any of the vehicle occupants as a 'driver', instead they are simply vehicle users. Indeed the term vehicle user would extend to include a person who chose to use a fully automated vehicle by sending it on a journey remotely.

3. International situation

Introduction

- 3.1 The increased interest in automated vehicle technologies has led some countries around the world to review their regulatory requirements and a few have already taken steps to amend their legislative framework accordingly.
- 3.2 This section summarises the situation, at the time of writing, in those countries where it is known that testing of automated vehicles has progressed. More detailed information can be found in the full supporting document: *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies*.

Vienna Convention

- 3.3 Many countries are signatories to the Vienna Convention on Road Traffic. This requires that 'every moving vehicle or combination of vehicles shall have a driver' and that 'every driver shall at all times, be able to control his vehicle'. Some have taken this to be a barrier to the introduction of automated vehicles. The Convention is in the process of being amended to allow a car to drive itself so long as the system can be overridden or switched off by the driver, though it has been argued a further change is needed to allow automated vehicles on the roads in many countries.
- 3.4 The Vienna Convention is not considered an obstacle in the UK. The UK has signed but not ratified the convention and testing is consistent with proper driver control.

The UK is a premium location to develop automated vehicles

We believe the UK is uniquely positioned to become a premium location globally for the development of these technologies. Those wishing to conduct tests are not limited to the test track or certain geographical areas, and do not need to obtain certificates or permits. Provided they have insurance arranged, they are not required to provide a surety bond.

North America

- 3.5** North America has been the first country to introduce legislation to permit testing of automated vehicles, but only four states have done this. State-by-state laws vary significantly and according to one source no state has fully determined how existing traffic laws should apply to automated vehicles.⁴
- 3.6** Examples of requirements set out by the four states include an insurance or surety bond up to the value of \$5 million and testers being required either to have a specific permit or special vehicle license plates.
- 3.7** Fifteen states are reported to have rejected bills related to automated driving.⁵ The National Highway Traffic Safety Administration (NHTSA) has issued a preliminary statement of policy which advises states against authorising members of the public to use self-driving vehicle technology at this time.

Europe

- 3.8** In Europe legislators are considering how to accommodate the development and testing on their roads of automated technologies.
- 3.9** In Germany, the Federal Highway Research Institute published a report concluding that although existing levels of automation comply with German law, highly and fully automated vehicles do not. Currently each Federal state can grant exemptions from the German Road Traffic Licensing Regulations allowing the testing of automated vehicles, provided there is a driver in the driver's seat who has full legal responsibility for the safe operation of the vehicle.
- 3.10** France published its roadmap for automated vehicles in July 2014. This indicates pilot zones for testing, changes to driver training and research and development projects running to 2018, with authorisation of experimental on-road testing of highly automated vehicles expected to begin in early 2015.
- 3.11** In January 2015 a proposal to extend exemption rules to allow 'large-scale' testing of self-driving cars and trucks was approved. A spokesperson stated that testing would start in summer 2015 once parliament approved the necessary legislative changes.
- 3.12** Sweden has already permitted testing of highly automated vehicles on public roads as part of the Volvo 'Drive Me' project in restricted areas in and around Gothenburg.

4 Bryant Walker Smith of Stanford Law School's Center for Internet and Society (reported here: <http://www.wired.co.uk/news/archive/2014-05/30/eu-embrace-self-driving-cars>)

5 Gabriel Weiner and Bryant Walker Smith, Automated Driving: Legislative and Regulatory Action, cyberlaw.stanford.edu/wiki/index.php/Automated_Driving:_Legislative_and_Regulatory_Action

Asia

- 3.13** Japan has argued that the International and European regulations need to be updated to allow further development of automated vehicle technologies. Japan has issued automated vehicles with a licence plate to allow testing on the public road since September 2013. Both Nissan and Toyota are currently working on autonomous vehicle projects.
- 3.14** In August 2014, the Land Transport Authority (LTA) in Singapore announced it was setting up the Singapore Autonomous Vehicle Initiative (SAVI) with public road testing beginning January 2015.

4. Review of regulation

Introduction

- 4.1 This section sets out existing UK regulation and its compatibility with the testing of driverless cars and other automated vehicles on UK public roads.
- 4.2 We have examined the rules and regulations for vehicles, drivers, and other road users. We have then identified actions that the Government will take to ensure that the UK is at the forefront of the testing and development of these technologies.
- 4.3 A more detailed overview of the regulatory situation, including a summary of the responses in the ‘call for evidence’ consultation can be found in the full supporting document: *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies*.
- 4.4 The detailed review document contains further information regarding changes to regulations which will be needed before driverless vehicles can come to market.

Testing of automated vehicles

- 4.5 The review of existing legislation found that our legal and regulatory framework is not a barrier to the testing of automated vehicles on public roads. Real-world testing of automated vehicles on public roads is possible in the UK today, providing a test driver is present and takes responsibility for the safe operation of the vehicle; and that the vehicle can be used compatibly with road traffic law.
- 4.6 National regulations require that vehicles must be used safely. To address this, greater clarity on what is meant by ‘safe use of vehicles’ in the context of testing of automated vehicles would be beneficial.
- 4.7 **Action: Provide clarity on what should be considered ‘safe vehicle use’ in relation to the testing of automated vehicles.**
- 4.8 Options for providing this clarity and promoting safety during testing were considered (see *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies*, chapter 17). The merits of different approaches were assessed and a non-regulatory code of practice, alongside responsibility to hold the appropriate insurance was identified as the most appropriate solution. This approach will help secure the UK’s position as a leading global location for real-world testing in this area.

Insurance

- 4.9** Human error was a factor in 94 per cent of all recorded road injury collisions in Great Britain. The financial costs to the insurance industry and the wider costs to society of road collisions are substantial. The potential safety benefits of automated vehicles are significant and the insurance industry is keen to recognise and reward technologies that will make vehicles safer. A reduction in insurance claims could lead to lower premiums.
- 4.10** Anyone conducting tests of automated vehicles on public roads must hold appropriate insurance. The manufacturer or company conducting the testing will either be using the vehicle itself, and so need to be insured, or will be liable for its test driver. The test driver must be continuously monitoring the road environment and remain ready and alert to resume active control of the vehicle. They should be in overall charge of the safe operation of the vehicle at all times.
- 4.11** Discussions with the insurance industry to-date indicate that organisations testing automated vehicles should be able to obtain suitable insurance from the existing market. British insurers are world leaders in providing corporate cover for innovative enterprises such as the testing of automated vehicles.

Code of Practice

- 4.12** The Government will publish a Code of Practice to promote safety and set clear standards to be followed in responsible testing. We will work closely with stakeholders to finalise and publish the Code of Practice in spring 2015. It will then be subject to periodic review to ensure that it keeps pace with best practice and takes into account experience from testing.
- 4.13** The Code of Practice will set out the standards to be met by responsible manufacturers, testing organisations and their test drivers, when testing automated vehicles.
- 4.14** Similarly to *The Highway Code*, a failure to follow the guidance in a Code of Practice would be a clear indicator of negligence. A Code of Practice that reflects good and responsible practice with regard to the safety of other road users would carry considerable weight on any issue of liability. By involving industry stakeholders in developing the code we expect them to act in accordance with it. Those involved in the three trials jointly funded by Government will be required to comply with the Code.
- 4.15** A draft Code of Practice will be produced in the next month and will contain the following overarching requirements. These are based on the review of regulation in combination with the results of the call for evidence and best practices identified from our survey of international developments:

- **Test driver required** – A suitably qualified test driver should monitor testing at all times and be ready and able to take manual control if necessary. Test drivers will need to have received training and be experienced with the technology under test.
- **Data recorder must be fitted** – some form of data recorder should be fitted to test vehicles. In the event of an incident or collision this data should be made available to the relevant authorities so they can analyse the circumstances leading to the event, including whether the vehicle was in an automated mode or under manual control.
- **Vehicle technology must be proven** – Organisations wishing to test automated vehicles on public roads will need to ensure that the vehicles have successfully completed in-house testing on closed roads or test tracks.

4.16 The role of the test driver is central to maintaining safety. The test driver must be continuously monitoring the road environment, and remain alert and ready to resume control.

Figure 4.1 – Test driver and passenger monitoring an Audi automated vehicle test



4.17 The test driver would be expected to have had training to ensure they understand how the test vehicle's automated systems operate, in particular the procedures for taking direct control. It seems logical that the responsibility for ensuring test drivers have those competences should lie with the vehicle manufacturer and the testing organisation.

- 4.18** It may be appropriate for testing organisations to grade test drivers according to their experience and expertise. This would enable them to select the most appropriate test driver for each type of test to be undertaken. For example ensuring that only the most experienced and skilled test drivers are utilised for initial tests of a new software level.
- 4.19** It would be sensible for manufacturers to check that test-drivers have nothing in their driving record that would indicate that they represent a particular risk. Given the levels of concentration required it would also seem sensible to monitor the performance of test-drivers and, where relevant, to set limits on the amount of time they would be expected to maintain that level of concentration.
- 4.20** **Action: Require that testing is conducted with a suitably qualified test driver who is ready and able to take control.**
- 4.21** **Action: Require that test drivers are authorised by the organisation responsible for testing and should receive training on the safe use of the vehicle from that organisation.**

Liability during testing

- 4.22** Perhaps the most commonly asked question regarding driverless and automated vehicles is whose fault would it be if there was a collision or other incident – the ‘driver’ (or operator or occupant) or the vehicle manufacturer?
- 4.23** In reality this question is too simplistic. In most road traffic collisions there is a range of different people or bodies which may bear or share liability:
- Vehicle drivers
 - Vehicle owners
 - Vehicle operators
 - Vehicle manufacturers
 - Vehicle suppliers/importers
 - Service providers
 - Data providers
- 4.24** Each of these parties may be found to be civilly (or in some cases criminally) liable to a greater or lesser extent depending on the exact circumstances of the situation. In the event of a collision where the parties are unable to resolve where liability lies, this process would probably take place in a court of law. The available evidence would be examined in detail and a judge would assess whether each party is liable in law and the extent to which their fault had contributed to the loss.

- 4.25** Currently over 90% of collisions are found to involve human error, however vehicle manufacturers may be held liable where it can be shown that they failed to fulfil their legal obligations. Failure of the automated equipment might be treated in a similar way as today, with the equipment manufacturer being liable for a fault.
- 4.26** The Code of Practice will make clear that the Government would expect the test driver (and the testing organisation for whom they are acting), to take responsibility for ensuring the safe operation of the vehicle at all times, whether the vehicle is operating autonomously or in manual mode.
- 4.27** **Action: Make clear that the test driver (and the testing organisation for whom they are acting), will be considered responsible for the safe operation of the test vehicle whilst on public roads.**
- 4.28** The Code of Practice will also state that automated vehicles under test should be fitted with event data recorders. This technology records whether a vehicle was operating autonomously or was in manual control at the time of any collision. It can also record how soon prior to any collision the mode of operation changed, for which there may well be no other or better source of evidence. Recording additional parameters such as vehicle speed, location, steering and braking inputs can help build up a clearer picture of events leading up to a collision or other incident.
- 4.29** **Action: Specify requirements for data recording. In the event of an incident or collision this data should be made available to the relevant authorities in a format which allows them to conduct analysis of the circumstances leading to the event.**
- 4.30** The legal position of the driver when ceding control over the steering and similar controls in a highly automated vehicle is untested before British courts. In a given case, whether liability lies in the hands of the test driver, the body carrying out the tests, or the manufacturer of the vehicle is ultimately a matter for the courts to decide.
- 4.31** It is likely that the test driver would be responsible for observing road traffic law and the liability for harm caused to third parties when the vehicle is used in autonomous mode. For example, the test driver would be responsible for ensuring that the vehicle drives at the appropriate speed within the speed limit.
- 4.32** The question of liability is more complex when examining the situation when automated vehicles come to market and are sold for public use. *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies* has an in-depth analysis of this, including the applicability of existing product liability laws.

Cyber security

- 4.33** Automated vehicles undergoing testing will have a high level of computer technology on board and may be connected to the internet, other vehicles and possibly their surroundings. As a result cyber security issues need to be carefully considered.
- 4.34** Vehicle manufacturers design safety critical electronic control systems to ensure that they are 'fail safe'. For example electronic braking systems still allow full manual braking in the event of a failure, and the first steer by wire system on the market retains a conventional mechanical steering column which engages in the event that the electronic system fails.
- 4.35** The manufacturers providing vehicles for testing will need to ensure that all prototype automated controllers and other vehicle systems have appropriate levels of security built into them. Such safeguards should be in addition to the vehicle continuing to meet all existing requirements regarding measures to prevent unauthorised use.
- 4.36** The key Government and industry bodies will continue to work closely together on protecting these technologies against any potential cyber security issues.
- 4.37** **Action: Liaise with manufacturers and stakeholders to ensure an appropriate level of protection from unauthorised access, control or interference for automated vehicles engaged in testing.**

Road infrastructure standards

- 4.38** During the testing phase, the expectation is that the test driver will retain responsibility for the vehicle and no bespoke road infrastructure will be necessary. We recommend that organisations planning to undertake such testing first inform, consult with and seek the advice of the relevant road authority or authorities.
- 4.39** Any specific infrastructure requirements that are considered necessary to support testing, including traffic signing, will need to be agreed with the appropriate authorities responsible for the roads and considered as part of the costs of the testing activity. For the purposes of testing, any data or digital mapping required for trial purposes would be expected to be procured by the entity responsible for the trial.

Figure 4.2 – Automated vehicles can give advance warning of possible hazards



4.40 Testing of automated vehicles will be a valuable chance for local highway authorities to get a first-hand insight into the possible future path of vehicle development. This is likely to reveal opportunities for improving both safety and traffic flows, while optimising the efficiency with which our road networks can be used. Our analysis suggests that during the testing phase, legal standards for duty of care are unlikely to significantly differ from those currently required.

4.41 Action: Make clear that organisations planning to undertake automated vehicle testing should consult with the relevant highway authorities well before starting to test.

Public education materials about testing

4.42 Government will work with those engaged in testing to ensure the approach to testing and development of these technologies on UK roads is communicated.

4.43 Action: Recommend that those conducting testing provide information about their testing to the public, as part of their risk management process, taking into account the views of relevant stakeholders such as local highway authorities.

5. Next steps for delivery

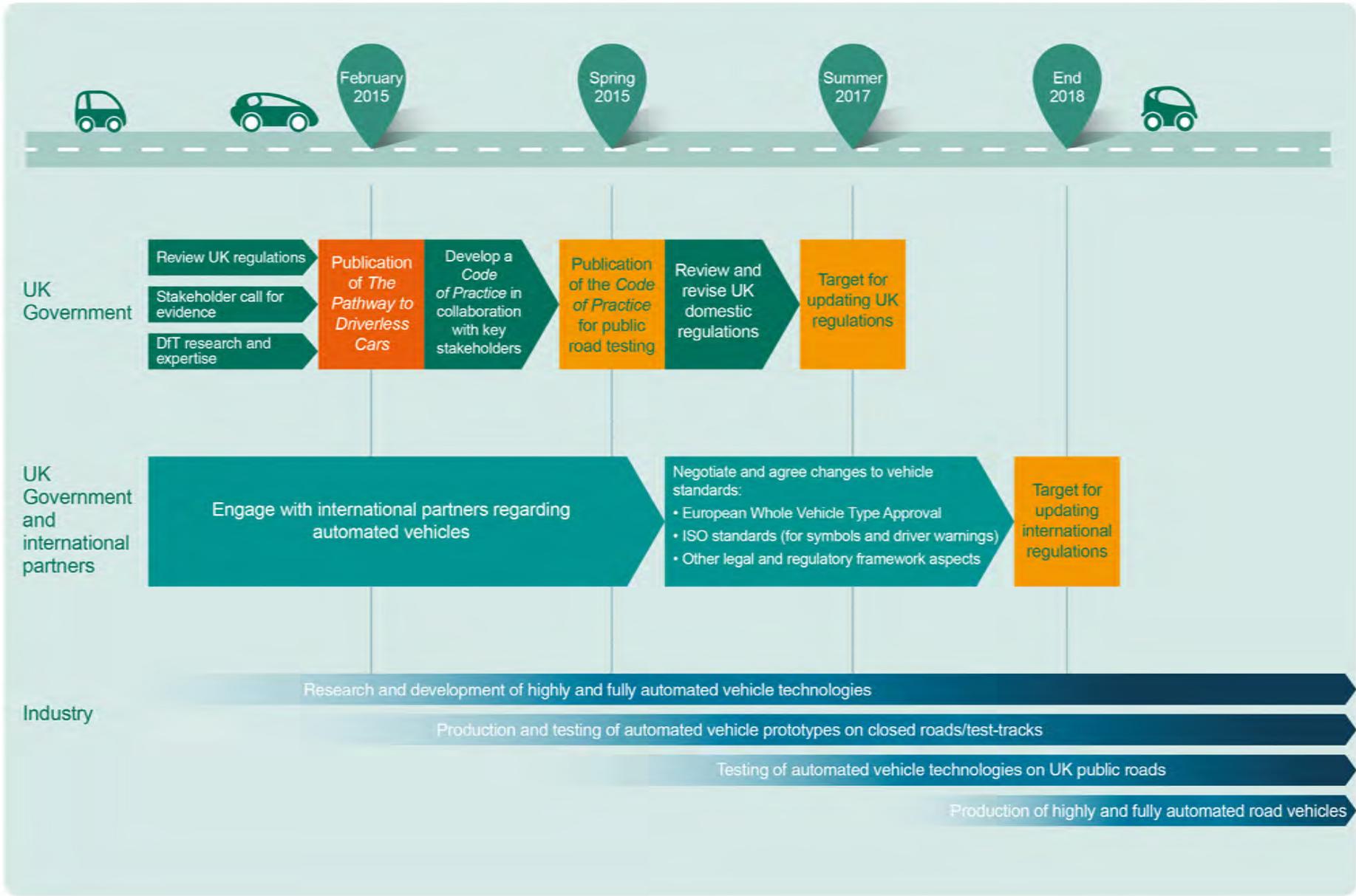
Developing the Code of Practice

- 5.1** The primary action from this review is for the Government to publish a Code of Practice, to promote safety and set clear guidance to be followed in responsible testing. We will work closely with stakeholders to develop the Code of Practice for publication in spring 2015. It will then be reviewed on an ongoing basis.
- 5.2** The aim is to achieve a light-touch, non-regulatory approach which provides the clarity industry needs to invest in further research and development while maintaining safety. It can be updated periodically, which is particularly beneficial in a field where the technology, and our understanding of its benefits and limitations, is developing rapidly.
- 5.3** A Code of Practice that reflects good and responsible practice with regard to the safety of other road users would carry considerable weight on any issue of liability. By involving industry stakeholders in developing the code we expect them to act in accordance with it. Those involved in the three trials jointly funded by Government will be required to comply with the Code.

Bringing driverless vehicles to market

- 5.4** There are a number of actions necessary before highly and fully automated vehicles can be made available for public sale and use on the UK's roads:
- Actions to create or amend domestic legislation;
 - Actions to engage with international bodies with a view to creating or amending international standards or legislation; and
 - Other actions: for example to monitor testing and carry out further research.
- 5.5** An indicative summary of the timing of the main actions necessary is shown in the following timeline for development of highly and fully automated vehicles. *The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies* includes a more detailed explanation of the background and reasons for why these actions are necessary.

Timeline for the development of highly and fully automated vehicles



6. Summary

Introduction

- 6.1** This review has examined the compatibility of existing legislation, covering both vehicles and drivers, in relation to highly and fully automated vehicles.
- 6.2** It has also examined the developing regulatory environment in this area for other European countries, North America, and Asia.
- 6.3** The views of stakeholders have been sought in a 'call for evidence'. Responses from the automotive and insurance industries, the legal profession, technical institutions, and groups representing a wide range of road users, from children and disabled people to drivers, motorcyclists and cyclists have been taken into account.
- 6.4** The aim has been to provide a clearer understanding of how our existing legislation supports the development of automated vehicle technologies and to set out a plan of action to ensure that the UK continues to develop its place in this field as a leading automotive nation attracting investment from across the globe.

Findings

- 6.5** The main conclusion is that our legal and regulatory framework is not a barrier to the testing of highly automated vehicles on public roads. Real-world testing of automated technologies is possible in the UK today, providing a test driver is present and takes responsibility for the safe operation of the vehicle; and that the vehicle can be used compatibly with road traffic law.
- 6.6** In many other countries it would appear existing legislation currently prevents such testing. Those countries that have made arrangements to allow tests of automated vehicles have generally done so in a limited geographical region. Four states in America have introduced legislation to permit testing of automated vehicles, but fifteen have rejected similar legislative proposals.
- 6.7** The UK would therefore appear to be uniquely positioned to become a premium location globally for the development of these technologies. Those wishing to conduct tests are not limited to the test track or certain geographical areas, do not need to obtain certificates or permits, and are not required to provide a surety bond (provided they have insurance arranged).

Plan of action

- 6.8** The Government recognises the importance of facilitating the development of automated vehicle technologies given the numerous benefits that they are expected to bring. The rate of technological progress in this area is high and it is important that this innovation is not stifled.
- 6.9** The Department does not believe that new regulation or a permit system for testing is appropriate at this early stage. Instead the recommendation is to utilise a light-touch non-regulatory approach which provides the clarity industry needs to invest in further research and development, while maintaining safety.
- 6.10** This will be done through the publication of non-statutory guidance, in the form of a Code of Practice, in spring 2015. This will be developed with input from stakeholders to ensure that it is informed by existing best practice and experience. A Code of Practice would be an effective means of setting out the standards to be met by responsible manufacturers and testing organisations and their test drivers in the unusual circumstances of carrying out testing on automated vehicles.
- 6.11** In addition Government will commence work on amending national and international legislation to facilitate the production and marketing of highly and fully automated vehicles. It is envisaged that national legislation can be amended by 2017 and there should be an aim to finalise amendments to international regulations by the end of 2018.

Conclusion

- 6.12** The UK is uniquely positioned to help develop automated vehicle technologies and bring these to market. The Government is developing a light touch non-regulatory approach to the testing and development of these technologies through the use of a Code of Practice. This will facilitate long distance and large area public road testing of these technologies.
- 6.13** The UK has some of the most challenging and diverse traffic, road and weather conditions in Europe and London is Europe's only 'Megacity'. This makes the UK the ideal centre for testing and developing these technologies.

Annex: Summary of actions for Government

Table A.1 Summary of actions for Government				
#	Action	Date for completion	Paragraph number in summary report ⁶	Paragraph number in detailed review
1	Provide clarity on what should be considered 'safe vehicle use' in relation to the testing of automated vehicles.	Spring 2015	4.7	10.21
2	Require that testing is conducted with a suitably qualified test driver who is ready and able to take control.	Spring 2015	4.20	7.55
3	Require that test drivers are authorised by the organisation responsible for testing and should receive training on the safe use of the vehicle from that organisation.	Spring 2015	4.21	7.56
4	Make clear that the test driver (and the testing organisation for whom they are acting), will be considered responsible for the safe operation of the test vehicle whilst on public roads.	Spring 2015	4.27	5.18
5	Specify requirements for data recording. In the event of an incident or collision this data should be made available to the relevant authorities in a format which allows them to conduct analysis of the circumstances leading to the event.	Spring 2015	4.29	7.54

⁶ Note: The location of each action within the summary report and detailed review documents is provided as a paragraph number for the convenience of the reader.

Table A.1 Summary of actions for Government				
#	Action	Date for completion	Paragraph number in summary report⁶	Paragraph number in detailed review
6	Liaise with manufacturers and stakeholders to ensure an appropriate level of protection from unauthorised access, control or interference for automated vehicles engaged in testing.	Ongoing	4.37	15.17
7	Make clear that organisations planning to undertake automated vehicle testing should consult with the relevant highway authorities well before starting to test.	Ongoing	4.41	12.16
8	Recommend that those conducting testing provide information about their testing to the public, as part of their risk management process, taking into account the views of relevant stakeholders such as local highway authorities.	Spring 2015	4.43	6.19
9	Review existing legislation and provide clarity on how liability passes between the driver and the vehicle manufacturer according to mode of operation.	Summer 2017	N/A	13.12
10	Work with the insurance industry to develop requirements governing insurance of highly and fully automated vehicles and engage with the EU over their plans for automated vehicles.	Ongoing	N/A	13.21
11	Consider the existing licensing requirements for owners and users of highly and fully automated vehicles.	Summer 2017	N/A	4.20
12	Analyse existing regulations on vehicle use to ensure that automated vehicles are used and maintained in such a way as to preserve their compliance with road traffic law.	Summer 2017	N/A	5.30

Table A.1 Summary of actions for Government				
#	Action	Date for completion	Paragraph number in summary report⁶	Paragraph number in detailed review
13	Review the allocation of criminal and civil liability between driver and manufacturer and amend the appropriate legislation, as necessary.	Summer 2017	N/A	5.22
14	Consider appropriate measures to ensure that automated vehicles are designed to respect road traffic law.	End of 2018	N/A	5.25
15	Consider the need for requirements governing decisions in vehicle control software and algorithms which may have safety implications for other road users.	End of 2018	N/A	5.27
16	Consider whether requiring a higher standard of driving than would be expected of a conventional driver is possible for vehicles operating in an automated mode.	Summer 2017	N/A	5.34
17	Review the applicability of existing restrictions on vehicle users in regard of fully automated vehicles prior to such vehicles becoming available on the market.	Summer 2017	N/A	5.36
18	Determine whether a section on automated vehicles should be developed and included in <i>The Highway Code</i> , to help guide how road users should interact with these vehicles.	Summer 2017	N/A	6.29
19	Engage the international community, through the European Union and the United Nations Economic Commission for Europe, to examine the vehicle type approval framework and its detailed technical standards to ensure suitability for automated vehicles.	End of 2018	N/A	8.14

Table A.1 Summary of actions for Government				
#	Action	Date for completion	Paragraph number in summary report⁶	Paragraph number in detailed review
20	Examine whether standardisation of the warning symbols and system for the driver to re-take control in an automated vehicle is required.	End of 2018	N/A	8.15
21	Examine the need to amend legislation to clarify when driving is allowed with the driver absent from the vehicle, and the need to include additional safeguards.	End of 2018	N/A	8.13
22	Review existing roadworthiness testing processes and legislation over time to ensure they remain appropriate for highly automated vehicles.	Ongoing	N/A	9.13
23	Ensure that malfunction of the automated technology is made clear to the driver and consider allowing use of the vehicle to continue in 'manual mode' only.	End of 2018	N/A	9.14
24	Keep the issues of ease of repair and an appropriate vehicle lifetime under review as this area of technology develops.	Ongoing	N/A	9.23
25	Review existing vehicle use requirements in the light of evidence and experience gained from automated vehicle testing. Consider how this should feed into European type approval requirements and domestic 'use' regulations.	Summer 2017	N/A	10.36
26	Consider the relative benefits and costs of whether to record the status of automation on the vehicle register.	Summer 2017	N/A	11.9

Table A.1 Summary of actions for Government				
#	Action	Date for completion	Paragraph number in summary report⁶	Paragraph number in detailed review
27	Keep under review the need for and provision of standards and requirements for additional roadside infrastructure to enable the sale and operation of automated vehicles on public roads.	Ongoing	N/A	12.23
28	Government to continue to engage at European and international level in the development and setting of regulations, standards and specifications in relation to the development and introduction of automated vehicles.	Ongoing	N/A	12.24
29	Government – in conjunction with road operators, vehicle manufacturers and other stakeholders – to keep road infrastructure design standards and long term roads policy under review in light of strategic and technological trends, including developments in automated vehicle technologies.	Ongoing	N/A	12.28
30	Participate in EU harmonisation activities to produce a standard for data recording for automated vehicles, and work with stakeholders on privacy issues.	End of 2018	N/A	14.20
31	Consider how the existing regulatory framework may be developed to ensure both automated and connected vehicle technologies are protected from possible cyber threats.	End of 2018	N/A	15.21

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