CATAPULT Transport Systems

SPECIFICATION INFORMATION TO INFORM APPROVALS FOR ADVANCED VEHICLE TRIALS

FINAL REPORT – February 2018

Contents

DISCLAIMER

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ACRONYM LIST

ACRONYM	TERM
ACS	Automated Control System
ADS	Automated Driving System
AV	Automated Vehicle
CCAV	Centre for Connected and Autonomous Vehicles (UK)
DfT	Department for Transport (UK)
DGT	General Directorate for Traffic (Spain)
DMV	Department of Motor Vehicles (California)
FMVSS	Federal Motor Vehicle Safety Standards
HMI	Human Machine Interface
LSE	London School of Economics
LTA	Land Transport Authority (Singapore)
NHTSA	National Highway Traffic Safety Admiration (USA)
NTC	National Transport Commission (Australia)
ODD	Operational Design Domain
OEDR	Object and Event Detection and Response
SAE	Society of Automotive Engineers
SAL	Safety Assessment Letter
TSC	Transport Systems Catapult

1 INTRODUCTION

1.1 BACKGROUND

Automated vehicles (AVs) have the potential to improve road safety, increase road network efficiency and improve accessibility to transport for the elderly and people with physical impairments. The UK Government is keen to support the safe and responsible testing and development of this technology. In 2015, the UK Government published a Code of Practice for testing automated vehicles on public roads , which set out one of the most open frameworks anywhere in the world for testing this technology.

Within the next few years the Government anticipates that developers will be ready to safely test more advanced automated vehicle technology on public roads in a way that would be inconsistent with the current UK legal framework (for example, tests that would not involve a human safety driver or operator). UK Government Ministers may be able to provide approvals for advanced testing of this sort, if they have sufficient evidence to assure themselves that the testing will be carried out safely and responsibly.

1.2 SCOPE

The Centre for Connected and Autonomous Vehicles (CCAV) and the DfT's International Vehicle Standards division (IVS) have instructed the Transport Systems Catapult (TSC) to deliver a report including a list of information ("the list") that Government could ask an organisation (referred to in this report as "the testing organisation" or "AV developers") seeking to apply for an exemption to a Construction and Use Regulation, to enable testing of automated vehicles on UK public roads in a way which is likely to be inconsistent with UK law, to help inform a decision by Ministers on whether to provide approval for that test. The list should be designed to elicit evidence to demonstrate that the test will be carried out safely and responsibly.

The scope of this work is to provide:

- Recommendations on what should be on the list;
- Commentary on why that information has been considered and why other types of information have not been considered;
- Advice on what considerations Government officials should bear in mind when assessing the information provided by the testing organisation in response to the list.

1.3 APPROACH

The approach to this study has been as follows:

- **Background research into relevant issues;**
  i. Current areas of UK law which makes reference to a "driver" or "person" operating the vehicle
  ii. Regulatory approach currently taken by Governments and authorities around the world
  iii. Existing safety case examples
  iv. Public concerns: conclusions from public surveys into AVs
- **Stakeholder consultation.**
  i. One to one interviews
  ii. Stakeholder engagement work

[1] www.gov.uk/government/publications/automated-vehicle-technologies-testing-code-of-practice

1.4 REPORT STRUCTURE

This report is structured as follows:

- **Section 2** describes the UK Legal Framework and the context to the vehicle exemption process
- **Section 3** outlines what TSC consider to be best practices in the development of a safety case AV trials
- **Section 4** presents the results of a review of international regulatory approaches to AV testing, with a focus on how to handle the removal of the safety driver, with detailed information provided at Annex A
- **Section 5** discusses results from public attitude surveys related to AVs
- **Section 6** outlines the stakeholder engagement methodology and summarises the discussions
- **Section 7** discusses precedents currently applicable to the UK for safety tests that only achieve partial coverage
- **Section 8** presents considerations based on the findings

Annex A includes provides further detail on international regulatory approaches.

2 UK LEGAL FRAMEWORK

2.1 INTRODUCTION

This section considers rules and regulations where in certain settings and uses, an organisation testing an automated vehicle may have difficulties showing compliance.

The main regulations investigated include:

- The Road Vehicles (Construction and Use) Regulations 1986
- The Road Traffic Act 1988
- The Highway Code

The Road Traffic Act 1988 at section 44 contains a power by which the UK Government could potentially authorise, in some cases, the use of highly automated vehicles where it might be arguable that the proposed use would mean the testing organisation is not in compliance with an existing road traffic law made under section 41 of the Road Traffic Act ie. testing a vehicle without a human back-up safety driver who is able to take back control of the vehicle. Rule 44 of the Road Traffic Act states:

"Authorisation of use on roads of special vehicles not complying with regulations under section 41.

(1) The Secretary of State may by order authorise, subject to such restrictions and conditions as may be specified by or under the order, the use on roads:

(a) of special motor vehicles or trailers, or special types of motor vehicles or trailers, which are constructed either for special purposes or for tests or trials,

(b) of vehicles or trailers, or types of vehicles or trailers, constructed for use outside the United Kingdom,

(c) of new or improved types of motor vehicles or trailers, whether wheeled or wheelless, or of motor vehicles or trailers equipped with new or improved equipment or types of equipment, and

(d) of vehicles or trailers carrying loads of exceptional dimensions."

This power does not allow the Department to exempt a person/testing organisation from other road traffic laws that fall outside those regulations made under s41 Road Traffic Act 1988.

2.2 CONSTRUCTION AND USE REGULATIONS

The Road Vehicles (Construction and Use) Regulations 1986 are made under section 41 Road Traffic Act 1988, and apply to all road vehicles, including prototypes. The DfT Legal Department confirmed that it is these regulations for which a testing organisation could seek an exemption.

It is for the testing organisation to give consideration to and provide a credible explanation for who the responsible person is (civilly and criminally) for the purpose of compliance with UK road traffic law. Some of the more 'problematic' regulations from this perspective are set out below. Some examples of when an organisation may find they run the risk of not being in compliance with current regulations and where they may seek a modification of the C&U regulation as it relates to their test scenario were explored at the stakeholder engagement session. The relevant text from the sections have been quoted, but full wording and references to definitions can be viewed at the link below. [2]

[2] http://www.legislation.gov.uk/uksi/1986/1078/contents/made

Regulation 104

"No person shall drive or cause or permit any other person to drive, a motor vehicle on a road if he is in such a position that he cannot have proper control of the vehicle or have a full view of the road and traffic ahead."

It may be deemed by enforcement authorities and the courts that a vehicle, when in fully automated mode without an identifiable back-up safety driver, is in contravention of this regulation. For example, where the vehicle's automated control system takes on the role of the 'person driver', the passenger in the vehicle could be interpreted by enforcement authorities as having responsibility for ensuring the vehicle has a full view of the road and traffic ahead, particularly if the sensors were degraded due to environmental conditions.

Regulation 107

"(2), no person shall leave, or cause or permit to be left, on a road a motor vehicle which is not attended by a person licensed to drive it unless the engine is stopped and any parking brake with which the vehicle is required to be equipped is effectively set."

This regulation has clear implications for trials that are planning to run vehicles empty or without a licensed driver on public roads.

Regulation 109

"(1) No person shall drive, or cause or permit to be driven, a motor vehicle on a road, if the driver is in such a position as to be able to see, whether directly or by reflection, a television receiving apparatus or other cinematographic apparatus used to display anything other than information:

(a) about the state of the vehicle or its equipment;

(b) about the location of the vehicle and the road on which it is located;

(c) to assist the driver to see the road adjacent to the vehicle; or

(d) to assist the driver to reach his destination

(2) In this regulation "television receiving apparatus" means any cathode ray tube carried on a vehicle and on which there can be displayed an image derived from a television broadcast, a recording or a camera or computer."

This regulation has implications for what occupants of the vehicle (particularly the person in the driver seat) is able to do whilst the vehicle is driving.

Regulation 110

"No person shall drive a motor vehicle on a road if he is using:

(a) a hand-held mobile telephone; or

(b) a hand-held device of a kind specified in paragraph (4)"

This regulation is perhaps more relevant to vehicles of Level 3 and below (as described by the SAE standard J3016[3]), where there is some sharing of responsibilities between the human and the automated control system. However, even in a Level 4 vehicle, the person in the driver's seat (if the vehicle has driver controls) could still be interpreted as the driver by enforcement agencies.

[3] https://www.sae.org/news/3544/

2.3 ROAD TRAFFIC ACT

The Road Traffic Act 1988[4] includes the following sections. It was confirmed be the DfT legal team that these cannot be addressed by the vehicle exemption process, but are worthy of consideration as the testing organisation will need to consider how the trial will obey all elements of road traffic law. This is not an exhaustive list, however the sections that are likely to be most relevant to a testing organisation are set out below. The relevant text from the sections has been quoted, but full wording and references to definitions can be viewed at the link below. [5]

Section 3

"Careless, and inconsiderate, driving.

If a person drives a mechanically propelled vehicle on a road or other public place without due care and attention, or without reasonable consideration for other persons using the road or place, he is guilty of an offence."

Section 15

"Restriction on carrying children not wearing seat belts in motor vehicles.

(1) Except as provided by regulations, where a child under the age of fourteen years is in the front of a motor vehicle, a person must not without reasonable excuse drive the vehicle on a road unless the child is wearing a seat belt in conformity with regulations."

Section 35

"Drivers to comply with traffic directions.

(1) Where a constable [or traffic officer] is for the time being engaged in the regulation of traffic in a road, a person driving or propelling a vehicle who neglects or refuses:

(a) to stop the vehicle, or

(b) to make it proceed in, or keep to, a particular line of traffic, when directed to do so by the constable in the execution of his duty [or the traffic officer (as the case may be)] is guilty of an offence.

(2) Where;

(a) a traffic survey of any description is being carried out on or in the vicinity of a road, and

(b) a constable [or traffic officer] gives to a person driving or propelling a vehicle a direction –

(i) to stop the vehicle,

(ii) to make it proceed in, or keep to, a particular line of traffic, or

(iii) to proceed to a particular point on or near the road on which the vehicle is being driven or propelled, being a direction given for the purposes of the survey (but not a direction requiring any person to provide any information for the purposes of a traffic survey), the person is guilty of an offence if he neglects or refuses to comply with the direction

(3) The power to give such a direction as is referred to in subsection (2) above for the purposes of a traffic survey shall be so exercised as not to cause any unreasonable delay to a person who indicates that he is unwilling to provide any information for the purposes of the survey."

[4] https://www.legislation.gov.uk/ukpga/1988/52/contents
[5] https://www.legislation.gov.uk/ukpga/1988/52/contents

Section 36

"Drivers to comply with traffic signs.

(1) Where a traffic sign, being a sign:

(a) of the prescribed size, colour and type, or

(b) of another character authorised by the [national authority] under the provisions in that behalf of the Road Traffic Regulation Act 1984

has been lawfully placed on or near a road, a person driving or propelling a vehicle who fails to comply with the indication given by the sign is guilty of an offence."

Section 40A

"Using vehicle in dangerous condition etc.

A person is guilty of an offence if he uses, or causes or permits another to use, a motor vehicle or trailer on a road when:

(a) the condition of the motor vehicle or trailer, or of its accessories or equipment, or

(b) the purpose for which it is used, or

(c) the number of passengers carried by it, or the manner in which they are carried, or

(d) the weight, position or distribution of its load, or the manner in which it is secured,

is such that the use of the motor vehicle or trailer involves a danger of injury to any person."

Section 87

"Drivers of motor vehicles to have driving licences.

(1) It is an offence for a person to drive on a road a motor vehicle of any class [otherwise than in accordance with] a licence authorising him to drive a motor vehicle of that class.

(2) It is an offence for a person to cause or permit another person to drive on a road a motor vehicle of any class [otherwise than in accordance with a licence authorising that other person] to drive a motor vehicle of that class."

Section 143

"Users of motor vehicles to be insured or secured against third-party risks.

(1) Subject to the provisions of this Part of this Act:

(a) a person must not use a motor vehicle on a road [or other public place] unless there is in force in relation to the use of the vehicle by that person such a policy of insurance or such a security in respect of third party risks as complies with the requirements of this Part of this Act, and

(b) a person must not cause or permit any other person to use a motor vehicle on a road [or other public place] unless there is in force in relation to the use of the vehicle by that other person such a policy of insurance or such a security in respect of third party risks as complies with the requirements of this Part of this Act.

(2) If a person acts in contravention of subsection (1) above he is guilty of an offence.

(3) A person charged with using a motor vehicle in contravention of this section shall not be convicted if he proves:

(a) that the vehicle did not belong to him and was not in his possession under a contract of hiring or of loan,

(b) that he was using the vehicle in the course of his employment, and

(c) that he neither knew nor had reason to believe that there was not in force in relation to the vehicle such a policy of insurance or security as is mentioned in subsection (1) above.

(4) This Part of this Act does not apply to invalid carriages."

Section 170

"Duty of driver to stop, report accident and give information or documents.

(1) This section applies in a case where, owing to the presence of a [mechanically propelled vehicle] on a road [or other public place], an accident occurs by which:

(a) personal injury is caused to a person other than the driver of that [mechanically propelled vehicle], or

(b) damage is caused:

(i) to a vehicle other than that [mechanically propelled vehicle] or a trailer drawn by that [F1mechanically propelled vehicle], or

(ii) to an animal other than an animal in or on that [mechanically propelled vehicle] or a trailer drawn by that [mechanically propelled vehicle], or

(iii) to any other property constructed on, fixed to, growing in or otherwise forming part of the land on which the road [or place] in question is situated or land adjacent to such land.

(2) The driver of the [mechanically propelled vehicle] must stop and, if required to do so by any person having reasonable grounds for so requiring, give his name and address and also the name and address of the owner and the identification marks of the vehicle.

(3) If for any reason the driver of the [mechanically propelled vehicle] does not give his name and address under subsection (2) above, he must report the accident.

(4) A person who fails to comply with subsection (2) or (3) above is guilty of an offence.

(5) If, in a case where this section applies by virtue of subsection (1)(a) above, the driver of [a motor vehicle] does not at the time of the accident produce such a certificate of insurance or security, or other evidence, as is mentioned in section 165(2)(a) of this Act:

(a) to a constable, or

(b) to some person who, having reasonable grounds for so doing, has required him to produce it, the driver must report the accident and produce such a certificate or other evidence.This subsection does not apply to the driver of an invalid carriage.

(6) To comply with a duty under this section to report an accident or to produce such a certificate of insurance or security, or other evidence, as is mentioned in section 165(2)(a) of this Act, the driver:

(a) must do so at a police station or to a constable, and

(b) must do so as soon as is reasonably practicable and, in any case, within twenty-four hours of the occurrence of the accident.

(7) A person who fails to comply with a duty under subsection (5) above is guilty of an offence, but he shall not be convicted by reason only of a failure to produce a certificate or other evidence if, within [seven] days after the occurrence of the accident, the certificate or other evidence is produced at a police station that was specified by him at the time when the accident was reported.

(8) In this section "animal" means horse, cattle, ass, mule, sheep, pig, goat or dog."

2.4 HIGHWAY CODE

The Highway Code includes the following rules, which provide examples of aspects of the code that AV developers need to consider. The full Highway Code document can be viewed at the link below.[6]

Rule 160

"Once moving you should: [third bullet point] drive with both hands on the wheel where possible. This will help you to remain in full control of the vehicle at all times."

Rule 219

"Emergency and Incident Support vehicles.

You should look and listen for ambulances, fire engines, police, doctors or other emergency vehicles using flashing blue, red or green lights and sirens or flashing headlights, or traffic officer and incident support vehicles using flashing amber lights. When one approaches do not panic. Consider the route of such a vehicle and take appropriate action to let it pass, while complying with all traffic signs. If necessary, pull to the side of the road and stop, but try to avoid stopping before the brow of a hill, a bend or narrow section of road. Do not endanger yourself, other road users or pedestrians and avoid mounting the kerb. Do not brake harshly on approach to a junction or roundabout, as a following vehicle may not have the same view as you."

[6] https://www.gov.uk/guidance/the-highway-code

3 BUILDING A SAFETY CASE

3.1 INTRODUCTION

To trial AVs on public roads or in public spaces, a case relating to the safety of the trial must be made. This safety case provides the claims and evidence that the trial activity can be conducted safely (with safety defined as the absence of unreasonable risk). This is increasingly important with the introduction of highly automated vehicles for which there may be no safety driver in the vehicle. Therefore, the Safety Case may be a vital piece of evidence that would be considered by the Department when considering whether to grant an exemption from Construction and Use regulations. This section details what a 'good practice' safety case might include. This was presented to and discussed with stakeholders, as discussed later in this report.

3.2 CONTENTS OF A SAFETY CASE

A 'good practice' safety case might be expected to communicate the following:

Details of the trial

Basic information which sets out the nature of the trial, including:

1. The type and number of vehicles that will be used in the trial. This could include details such as number of seats, seat-belt usage and air bags fitment.
2. The 'Operational Design Domain' (ODD) in which the automated vehicle functionality is to be tested. This might include road types, geographical range, speed range and environmental conditions under which the automated feature(s) can be activated.
3. Vehicle routes and trial areas shown diagrammatically.
4. Duration, starting and ending dates of the trial.

Evidence that vehicle is safe enough for trialling within the ODD

This might include the following:

5. Hazards associated with the ODD, analysis of the risks and a risk management strategy.
6. How the safety case has balanced safety risk for vehicle occupants with other road users, and how the safety risk has been balanced with wider operational or performance considerations.
7. How safety will be maintained in the event of failure of critical vehicle systems.
8. Safeguards for ensuring the automated feature is not activated outside of its ODD.
9. How modifications to any host or base vehicle to which automated functionality is added have been assessed with regard to safety, including assurances that pre-existing safety arguments related to the host or base vehicle are not invalidated by these modifications.
10. Any known limitations of the system and how these limitations will be managed. These limitations may relate to capability in certain environmental conditions or certain interactions with other road users, etc.
11. An assessment of the interaction between the automated vehicle and other road or public-space users from a safety regard.
12. An assessment of the human machine interface between the automated vehicle and any in-vehicle test driver or remote vehicle operators. Human factors to be considered include, but not limited to, takeover and handover, reliability of intervention rates, fatigue and distraction.

13. An assessment of the integrity and fail-safe characteristics of any communications system in context of its identified role in ensuring safety.
14. How the vehicle's design and manufacture limits the severity of injuries from any collision that does occur. Justification of the crash worthiness of the vehicle in relation to the ODD. If a vehicle has been type approved then this is likely to be the basis for this justification.
15. Details of previous testing that has been undertaken in virtual environments and / or in testing facilities on private land. It is expected that the testing organisation will be satisfied that the vehicle software and systems can handle safety critical events prior to tests on public roads or in public places.
16. Reference to relevant standards that have been followed (in part or whole). This could include functional safety standards, quality standards or software coding standards and be drawn from the automotive or wider domains.

Management of trial:

17. How updates to the system are managed throughout the course of the trial. This may include repeating part of the test programme and updating the safety case.
18. The process for monitoring trial safety and making changes to the system or ODD as a result of the monitoring.
19. A process for collection of event data relating to near misses and collisions and communication of information with the relevant authorities where necessary.
20. The process for fully investigating any collision and near miss, and for how a vehicle is reinstated after being involved in a collision.

How the proposed trial will align with current regulations:

21. How vehicles under test on public roads will obey all relevant road laws and guidelines set out in the Code of Practice.
22. How the test vehicle, if considered a prototype, satisfies the relevant sections of the Construction and Use and Lighting Regulations. Schedule 11 of The Road Vehicles (Authorisation of Special Types) (General) Order 2003 sets out which sections apply to prototype vehicles.

Responsibilities:

23. Identify the organisation that will have responsibility for compiling, authorising and maintaining the safety case.
24. A clear breakdown of responsibilities of various participants and organisations in relation to safety.
25. Describe how the safety case will be communicated and routinely followed by those taking part in the trial. This should include any / all test drivers, operators and other trial participants.

Stakeholder engagement:

26. Outline of how stakeholders are expected to contribute towards safety, and how this will be communicated and managed.
27. The process for consultation with police and emergency services, other relevant authorities and other stakeholders.
28. A point of contact for stakeholder concerns regarding safety.

4 INTERNATIONAL REGULATORY APPROACHES

4.1 INTRODUCTION

This study has reviewed the regulatory approaches taken by Governments around the world, which may help influence how the UK Government proceeds with adapting regulations. A review of the regulatory approaches across Europe, the USA and the rest of the world is included at Annex A; a summary of this is provided below.

4.2 SUMMARY OF REGULATORY APPROACHES

At the time of review (November 2017), most Governments require a human safety driver to monitor the AV and to be able to take control of it to enable testing on public roads. Some Governments will permit testing of the AV with the safety driver outside of the vehicle under certain circumstances, and some governments have no stipulation for the vehicle to be monitored by a human by any means. As a general rule, the emphasis remains upon the manufacturer to provide suitable evidence to show how the vehicle is safe, with the format and contents of any such documentation left open to the manufacturers rather than being prescribed by government.

Testing of AVs is influenced by the 1949 Geneva Covention and the 1968 Vienna Convention on Road Traffic; the latter has been updated to allow the use of driver assistance systems provided that the systems can be "overridden or switched off by the driver". Some European states argue that this is satisfied if there is a person in the vehicle able to press an override button, regardless of whether they have access to conventional driver's controls. Finland, the Netherlands, Sweden (all 1968 Contracting Parties), as well as Spain (a 1949 Contracting party) allow testing of AVs without a safety driver present.

The regulatory system in the United States (also a 1949 Contracting Party) is particularly complex as there is disparity between the policies of individual states; the analysis in Annex A therefore examines all the states that permit testing of AVs separately. For example, California has very detailed requirements for what a manufacturer must submit, whereas many states only have a few, more general requirements such as for proof of insurance and evidence of the ability of the vehicle to reach a minimal risk condition in the event of failure. Nevada allows deployment of AVs without any sort of safety driver not just for testing purposes, but also for commercial deployment, but most states currently only allow testing.

There are, however, efforts to provide more standardisation at a federal level, with the SELF DRIVE act, currently in the later stages of the legislative process, limiting the ability of states to restrict testing of AVs, and NHTSA's voluntary guidance, 'A Vision for Safety', providing guidance on what is regarded good practice.

In the rest of the world, states that currently allow testing without a safety driver, or are in the process of passing legislation to allow it, include Australia, Japan, New Zealand and Singapore (all both 1949 Contracting Parties). Two particularly interesting cases are India, which has banned AVs in order to protect jobs, and China, which has recently halted testing while new regulations are developed.

It is worth noting that the Global Forum for Road Traffic Safety, the UN body responsible for both Vienna Conventions, is developing guidance on how highly and fully automated vehicles, including ones where the user does not have to steer, accelerate, or brake, can be used in road traffic.

5 PUBLIC CONCERNS

5.1 INTRODUCTION

An important consideration relating to the introduction of AVs, even at trial phase, is public trust. This section discusses the result of TSC's investigations into public attitude surveys on AVs to see if there is any relevant information that should be taken into account when considering evidence that might enable a trial to be authorised.

A 2017 article by Deb et al. on pedestrian attitudes to AVs highlights the difference between **acceptance** of (willingness to use) and **receptivity** to (willingness to interact with) a technology. For this report, receptivity to AVs is of more relevance as those using AVs would have agreed to be part of the trial. Whereas several studies in recent years have attempted to assess public awareness of and attitudes to AVs, these have overwhelmingly focused on willingness to use or own an AV (acceptance). There is very little research available from the perspective of pedestrians, cyclists, or users of non-AV vehicles (receptivity).[7]

5.2 GENERAL PERSPECTIVES

Given the lack of evidence regarding non-AV users, one approach is to make some tentative inferences about potential receptivity to AVs from more general survey results. For example, various studies have assessed respondents' awareness of AVs:

- A 2017 survey commissioned by UK Autodrive (n=2,850) showed 76% of respondents had heard of driverless cars. [8]
- A 2014 study by Schoettle & Sivak indicated that 66% of UK residents (n=527) had heard of autonomous or self-driving vehicles. [9]

Enhancing public awareness of AVs is likely to be a crucial first step in ensuring public receptivity.

When surveys consider general acceptance of AVs, responses are varied – some surveys indicate a majority are willing to use AVs, and others suggest a majority would be reluctant to do so.

A few articles have attempted to synthesise an overview of research pertaining to awareness of and attitudes towards AVs. The most useful is a 2017 review by UCL's Transport Institute (pg 93-100), which reviewed interest levels in AVs; attitudes to safety, security, and trust; perceived benefits; and perceived financial costs. [10]

5.3 KEY SAFETY CONCERNS

The most prevalent general safety concerns about AVs across the relevant literature include: (a) system failure/ malfunction and (b) hacking/misuse. (The above referenced UCL report makes this point on pg 97.)

For example, in a study by Schoettle & Sivak, 81% of survey respondents answered that they felt 'very' (47%) or 'moderately' (34%) concerned about safety consequences of equipment failure or system failure. In the same study, 68% reported being 'very' or 'moderately' concerned about system or vehicle security as a result of hacking.

(This study includes a detailed breakdown (pg.14) of levels of concern around several possible concerns, broken down by country (US, UK, and Australia).) [11]

[7] http://www.sciencedirect.com/science/article/pii/S0968090X17302383
[8] http://www.ukautodrive.com/survey-finds-uk-public-still-open-minded-about-self-driving-vehicles/
[9] https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108384/103024.pdf
[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/585732/social-and-behavioural-questions-associated-with-automated-vehicles-literature-review.pdf
[11] https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108384/103024.pdf

5.4 OTHER DRIVERS

A 2016 study (n=11,827) by the London School of Economics on behalf of Goodyear asked the question:

"How would you feel about driving alongside autonomous cars?"

The results indicated that two-fifths of participants would feel uncomfortable. However, the report also noted that these sentiments shifted noticeably after participants spent only 20 minutes reflecting on AVs during the course of the survey. This suggests that, for some people at least, greater familiarity with AVs has the potential to help alleviate concerns. [12]

	All levels of uncomfortable	Neither comfortable or uncomfortable	All levels of comfortable	Don't know
Beginning of survey	41%	21%	29%	9%
End of survey	32%	27%	34%	7%

(Adapted from LSE report)

Other key findings from the study indicated that 70% of respondents felt that humans should be in control of their vehicles 'as a point of principle', while 80% felt that an AV should have a steering wheel.

5.5 PEDESTRIANS

Despite featuring a relatively small (n=482) and not entirely representative sample from the US, a few of the survey questions from a study by Deb et al. offer valuable insights into pedestrians' views on AVs (they use the term Fully Autonomous Vehicle (FAV)).[13] These results indicate that while a majority of participants agree that AVs will make the roads safer, when faced with the prospect of crossing a road with AVs, responses were very mixed.

	FAVs will make the roads safer	I would feel safe to cross roads in front of FAVs	I would feel comfortable if my child, spouse, parents – or other loved ones – cross roads in the presence of FAVs
Strongly Disagree	5%	12%	15%
Disagree	13%	27%	26%
Neutral	21%	13%	17%
Agree	44%	39%	33%
Strongly Agree	16%	9%	9%

(Percentages do not always sum to 100% as they have been rounded from two decimal places)

[12] http://www.lse.ac.uk/website-archive/newsAndMedia/PDF/AVs-negociating-a-place-on-the-road-1110.pdf
[13] http://www.sciencedirect.com/science/article/pii/S0968090X17302383

The same article highlights five factors influencing pedestrian receptivity towards AVs.

- **Attitude toward AV**s – AVs in general and specific technologies
- **Social Norms** – Individual perception of what important and influencing people think about FAVs
- **Trust** – Individual belief that an AV will perform its intended task with high effectiveness
- **Effectiveness** – Extent to which an AV successfully detects pedestrians and other obstacles on the road, stops for them and/or allows safe pathway for them
- **Compatibility** – Degree to which an AV is perceived as being consistent with the existing transportation system

Adapted from Table 1, Deb et al. (2017, pg 181)

A second study on pedestrians and AVs (Hulse et al. - almost 1000 participants), concluded that, while being a passenger in AVs was perceived as riskier than being in a human-operated car, for pedestrians, AVs were seen as less risky than human-operated cars. [14]

5.6 SIGNALLING INTENT

Certain manufacturers are considering how AVs can signal intent to other road users. This will be an important consideration in how the public perceive the safety of AVs, with the potential to help other road users feel more comfortable. For example, Ford reportedly are developing a system of flashing lights to show the pedestrian that the AV is yielding for them. [15]

5.7 CONCLUSIONS

The conclusions of investigations into public attitude surveys into AVs to see if there is any relevant information that should be taken into account when considering evidence that might enable a trial to be authorised are summarised as follows:

- There is a broad, and growing, awareness of the existence of AVs, but general attitudes towards them vary
- There is a shortage of available data on how other drivers, cyclists, and pedestrians will perceive and be receptive to AVs
- The surveys cited indicate that a significant proportion of the public would be wary of AVs. For example, in one survey 41% reported that they would be uncomfortable driving alongside an AV. In another survey, approximately 40% disagreed with the statement that 'I would feel safe to cross roads in front of a fully AV'
- The studies that do exist almost invariably depend on participants imagining scenarios rather than actually experiencing interacting with an AV. Only when we can study how the public respond to first-hand experience of AVs will it be possible to more accurately gauge perceptions of safety and trust
- There is evidence that increased familiarity with AVs will help alleviate concerns, perhaps relatively quickly
- The question of how AVs could interact with the public to allay concerns would be worthy of more extensive investigation
- Publishing information regarding AV safety and performance publicly where possible may help with public attitudes and trust, although this would require further investigation to confirm

[14] http://www.sciencedirect.com/science/article/pii/S0925753517306999
[15] https://www.engadget.com/2017/09/14/ford-self-driving-car-light-signals/

6 STAKEHOLDER ENGAGEMENT

6.1 INTRODUCTION

The stakeholder engagement has been a two-step process:

1. One-to-one interviews with key stakeholders, either in person or by telephone.
2. A stakeholder consultation event held close to the DfT office in London.

TSC has held initial discussions with a number of organisations, including AV technology developers (both small and large), proving ground operators, academia, regulatory bodies, legal / insurance experts and consultants. A total of 12 one-to-one interviews were undertaken and a workshop was attended by 31 participants.

6.2 ONE TO ONE INTERVIEWS

During the one to one interviews, interviewees were asked for their initial response to the key question:

"What information should be provided in the safety case / application for an exemption to construction and use regulations?"

The interview pursued with follow up questions based on the participant response and the expertise of the interviewee. Much of the responses fed into the design of the stakeholder workshop.

6.3 STAKEHOLDER WORKSHOP

The stakeholder workshop was held in Central London on 29th November 2017. The programme for the workshop included:

- Introduction from CCAV on the project aims
- Presentation from TSC on initial findings in the areas of safety case best practice, international regulations and public perceptions
- Presentation from Thatcham on their work with the insurance industry and Euro NCAP
- Presentation from Loughborough University on the safety of CAVs in the real world

The workshop participants were then split into four groups. Each group was invited to spend 10-15 minutes discussing four different workstations. Each workstation presented background information and participants were asked to discuss and provide comments with post-it notes. A summary of the workstation themes and resulting discussions is included as follows:

Workshop Theme 1: CAV scenarios

This scenario involves a Level 4 vehicle with no safety operator operating on a motorway between junction 'A' and 'B'. The vehicle is driven manually to junction A and the ADS is engaged, handing over complete control to the vehicle. The occupant watches a film so cannot resume control quickly.

Figure 6.1: Example of Motorway Chauffeur Operation Design Domain

The following points were noted during the stakeholder discussion in relation to this scenario:

- Clarity would be needed as to the vehicle operating parameters, whether it would be capable of changing lanes and reacting to traffic events
- A strategy would be needed for coping with unusual, but predictable, situations, such as a tyre bursting, as well as the more unpredictable situations
- The vehicle may need to somehow liaise with the road owner and enforcement agencies
- The safety case will need to detail how many hours of simulation in a similar environment/context have been conducted.
- The vehicle will need to adjust appropriately to temporary/variable speed limits

Broader questions discussed included:

- Is the inclusion of communications systems and safety marshals during testing, which may not be provided for the final commercial roll out, a manipulation of the ODD? Does this make any data collected less valid?
- Is it beneficial for the vehicles to be marked as being AVs?
- How much data can be provided without there being an IP risk? Is it desirable for OEMs to have different IP?
- Perhaps some vehicles will be programmed to take different levels of risk – should this be regulated?
- Consideration of driver distraction issues and existing regulations. Under existing regulations, the occupant who has handed over control to the vehicle may be seen by enforcement authorities as being in breach of Regulation 109 C&U which prohibits a driver from watching a 'television receiving apparatus" (see page 6 for the full regulation) even though the occupant is not responsible for the driving task while the vehicle is in L4 automated mode. Consideration of risks and mitigation of the same, of requiring occupant to resume control of vehicle if requested to do so by the vehicle in L3 mode

Scenario 1b – Automated Valet Parking (no human safety operator whilst ADS engaged)
In this scenario, a human driver takes a vehicle to the local high street shops, gets out of the vehicle at the shop entrance, presses button to hand over full control, and the car goes to park in local authority car park on public land.

Figure 6.2: Town Centre to Car Park, 'Auto-Valet Park' Scenario

It was discussed that the safety case should consider:

- How the vehicle will handle conflicts with pedestrians and other road users (randomised behaviours)
- Evidence to demonstrate that vehicle can handle scenarios in a controlled environment, to prove the concept, in a 'pseudo' type approval test
- A range of possible scenarios and performance criteria, i.e. when to stop, when to move out the way, etc
- How the vehicle will handle different weather types, alternative routes, etc
- How well the driver is informed about the operation of the system; how well he / she knows what to do in certain circumstances

Regarding Section 170 of the Road Traffic Act, "Duty of driver to stop, report accident and give information or documents":

- Sensors should monitor and record minor crash data
- Systems may currently be too crude to be useful in terms of identifying liability
- The vehicles should always be 'supervised' during trials in any case

Further thoughts:

- Perhaps an independent person/body should witness the tests before the safety case is presented to Government
- Consideration is needed of how the case example complies with current regulations, for example 104 and 107 Construction and Use Regulations (see page 6) and the role of exemptions

Scenario 2a – Automated Shuttle Service (vehicle completely self-driving)
This scenario involves a Level 4 vehicle with no human safety operator that operates as a shuttle service between a town centre and a hospital.

Figure 6.3: Town Centre – Hospital Automated Shuttle Service

It was discussed that the safety case should consider what the variations between the start and end point of the journey might be, and how the shuttle would handle those.

Participants contributed with the following further thoughts:

- There is a risk that testers will only present the scenarios it can test and pass, and Government won't see the full picture.
- Even just understanding/identifying different scenarios is IP and a competitive advantage.
- Perhaps a standard set of scenarios, or a minimum standard, should be set. But then how many testers would be diligent enough to go above the minimum threshold?
- Perhaps the safety case should be audited by an external body, that is not open to freedom of information requests. That body can then provide evidence to Government.
- Risk of an external auditor is that they could be bought out a large company that is involved in AV development, then one company has all the IP.

Scenario 2b – Automated Taxi (vehicle completely self-driving)
This scenario is similar to 2a but dynamic and on demand (i.e. a taxi service) within a defined area. Again, no safety driver is present in the vehicle.

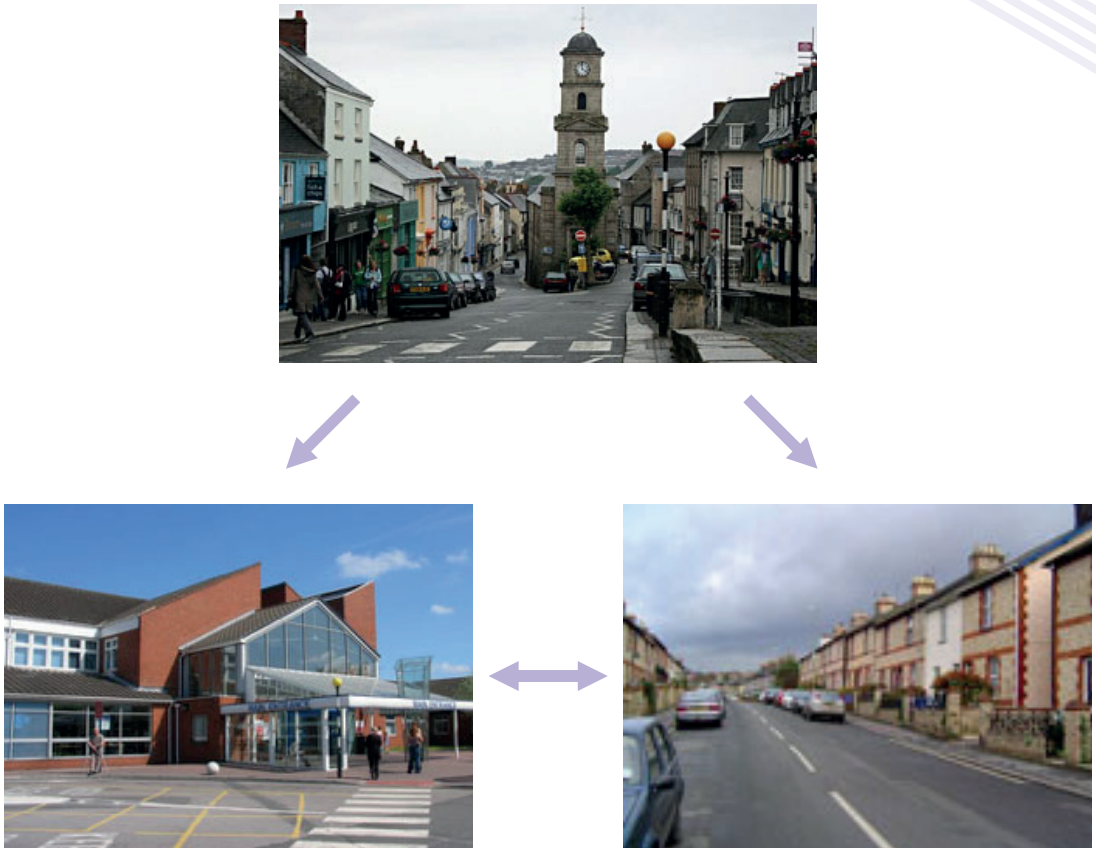

Figure 6.4: Automated Taxi Service within geographically limited area

With respect to this scenario participants pointed out that the safety case should consider:

- How the ODD is mapped? Can statistics be derived for the ODD, and possible scenarios predicted in advance?
- What is the impact of the vehicle's driving style on other road users?
- What are the environmental limitations of the vehicle? Can it handle all weather conditions?
- What is the vehicle's minimal risk manoeuvre for foreseeable incidents?
- How will the vehicle handle unforeseeable, or unforeseen, incidents?
- How will the vehicle balance safe driving and road traffic law, i.e. overtaking cyclists?
- How is the vehicle monitored?
- If electric, how does the vehicle manage its range? Does it take itself to a charging point?
- Relevant details of previous trials, which have led up to this point.
- Cybersecurity

Regarding Section 170 of the Road Traffic Act, "Duty of driver to stop, report accident and give information or documents.", participants suggested:

- The vehicle should include a functionality to enable passengers to call police
- A black box is required
- The testing organisation go to the scene/be within easy reach of the scene?

Further thoughts:

- The business model behind the trial could have an impact. For example, automated taxis could compete on either speed (i.e. getting customers from A to B as fast as possible, and thus maximising revenue), or safety (i.e. driving very conservatively).
- Should testing organisations consider recovery requirements, i.e. should the vehicles have steering wheel, tow hook, etc. to allow the vehicle to be manually removed from the scene? If so, how has AV developers made provisions for this?
- What are the rights of taxi passengers? If they would like the vehicle to stop, to enable them to get out before the end point, how can this be achieved?

Workshop Theme 2: Safety case

Suggestions were shown on the type of information that would need to be submitted with a safety case for highly automated vehicle trials, as detailed in Section 3 of this report. Participants were asked to comment on whether this type of information is appropriate for submission to enable an exemption to Construction and Use regulations to be granted, and what level of detail is appropriate. The themes of the safety case were displayed as below.

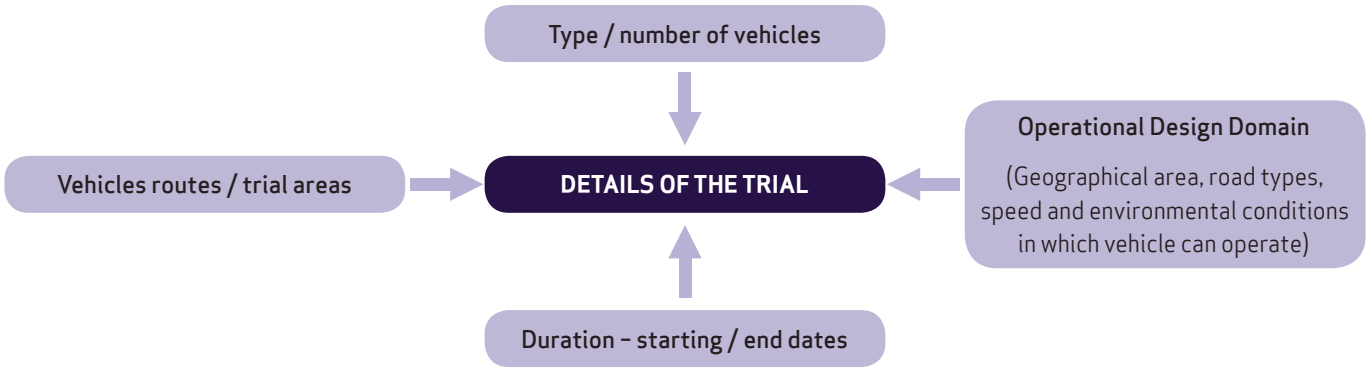

Figure 6.5: TSC Safety Case suggestions – Details

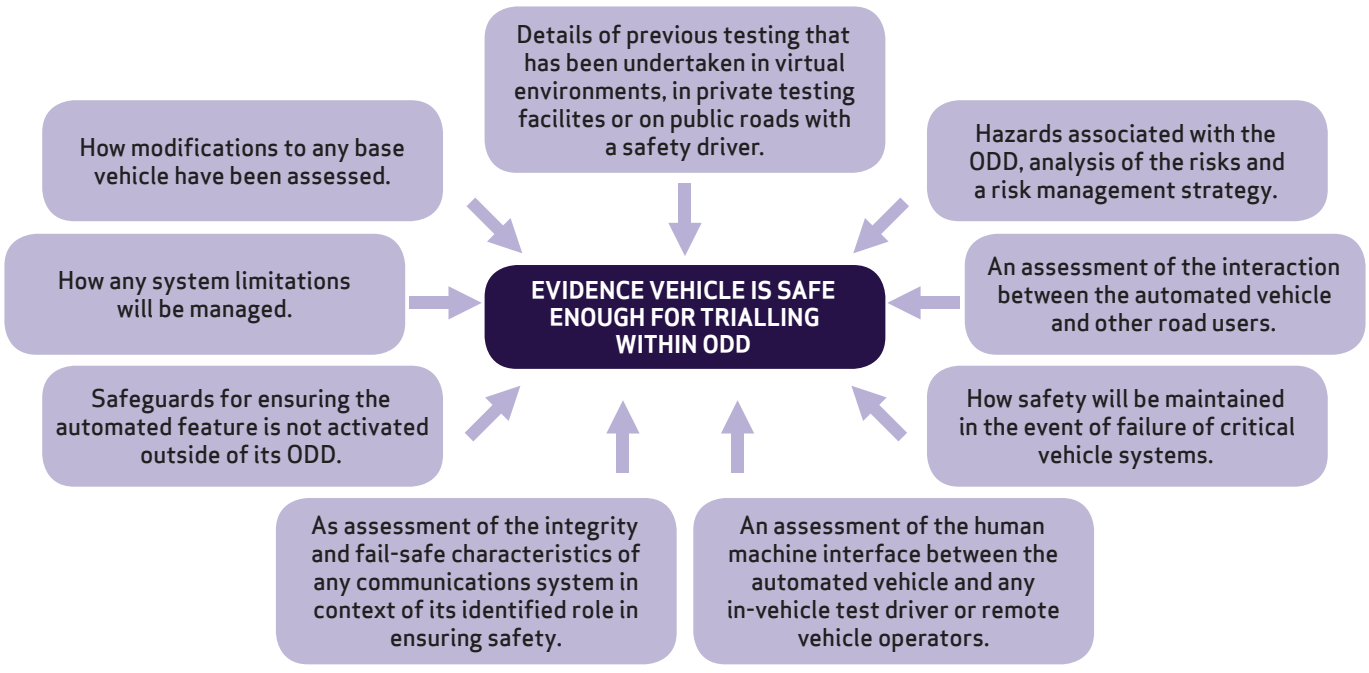

Figure 6.6: TSC Safety Case suggestions – Evidence Vehicle is Safe Enough for Trialling within ODD

Figure 6.7: TSC Safety Case suggestions – Responsibilities

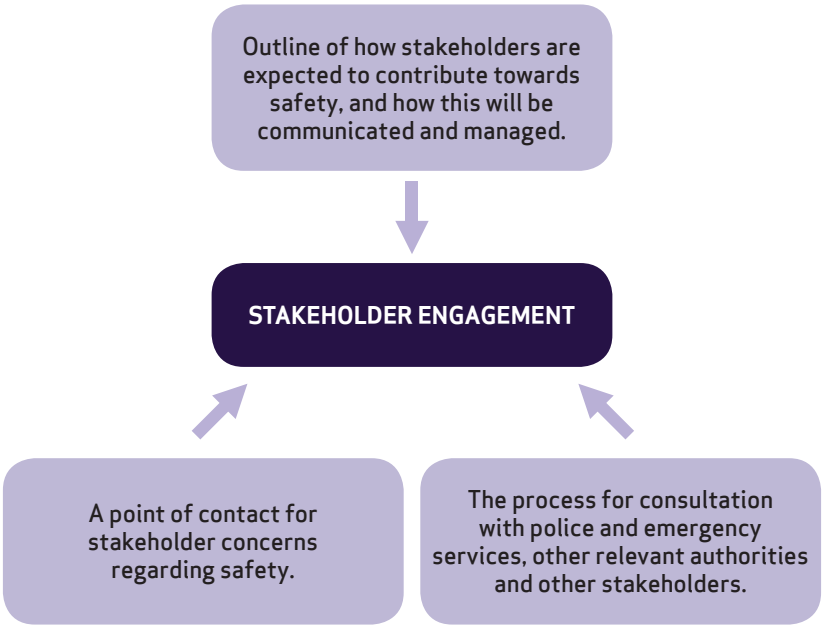

Figure 6.8: TSC Safety Case suggestions – Stakeholder Engagement

Figure 6.9: TSC Safety Case suggestions – Alignment with Standards and Regulations

Participants agreed that assessment of safety case evidence would need to be independent of the AV developer. Approval could be iterative process. The AV developer could submit information to an independent expert panel, who then responds with questions. Approval would not be granted until the questions are resolved.

It was felt that whilst there is a need for consistency in AV tests, there needs to be sufficient variability to stop organisations being able to "ace" the test by optimizing. Therefore AV developers would need a robust overall design. It was agreed that use cases / scenarios could help agree targets.

The following points were noted during the stakeholder discussions:

- Safety case assessors would need to consider:
  1. Description of the trial, including ODD
  2. Human Factors report
  3. Failure Modes Effects Analysis (FMEA)
  4. Hazard Analysis and Risk Assessment (HARA)
  5. Validation Evidence
  6. Exemption authority to do physical test
- Those assessing AV performance should consider that the amount of testing is not necessarily as important as the quality of testing.
- The term "Near miss" needs a definition so that organisations can monitor these in a consistent way.
- There needs to be a means to detect emergency vehicles and traffic officers.
- There would be a need to identify the minimum passive safety levels of the vehicle based on ODD.
- Thresholds for resubmitting to safety testing during testing would need consideration – at what point does a modification to respond to the live event become material enough to invalidate safety testing?
- Outcome-based testing may be most appropriate, not necessarily by virtual means.
- Evidence of minimum performance requirements of vehicle systems would be needed.
- The Insurance companies could drive requirements. It is possible that 'A rated' insurance moves a certain amount of the safety case consideration away from Government, although the Minister takes some responsibility by waving certain aspects of UK law.
- We need tests that can be applied to vehicle-in-loop simulations akin to "driving test".
- Evidence of the corrective action process would be needed.
- Careful thought would be needed as to what evidence is made public and what is to remain confidential.
- Assessment would need to recognize that vehicle capabilities are developing over time. For example, a bicycle approaching at 45 degree angle might be difficult to handle now, but may be solved later.
- Standards could be introduced for functional requirements of AVs. Consideration is needed at various levels: Component level vs Vehicle level vs. System level. Functional safety case should be completed, but Operational safety case is more relevant. The best practice approach from particular organisations could be standardized.
- Further consideration of the definition of 'safe' is needed, and whether it is appropriate to consider human driving as a benchmark. Much depends on the appetite for risk.
- Processes are already in place for handling non-standard vehicles, which could be expanded for AVs.
- A catalogue of safety cases could be held by one organizations and shared with all to enable lessons to be learnt. This could be a centralised function.
- The safety case needs to consider and mitigate against the risks of deliberate sabotage.
- The safety case could look at steps for modifying ODD to make environment simpler. E.g. steps to reduce jaywalking.
- Test conditions should be created in a common, consistent and transparent manner? Rules established for industry test beds should be consistent with national rules.
- Consideration is needed as to how to keep authorities informed of updates and how to decide if the system is fundamentally different.
- The need for and role of a 'trials safety officer' should be considered.
- The safety case should identify relevant issues for the scenario and explain the "system" approach / response
- A near miss is a useful event for testing the technology, but they could be putting the public at risk.

Workshop Theme 3: International Regulations

Examples of the overseas practices and regulatory requirements were displayed, as detailed in Section 4 and Annex A of this report. Participants were asked to comment on whether the type of evidence required or general regulatory approach in other countries might be appropriate to the UK.

Much of the discussion centred around the list of 28 competencies that NHTSA has listed for traffic scenarios that an AV should be able to handle. The general consensus was that this list provided a good starting point, with caveats as detailed below.

- Any list should not be prescriptive – some scenarios will not be relevant, e.g. no need to be able to negotiate a roundabout if the ODD is restricted to motorways, and many of the competencies could become irrelevant if testing is only conducted at low speed. The list should therefore be seen as things to consider, not things to demonstrate. The result of the consideration may be to state how the scenario will be handled, or it may be to justify why it doesn't need to be handled.
- The list should not be seen as exhaustive – the emphasis should be on a thorough safety management plan which will highlight any scenarios that need to be covered, including those not on the list (this is in line with the Waymo approach as per the Safety Report published in October 2017, where they have added their own competencies in addition to the NHTSA list).
- It was noted by several participants that being able to perform all the manoeuvres on the list doesn't necessarily mean the vehicle is able to drive in a natural way to blend with human drivers (e.g. subtle communications by eye contact or positioning of the car, or the unwritten rule that everyone starts accelerating slightly before they enter a higher speed limit). However, nobody was able to suggest ways that this could be captured in a code of practice.
- There was broad agreement that the competencies covered in the safety management plan should include responding to mistakes and illegal manoeuvres by other road users – it was felt that whilst the list contains some scenarios along these lines (e.g. encroaching oncoming vehicle), this type of issue was under-represented and more scenarios should be considered.
- Some felt that the list needed to be more specific (e.g. what is a roundabout? Does it have multiple lanes? Traffic lights?), and some thought that the very existence of such a list was too prescriptive, but the majority view was that the list was broadly proportionate provided that it was acknowledged that the safety case should further decompose the scenarios into more specific/ detailed/ testable use cases, and that there should be flexibility to rule out the need to handle some scenarios and add in others, according to the ODD and the particular technology.
- It was suggested that the list should be broken up into normal driving scenarios (which would be very flexible according to the ODD) and abnormal scenarios (e.g. responding to emergency vehicles or to mistakes from other road users).
- It was observed that the list may need adaptation to be appropriate for UK roads, bearing in mind it was produced for the US, although no specific changes were identified as required.

Methods of approval were also discussed, and there was broad support for the principle of demonstrating competency with a safety driver present before any testing is permitted with a remote driver, and then if testing were to be done without even remote monitoring/ control of the vehicle, a certain amount of testing with a remote safety driver would first be appropriate. However, the consensus seemed to be that no specific test mileage requirements should be imposed for each stage, and it should be left to the entity managing the safety plan to determine what is appropriate.

It was suggested that if a remote driver is used, the safety plan should be required to address how the vehicle handles a loss of communication with the remote driver (e.g. regular checking of communication link, transition to minimal risk condition as soon as fault identified).

Using simulation technology to accrue mileage as part of the safety case was met with a mixed response; although it was acknowledged to be invaluable for development of the system, there were concerns about how virtual testing could be proven to be representative for validation purposes.

There was discussion of whether a system of regulatory approvals should be used as per current type approval, or whether self-certification backed up by the threat of punitive damages and product liability legislation should be adopted (the latter being in line with the US approach). The general consensus was that it would be impractical for regulators to set specific tests given the range of scenarios involved (although some felt there should be a set of tests to capture some of the more prevalent scenarios to at least gauge a reasonable level of basic competence), and that a self-certification approach would be needed, especially for testing (as opposed to commercial deployment). There were suggestions that a more stringent approach to punitive damages and product liability, in line with US practice, should be applied in order to enforce responsible behavior.

It was also suggested that the safety case should be required to address changes to the vehicle relative to the original type approval to ensure any changes do not result in a lowering of safety.

Workshop Theme 4: Public Perceptions

Findings from public opinion surveys were displayed, as detailed in Section 5 of this report. Participants were asked to comment on how public concerns can be taking into account when considering providing exemptions to Construction and Use regulations.

The main discussion points covered the public information and awareness of AVs, how to increase their trust in the technology as well as AV trials strategy.

Communication to road users (pedestrians, cyclists, other vehicles): Before the introduction of connected vehicles, AVs need to communicate to other non-connected (autonomous or not) vehicles, as well as other road users. Simple gestures like eye contact, waving to let someone go will not exist anymore. In turn, it was proposed to use LED lighting in front of vehicles to indicate intentions, or other forms of communication such as text banners, smileys etc.

It was felt that there is a need for more effort in public awareness, engagement and buy-in. In order to achieve this, AVs should be promoted at a national level (for example, what are AVs?) There are limited opportunities for public engagement with live trials.

The safety argument should be insisted on/stressed/highlighted more.

Social benefits should be highlighted, for example the potential accessibility benefits to elderly people, visually impaired people and those on low incomes that cannot afford to learn to drive and / or to own a car.

The public needs to experience riding in vehicles to understand how they work. This could help develop public trust. However, attendees debated whether the industry should adopt a transparent attitude about vehicle performances and limitations. It was suggested that in the event of an incident, the public and users should be informed that the vehicle makes the "best worst decision".

On the subject of communication of trial details perspectives were varied. The reluctant party suggests when details of a trial are released publicly, and vehicles are marked as 'self-driving', the data collected by AVs will not be accurate as other road users may behave in an unusual way, for example to try to test the or interfere with the trial.

Another approach could be to release high level details of the tests, but withhold the details, such as the exact timings. It was suggested that if there is an exemption to the regulations, this would probably be reported by the media. Therefore, it may be impossible to keep trial details withheld.

Designating areas of public highway for trials with appropriate signage could enable people to choose whether they enter a testing area or not. This would require public testing areas to be defined for which there are other route options for the travelling public.

It was agreed that a stakeholder engagement strategy should be carefully planned and managed. As well as informing the public and stakeholders, it could also build a body of evidence on how the public is reacting, be transparent about the vehicle performances and limitations.

Pedestrians and other road users may not benefit from the introduction of AVs, but may still be impacted by their introduction. The trials could consider how to mitigate any adverse impacts on other road users.

6.4 SUMMARY

The workshop outputs described above, along with desk based research and the one to one interview outputs were incorporated into the considerations for approving exemptions to The Road Vehicles (Construction and Use), as set out in Section 8.

7 SAFETY TESTS THAT ACHIEVE PARTIAL COVERAGE

7.1 INTRODUCTION

There are existing examples of European Union or United Nations Economic Commission for Europe (UN ECE) safety automotive regulations where it is acknowledged that it isn't feasible to conduct a test for every possible dangerous scenario, and therefore testing is carried out upon a limited subset capturing what is predicted to be the cases that carry the highest risk. This could therefore be seen as a precedent for AV regulations not attempting to cover every scenario but providing a reasonable overcheck. EuroNCAP test protocols, which have no regulatory status but have a strong influence through consumer pressure, are also relevant. A non-exhaustive list of examples are included in this section.

7.2 UN ECE REGULATIONS 94 AND 95

These regulations cover front and side impact crash testing respectively. These are key passive safety tests that are key passive safety tests that are expensive when bearing in mind the comparatively high costs of manufacturing prototype vehicles (relative to production vehicles), the destructive nature of the tests, and the need to do development tests prior to the final test that is witnessed for Type Approval. It is therefore recognised that it is not feasible for the regulator to assess every possible variant and version of each vehicle type. As a result, a particular configuration of vehicle is subjected to the physical test, which the manufacturer has agreed with the approval authority represents the 'Worst Case'. This decision is typically based upon simulation data, rather than requiring physical tests, as permitted by Article 11 of the EU Type Approval Framework Directive (2007/47/EC).

Furthermore, it should be noted that the speeds, geometries, masses and crash stiffnesses of the Offset Deformable Barrier that the test vehicle is propelled into for Regulation 94, and of the moving deformable barrier that is propelled into the test vehicle in Regulation 95, are optimised based on accidentology data to produce a generic crash representative of a high proportion of crashes resulting in death or serious injury in the real world. This could therefore be seen as another example of choosing a subset of cases to test that provides maximum coverage of the real world without being excessively onerous.

7.3 EUROPEAN UNION PEDESTRIAN PROTECTION REGULATION 78/2009/EC

Regulation 78/2009/EC sets out the required performance when impacted with a headform for two different zones. The Technical Service doing the tests will then select a number of points within each zone; there is no grid system, so a test point can be selected anywhere, and in practice is selected at points expected to be particularly challenging. The manufacturer is not required to provide any prior evidence to show performance at any test points. This provides a reasonable indication that the minimum requirements have been met, and a clear incentive for OEMs to ensure they can meet the standard at all points.

7.4 EURONCAP PEDESTRIAN PROTECTION PROTOCOL

The bonnet and bumper are marked with a grid and the manufacturer is required to provide information of how the vehicle will perform for each grid location – this may be derived from simulation and/ or from physical tests. EuroNCAP then choose test points based on expected worst-case positions (legform tests) or random selection (headform tests), to confirm the manufacturer data. Where there are discrepancies, a correction factor will be applied, up to a limit where further investigation will be required.

Relative to the previously described pedestrian protection regulation, the NCAP approach reduces the ability of the tester to target the suspected worst points to maximise the chance of uncovering any noncompliance, but provides a fairer means to compare different vehicles, which is important as EuroNCAP publishes the results to help inform buyer choice..

7.5 EURONCAP CITY AND INTER-URBAN AUTONOMOUS EMERGENCY BRAKING (AEB) PROTOCOL

This will, from 2018, require the system to respond to a static or slower moving car target not just at a range of speeds but also a range of overlaps (i.e. differing relative offsets between the two cars), creating a two-dimensional matrix of test scenarios. Manufacturers are required to provide data for each scenario, and then some scenarios are selected for testing at random to confirm the accuracy of the data provided. As per EuroNCAP pedestrian protection, a correction factor is applied to account for any discrepancy.

8 CONSIDERATIONS FOR APPROVING EXEMPTIONS TO C&U REGULATIONS

8.1 INTRODUCTION

The following considerations for approving exemptions to The Road Vehicles (Construction and Use) Regulations 1986 were derived from both the one to one interviews and the stakeholder workshop as summarised in Section 6, and desk based research.

8.2 MECHANISM FOR PROVIDING APPROVAL

Applications for exemptions to Construction and Use regulations could be examined and considered by an independent assessment panel, comprised of subject matter experts.

There are two key considerations to consider when appointing experts to the panel:

1. Impartiality – Whilst many large organisations already have procedures in place to maintain separation between teams so that one team is able to fairly and impartially audit the work of another team within the same organisation (indeed, such an approach is required under certain circumstances for functional safety standards such as ISO 26262), in practice there will always be a concern that there could be a bias, bearing in mind that any company having suitably up to date detailed knowledge of AVs is likely to either be involved in work with the organisation applying for an exemption, be interested in working with that organisation in the near future, or be impacted by that organisation or the consortia they are involved in as a competitor. In order to reduce the possibility of bias, and perhaps more crucially reduce the possibility of a perception or accusation of bias, it is therefore recommended that the panel should contain at least one representative from the public sector, who will be free from such bias. It is advised that this person should be of a technical background such that they are in a position to understand new technical information that is presented to them.
2. Cutting-Edge Knowledge - the technology involved in AVs is evolving rapidly and involves highly detailed technical information that is not readily available to those not actively working in the sector. This makes it difficult to maintain a suitable knowledge base within the public sector, as even if it proved possible to recruit suitably skilled personnel, their knowledge would quickly become obsolete once removed from the sector. It is therefore suggested that the panel should contain at least one representative from a company actively involved in the development of AVs, who should be someone with particular knowledge of AV safety.

By combining experts of different backgrounds within the team, it is possible to create a symbiotic relationship that overcomes, or at least reduces, the two concerns above; the industry experts can explain the key concepts to the public sector representatives to enable the latter to reach more informed conclusions, whilst the public sector representatives can ensure that the process is carried out fairly and without any bias.

It is also recommended that the panel should contain expertise on functional safety, cyber security and on verification/ validation testing methods (likely to be provided by industry), and expertise on the regulations that the vehicle would potentially be in breach of (likely to be provided by the public sector). No specific number of participants is recommended here as it is of limited consequence how many people are involved; what matters is that the panel covers all the required areas of knowledge. In theory all the above could be achieved by two people, one from the public sector and one from industry, if they have suitably diverse skillsets, but a suggestion for a typical panel would be:

- Panel Chairperson (representative from DfT or CCAV with experience of UK Road Traffic Regulations, a technical/ engineering background, and/ or an understanding of government policy in relation to CAVs)
- Other Public Sector Representative (with experience of any areas related to regulations, technology or policy that the Panel Chairperson is unfamiliar with. Could be an employee of DfT or CCAV, or some other public sector agency such as VCA or DVSA)
- Industry Safety Expert (could be from a manufacturer or a consultancy, must have recent experience of AV projects)
- Industry Testing Expert (could be from a manufacturer or a consultancy, must have recent experience of AV projects)
- Industry Cyber Security Expert (could be from a manufacturer or a consultancy, must have recent experience of AV projects)

It would be the responsibility of the organisation seeking the exemption to provide all the necessary information within their application. However, the process should be seen as iterative rather than a one-shot, pass/ fail assessment, and dialogue should be maintained and further information provided as required by the panel – this is of particular importance as it is not possible to enforce a standardised submission format at this point in time due to the rapid evolution of the technology and the diverse range of projects likely to be undertaken, making it more difficult for companies to know what information will be needed. It must also be borne in mind that updates to the approval may be required due to significant changes to the AV as the project evolves.

Once unanimous agreement is reached by the panel, the panel should make a recommendation to the Secretary of State to indicate whether they agree that a suitable level of safety has been demonstrated to allow the exemptions to be granted, and to state which regulations should be exempted and what, if any, requirements should be imposed in their place.

The panel should be provided with a detailed safety case for tests on public roads, which should include details described in Section 3 of this report. The panel could retain the right to ask for further evidence, and / or to witness physical testing of particular scenarios. It is likely that the scenarios chosen would be ones directly related to safety, e.g. response of the vehicle to a pedestrian stepping out in front could be tested in a similar manner to the Euro NCAP Pedestrian AEB tests. However, it is not appropriate to prescribe exactly what tests would be undertaken as it would depend on concerns related to the ODD and to the technology used, e.g. responding to pedestrians would be of minimal concern if testing is only going to be conducted on the motorway. Furthermore, the authorities should retain the right to ask for vehicles to be tested in a variety of ways to ensure that the vehicle must be developed to deal with a comprehensive range of scenarios that could be tested; this would avoid the risk that development could be optimised to the test if a limited number of test cases are prescribed, giving limited assurance that the vehicle will meet the same standard outside the test conditions.

In addition to examining the competence of the vehicle, technical experts should assess the quality of the process by looking for the presence and completeness of the following:

- a review of all applicable requirements from the Code of Practice, the Highway Code and aspects of Road Traffic Law.
- a hazard analysis and risk assessment,
- consideration of functional safety based upon established standards such as ISO26262 or IEC61508, and
- some means of conveying the overall safety argument, i.e. how all the pieces of evidence come together to make a compelling argument that the test will be conducted safely.

For each risk or regulatory clause, assessors would expect to see documentation of the proposed action to show how it is being addressed, together with verification testing data to show the measures proved successful, or a justification of why it isn't relevant. A Failure Modes and Effects Analysis (FMEA) or an equivalent would be expected to show how risks have been prioritised, and methods such as Fault Tree Analysis or Event Tree Analysis may optionally be used.

The applicant should clarify the insurance arrangements for the deployment. The decision to insure the trial by an insurance company could be viewed favorably by the panel.

8.3 EVIDENCE OF VEHICLE CAPABILITY WITHIN ODD

The AV developer's safety plan would be expected to include consideration of how much testing is appropriate before removing the safety driver. This should include real world testing in the intended ODD with a safety driver present – it is left to the AV developer to justify what number of miles or hours are appropriate to give confidence that the system is safe. Testing in the virtual domain or on closed roads may form a part of the evidence of safety, but will not be enough alone to demonstrate that the vehicle is safe to test without a safety driver onboard.

Independent verification at the detailed level of software and systems would not be required, but rather investigation of the overall system architecture and safeguards. It may be impossible to independently verify all evidence that is submitted to the panel, therefore the panel will need to make a judgement as to whether the AV developer's claims are genuine, but independent verification of the vehicle operating on a test track or under the supervision of the safety driver may be beneficial. This provides evidence of rather than proof of competency, but it would help in determining which AV developers are clearly not ready.

The safety plan should include consideration of how the vehicle can operate safely, legally and in a manner that is compatible with human drivers for all manoeuvres described within the UK Highway Code that are applicable to the ODD. It is advised that AV developers should produce a document considering each rule within the Highway Code in turn, to document whether it is applicable, and if so, how it will be met. AV developers should not view the Highway Code as being an exhaustive list of requirements; it is the duty of AV developers to identify any scenarios and risks that need to be addressed beyond the content of the highway code.

AV developers would be expected to explain in sufficient detail how their vehicle will handle 'typical' scenarios that would be expected to occur regularly or predictably without a safety driver. For example, it may be insufficient to be able to navigate 'a roundabout', the vehicle must be able to navigate all roundabouts within the ODD, and therefore consideration must be given to the range of configurations that may be encountered, such as multiple lanes, filter markings, traffic signals on the roundabout, queueing traffic, unusual roundabout configurations, etc, This is left to the manufacturer rather than being defined by Government as the challenges faced will vary significantly according to the ODD and the technology used.

It may be necessary to have a strategy for scenarios where communication is needed between road users, such as situations where nobody has a clear right of way (for example, when there is a car waiting on all entries to a mini-roundabout) or where road users let one another out of a side road through courtesy. In such situations, human drivers use gestures, eye contact or assertive driving to decide who should proceed first, and a strategy is therefore needed for how an AV will behave.

The AV developers will also need to be able to detail how their vehicle will handle 'atypical' scenarios which could occur at any time, such as objects falling onto the roadway, mistakes by other road users, presence of emergency vehicles, accidents in the vicinity of the AV, traffic being directed manually using hand signals (whether by police or public), vehicles encroaching onto the wrong side of the road, overtaking an unsteady cyclist, pedestrians stepping out at short notice, etc. The more unusual scenarios may be the most challenging to handle, for example, as stated by one stakeholder, the vehicle software may be able to detect and behave appropriately around a cyclist travelling in the same direction as the vehicle, but not if the cyclist is approaching the vehicle at a 45-degree angle having just left the footway. Care must be taken to justify the decision that an 'atypical' scenario lies outside the ODD and therefore needs no further consideration, as by their very nature the occurrence of such scenarios is less predictable.

As part of the specification of the ODD, the safety case should indicate what environmental conditions the autonomous system is intended to be able to operate in, and what conditions would be inappropriate. Consideration must be given to how to safely bring the trial to a halt if conditions change while the trial is in progress.

The list of evidence should consider best practice overseas, such as the vehicle competencies detailed in the US guidance, and should be based on a thorough Safety Case which would include all aspects of operation, communications, vehicle recovery etc, although this should be tailored to the specific operational design domain (ODD).

The UK Government should consider aligning requirements with those of other countries so that an AV developer can resubmit much of their safety case information various countries, and does not need to start from scratch for each country, although much of the information should be specific to the ODD of the country of the application.

8.4 REMOTE OPERATION

Progressing from testing with a Safety Driver present in the vehicle to testing with a Remote Safety Driver would require the following:

- How the vehicle will reach a minimal risk condition if communication is lost between the vehicle and the remote driver
- Cyber security measures to ensure that unauthorised third parties cannot interfere with the test, whether deliberately or accidentally
- What field of view requirements will be needed for a remote safety driver to be able to monitor and intervene for all relevant risks
- Controls a remote safety driver needs to mitigate risks. They may only need a single button to tell the vehicle to transition to a minimal risk condition, they may need to be able to take full control, or they may need some partial level of control, e.g. braking only or steering only – this will depend upon what particular risks the safety driver is providing back-up protection against
- How the system will allow the driver to intervene such that it won't fight for control, including consideration of what control inputs from the remote safety driver would result in the automated system disengaging

8.5 VEHICLE CONSIDERATIONS

Vehicle considerations will be a key component of the safety case, and should include the effect of any changes to a type approved base vehicle which would have a negative impact upon the passive safety of the vehicle, and a risk assessment should be conducted to determine whether any mitigating actions are required. This risk assessment should bear in mind that the balance of exposure to different crash types may be significantly changed. For example, passive safety regulations are very stringent for frontal impacts, but it may be determined that this is of less concern for an AV if it is expected to be less likely to drive into an obstacle head-on (since many such accidents are caused by the distraction of a human driver, which wouldn't be an issue for an AV). On the other hand, regulations are less stringent for the integrity of the vehicle if struck from the rear, but this may become a more prevalent crash mode for AVs if reaching a minimal risk condition sometimes involves stopping within the carriageway on roads where other vehicles will be travelling at speed.

AV developers must update the safety case to reflect any changes to the system that deviate from the evidence that has previously been presented. This includes changes to the safety case and also any changes to the sensors, processing, actuators or communications, including further learning of any deep learning artificial intelligence, that would mean that statistical data on robustness previously collected would no longer be representative of the vehicle being tested. The independent panel should assess whether updates require resubmission for approval.

The panel should assess how redundancy of systems is managed and how single points of failure are addressed with the removal of a safety driver. As mentioned by one stakeholder, the safety driver is not just a back-up brain, but also back up muscle that can apply brakes mechanically.

There could be a significant number of vehicles produced for running under trial conditions, which presents a challenge if each vehicle requires separate approval. In this situation the panel should consider assessment with sample vehicles and then investigating the quality assurance processes of the organisation to ensure other vehicles are produced to the same standards.

8.6 CLEAR DEFINITIONS

Some key terms require clear definition, such as 'near miss', 'operational design domain', 'manual intervention', etc. This becomes important for benchmarking if such metrics (such as near miss and manual intervention) are used as evidence of AV capability. Consistency will be required not just within the UK but also internationally.

8.7 CONFIDENTIAL VS PUBLIC

Applicants should be aware that any information held by the Department could be the subject of a Freedom of Information request. Any information presented by an applicant that is commercially sensitive should be marked as such, to help assess if the information falls within an exemption and can be protected from disclosure, if a request is made under the Freedom of Information Act that relates to the information.

Consideration should be given to whether the public should be informed about the tests in advance, and whether there should be signs demarking the AV during the test (or some other means of conveying its presence). The reasoning behind the decision should consider whether the public are able to mitigate risks through acting differently around the vehicle, and whether any affect upon behaviour would compromise the validity of any data collected.

It was felt by many at the workshop that more effort was needed into promoting the potential benefits of the technology which could help secure public support and cooperation for testing.

8.8 AV INCIDENTS

Appropriate Action at Time of Incident

Without a safety driver, there needs to be a process for ensuring that the vehicle detects when a collision has occurred and stops accordingly, and a procedure for communicating with others involved in the collision, such as exchanging insurance data after an accident or speaking to Police officers who have stopped the vehicle. Examples of solutions might include: escort vehicle following behind with an occupant who is able to assist, a telephone number to ring in an emergency clearly marked on the vehicle, any non-driving occupant being provided with information on what to do.

The vehicle also needs to be capable of responding to the instructions of police and traffic officers.

Mandatory reporting and Data Logging

AV developers will need to report collisions that their vehicles are involved in, and record sufficient data to enable the causes of those incidents to be investigated. This is already highlighted within the current code of practice. The reporting of "near misses" should be considered, although the definition of a near miss would require detailed consideration prior to this.

The above information could be supplemented with an annual report using a standardised format containing details of the AV performance during trials. This might include:

- The vehicles used
- Mileage of testing
- Number of hours of testing
- Number of incidents (collisions / near misses, etc)
- Number of times the vehicle has not performed as expected but no accident has occurred
- Number of times the driver has had to override the system (with a breakdown of reasons for override, e.g. unexpected event outside ODD, vehicle straying outside territory of ODD, failure to react to obstacle, failure to stay within lane)
- Number of times the system has disengaged or transitioned to a minimal risk condition in response to a fault

This information could provide useful indicators of AV performance and help with public reassurance, although there is a danger that requiring the reporting of such data might provide a perverse incentive for a trial participant to take risks in an attempt to try to improve the trail statistics, for example by not intervening when they should.

ANNEX A: INTERNATIONAL REGULATORY APPROACHES

INTRODUCTION

This study has reviewed the regulatory approaches taken by Governments around the world, which may help influence how the UK Government proceeds with adapting regulations. A review of the regulatory approaches across Europe, the USA and the rest of the world is included in this Annex.

Please note that this is an area where change is occurring rapidly, and as such the data presented here represents the legal climate, as accurately as it could be ascertained, at the time of conducting research for this report; the findings should be used judiciously for any future work and further research should be conducted where necessary to ensure that up-to-date information is used.

EUROPE

The UK has signed and ratified the 1949 Geneva Convention on Road Traffic, and is now in the process of ratifying the subsequent 1968 Vienna Convention on Road Traffic. The majority of EU member states have either ratified the 1968 Convention only, or ratified both the 1949 and 1968 Conventions (Republic of Ireland, Spain, and Malta have only ratified the 1949 Convention). Countries that have ratified one or both Conventions are obligated to ensure that their national laws comply with the requirements of the Conventions. The Global Forum for Road Traffic Safety, Working Party 1 of the United Nations Economic Commission for Europe (WP1), the UN body responsible for the Conventions, has agreed that they do not prohibit the testing of automated vehicle technologies.[16]

On the 23rd March 2016, a paragraph was added to Article 8 of the 1968 Convention, stating that driver assistance systems are permitted as long as the system can be "overridden or switched off by the driver"; this does not necessarilly mean that a full set of conventional driver controls are required, as long as some means to override and/ or switch the system off are accessible to a vehicle occupant. Rather than looking to amend the Conventions for automated vehicles, WP1 has opted to explore the creation of a Consolidated Resolution to provide guidance on the use of highly and fully automated vehicles in road traffic.[17]

It is seen that for partial and conditional automation-enabled vehicles, the role of the driver is still very important as they either perform all tasks or monitor the environment and act as a fall back in case of failure in the latter case (the supervisor role). For fully-automated vehicles such as taxi pods and autonomous shuttles, several trials have been carried in Europe, but always with a driver being close-by or a safety driver on board to react in case of system failure

Austria

The Austrian government has published a roadmap document[18] for AVs in Austria.

The Federal Ministry of Transport, Innovation and Technology is able to give permission to allow AV testing in contravention of the regulations if supervised by experienced test drivers, and this has been done to allow at least two trials. [19] [20]

Belgium

In Belgium, the Mobility Minister published a code of good practice for AV trials in September 2016. The code, which appears to replicate the themes of the UK Code of Practice, is considered guidance rather than a definite book of rules. A person must be present in the vehicle at all times in order to take control if necessary, and a report must be submitted to the authorities after each test. [21]

[16] https://www.unece.org/fileadmin/DAM/trans/doc/2016/wp1/ECE-TRANS-WP.1-153e.pdf
[17] https://www.unece.org/fileadmin/DAM/trans/doc/2017/wp1/ECE-TRANS-WP1-159e.pdf
[18] http://www.ecsel-austria.net/newsfull/items/automated-driving-roadmap.html
[19] https://www.avl.com/press-releases-2016/-/asset_publisher/AFDAj3gOfDFk/content/press-release-avl-testet-erstmals-selbstfahrendes-auto-auf-osterreichischer-autobahn?inheritRedirect=false&redirect=https%3A%2F%2Fwww.avl.com%3A443%2Fpress-releases-2016%3Fp_p_id%3D101_INSTANCE_AFDAj3gOfDFk%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-2%26p_p_col_count%3D1
[20] https://blogs.nvidia.com/blog/2017/08/23/testing-self-driving-cars/
[21] https://www.lecomparateurassurance.com/103363-e-assurance/108959-voiture-autonome-reglementation-france-europe

Denmark

In May 2017 the Danish parliament enabled pilot tests of AVs on public roads to be conducted. Each project is treated on a case-by-case basis and the project must be pre-approved by the Ministry of Transport. At present the law requires a driver to be on board.[22]

Finland

In Finland, testing of automated vehicles is possible through use of a test plate certificate. The driver can be inside or outside the vehicle and any liability falls under the driver, defined as the person who makes decisions on the movement of the vehicle. The applicant must enclose a trial plan that includes:

- A general description of the trials
- Technical specifications of the test vehicles
- Information on the road area where the trials are intended to be conducted
- Proof of insurance cover for third party liability
- Description of how road safety will be ensured.[23]

Related to testing in the Helsinki neighbourhood of Hernessari, the Finnish Transport Safety Agency interpreted compliance with the Vienna treaty driver requirement by ensuring a person is present in the AV, which doesn't have to have a steering wheel, to press the emergency brake in case of failure.[24]

France

In November 2017, the French Government introduced a law permitting the testing of AVs. The trial organiser must apply for cross-ministry authorisation, and the application process will be defined by an upcoming decree of the Conseil d'État. Testing is only authorised if the vehicles can be controlled or deactivated by the driver, or conform to the UN rules. While safety is the top priority, the details of any restrictions are not specified in the legislation.

The relevant article is included below. [25]

Germany

In May 2017 the German Parliament adopted a law permitting vehicle manufacturers to test AVs on public roads. The law required the presence of a supervising driver behind the steering wheel. Looking at a telephone is only permitted for vehicle monitoring purposes and the installation of a black box in the vehicle is required to assess who was in control in the event of collision. It is planned that this law will be revised every two years to adapt with the rapidly growing and innovative market and tests.

Highly and fully automated driving functions are not currently permitted. However, Germany has opened an AV highway, and the Federal Transport Minister has created an ethics commission.

The driver is permitted to take their eyes off the road and hand off the vehicle controls for L3 automation but the driver has to be able to takeover, or the machine has to have enough robustness to readjust or stop.[26] [27]

On the subject of the amendment to the Road Traffic Act, the Federal Ministry of Transport and Digital Infrastructure (StVG) states that a driver should still be on board but in the case of a fully AV, since the driver is only abiding by the new system, the liability falls under the vehicle manufacturer.[28]

A document has been published that clarifies that liability falls to the manufacturer.[29]

[22] https://www.twobirds.com/en/news/articles/2017/global/at-a-glance-autonomous-vehicles
[23] https://www.trafi.fi/filebank/a/1475139801/c715fc7cabf057b9320be4bbd6714cbe/22483-Testing_automated_vehicles_in_Finland_2016.pdf
[24] https://www.euractiv.com/section/transport/news/eu-countries-want-legal-change-for-driverless-cars-but-theyll-have-to-wait/
[25] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000032977611&dateTexte=20171107
[26] https://ocr.space/blog/2015/01/germany-plans-self-driving-cars-test-track.html
[27] http://auto2xtech.com/germany-to-make-legal-automated-driving-technology-that-allows-eyes-off-the-road/
[28] http://www.bmvi.de/SharedDocs/EN/PressRelease/2016/157-dobrindt-ethics-committee-automated-driving.html
[29] https://www.inverse.com/article/20716-germany-outlines-three-laws-of-robotics-for-self-driving-cars

Italy

The Italian Highway Code establishes that vehicles are driven by a human driver, which is incompatible with level 4 and 5 automated driving systems. The code is currently being discussed and could in the future permit highly automated driving.[30]

Netherlands

Innovation and transport play an important role in the Netherlands. The Ministry of Infrastructure and Environment (I&M) has opened the public roads to enable large-scale tests with automated passenger cars and trucks.

The procedure includes three organisations:

- The RDW (Netherlands Vehicle Authority), which coordinates permission for a field trial and is responsible for the vehicle component
- The CROW Taskforce Dutch Roads, and
- The SWOV which is responsible for the human behaviour

The Dutch cabinet has adopted a bill, which soon will enable experiments to be conducted with AVs without a driver being physically present in the vehicle.[31] The law governing the experimental use of AVs will enable companies to apply for a permit to conduct tests on public roads, with a human being ready to take command via remote control.

The RDW will decide on the safety approach to take for other vehicles on the road. For example, other drivers might need to be informed as to the possibility of encountering an AV.

AV testing organisations must first convince and demonstrate that the tests will be conducted in a safe manner. To that end, they need to submit an application through the National Vehicle Authority, the RDW for admission and go through the ITS admittance procedure.[32] Tests will therefore be investigated on a case-by-case basis.[33]

Spain

In November 2015 legislation was introduced to permit testing of fully AVs.[34]

In order to undertake tests on Spanish roads the AV testing organisation must comply with certain criteria, such being suitably insured, be accredited by the National Accreditation Body (ENAC) or provide evidence of an authorisation by another EU state member to conduct tests on public roads.

According to a draft report published by the General Directorate for Traffic (DGT)[35], because article 13 of the road traffic law does not state that a vehicle must be driven by a human driver and does not specify the term “driver” in detail, it is concluded that a machine can handle the steering and control of the vehicle, thus AV tests under the supervision or control of a person in full compliance with the law. Drivers are required to override in case of a system failure or malfunction. However it is acknowledged that further work is needed to determine the range of tasks permitted by the human driver. For the DGT the driver is still responsible for the vehicle until the system proves itself being capable to safely stop or operate safely on its own.

Sweden

Swedish law does not require the driver to hold the steering wheel and is believed to be compatible with level 1 or 2 automated driving. The legality of higher levels of automation is less clear, with issues relating to liability being a particularly difficult issue. However, the Swedish Transport Agency is able to issue permits to allow exceptions to be made if it is felt that a vehicle may not meet the regulations.

[30] https://www.twobirds.com/en/news/articles/2017/global/at-a-glance-autonomous-vehicles
[31] https://www.government.nl/latest/news/2017/02/24/driverless-cars-on-the-roads
[32] https://www.rdw.nl/englishinformation/Paginas/Method-admittance-procedure-ITS.aspx
[33] https://www.government.nl/topics/mobility-public-transport-and-road-safety/self-driving-vehicles
[34] http://www.gomezacebo-pombo.com/media/k2/attachments/are-all-systems-go-for-self-driving-cars-in-spain.pdf
[35] https://circabc.europa.eu/webdav/CircaBC/GROW/automotive/Library/GEAR%202030/Working%20Group%202%20%E2%80%93%20Highly%20automated%20and%20connected%20vehicles/Reference%20documents/Topic_%20Road%20Safety/2016-08-16%20Spanish%20contribution%20on%20road%20safety%20and%20testing.pdf

To obtain a testing permit, entities must:

- Explain how cyber security has been adequately addressed
- Explain how the right to privacy will be maintained and how personal data will be protected
- Accept criminal liability when vehicles are in self-driving mode (the driver will be liable when in manual mode)
- Submit information from the vehicle's sensors for investigation of incidents
- Report on how safety shall be ensured (may include reports on testing using private test tracks or simulators)

A permit may be issued along with a number of conditions to ensure safety isn't compromised, and may be limited to a specific road or area, or for a limited duration. The trials will be supervised by the Swedish Transport Agency, who can require remedial measures or revoke the permit if they become aware of shortcomings.

Volvo's DriveMe project aims to allow members of the public to operate a level 4 AV. The trial is a collaboration between Volvo, the Swedish Transport Administration and the Swedish Transport Authority, and is being used as a test for future law changes, which may help explain the flexible approach being taken by government. [36] [37] [38]

4.3 UNITED STATES OF AMERICA

The Effect of Litigation in the USA

Before examining specific legislation, it should be noted that the USA is an unusual marketplace in terms of product liability due to the comparatively widespread awarding of punitive damages – this means that in addition to compensating the plaintiff for their loss, the court is able to award an additional sum as punishment against the defendant. Although some other nations award punitive damages, they typically only do so under exceptional circumstances, and for lower sums of money.

The value of such punitive damages in the USA can often be far higher than compensation for loss suffered, meaning that being found liable for an accident in the USA can be exceptionally expensive. Large companies, or companies perceived to have acted particularly irresponsibly, are likely to have particularly high damages imposed.

This helps provide an incentive to ensure absolute compliance in areas where manufacturers self-certify, meaning that in practice, it is possible to ensure compliance with a less stringent testing approach than would be required in other jurisdictions. However, it must be borne in mind that manufacturers are understandably wary of such costly litigation, and that this legal climate could be seen by manufacturers as a reason to test elsewhere, even in cases where a laissez-faire approach is used for the regulations themselves.

By contrast, it may be the case that other jurisdictions feel that they need more stringent and / or detailed regulations to ensure a vehicle is safe before allowing it to be tested or deployed, in the absence of the fear of punitive damages. This may not necessarily be something that deters manufacturers looking to test, as having more stringent safety requirements may be more than compensated for by a more favourable litigation culture. [39] [40]

[36] http://self-driving-future.com/legislation/europe/
[37] https://www.drivesweden.net/en/news/sweden-proposes-very-progressive-legislation-self-driving-vehicle-trials
[38] https://www.unece.org/fileadmin/DAM/trans/doc/2014/wp1/Autonomous_driving_eng_short.pdf
[39] https://en.wikipedia.org/wiki/Punitive_damages
[40] https://www.law.cornell.edu/wex/punitive_damages

SELF DRIVE Act

The bill for this act is currently under consideration; having passed House review it goes to the Senate next and upon passing that would go to the president to sign. The title of the act is an acronym of 'the Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution Act', and it has three main aims: [41] [42] [43] [44]

- Block States from banning AVs (it should be noted that no states currently explicitly ban AVs, although some individual legislators have made such proposals)
- Grant exemptions to existing safety standards for a company's first 100,000 vehicles (previously this was limited to 2,500). However, manufacturers will be limited to 25,000 vehicles for the first year of operation and 50,000 for the next
- Require manufacturers to develop plans to thwart cyber attacks

The act is intended to smooth out the disparate state laws that currently exist, to aid innovation, and has received wide cross-party support. There are some objections from consumer groups that in the absence of regulation at federal level (bearing in mind that compliance with the National Highway Traffic Safety Admiration (NHTSA) guidance is entirely voluntary), states should be free to set their own standards to prevent a situation where the public have no regulatory safety protections at all.

It remains unclear at this stage whether the bill will be enacted, and how state legislation will be interpreted in terms of which clauses in state legislation would be affected by the pre-emptive status of the federal legislation. The act does make clear that it does not prevent states from effecting or enforcing any regulations relating to sale or repair / service of vehicles.

The bill requires research into updating Federal Motor Vehicle Safety Standards (FMVSS) to commence within 180 days of its enactment, and a 'rulemaking and safety priority plan' within 1 year of enactment. Within two years, the Secretary of Transportation is required to issue a final rule regarding safety assessment certifications, which must specify which entities are required to submit certifications, what test results and data would be required, and under what circumstances the certifications would need to be updated or resubmitted.

NHTSA's 'Automated Driving Systems – a Vision for Safety'

This was published in September 2017 to replace the previous system which involved manufacturers submitting a Safety Assessment Letter (SAL); the SAL approach is now no longer applicable. NHTSA state that they are already working on the next version of their Vision for Safety and will continue to make updates in the future, and therefore it should be considered a live working document.

The document is not a regulation, so compliance is entirely voluntary, although deviation from the guidance without a reasoned and documented justification could have implications regarding liability should a collision occur. The framework provided remains flexible due to the rapidly developing technology, and entities are encouraged to publicly disclose their self-assessments to aid public confidence. Entities are encouraged to also follow any applicable standards by bodies such as ISO, SAE etc.

[41] https://www.govtrack.us/congress/bills/115/hr3388
[42] https://www.congress.gov/bill/115th-congress/house-bill/3388/text
[43] https://www.wired.com/story/congress-autonomous-self-driving-car-regulations/
[44] http://thehill.com/policy/transportation/337640-senators-outline-driverless-car-legislation

NHTSA's guidance is subdivided into the following areas of focus:

1. System Safety
2. Operational Design Domain (ODD)
3. Object and Event Detection and Response (OEDR)
4. Fallback (Minimal Risk Condition)
5. Validation Methods
6. Human Machine Interface (HMI)
7. Vehicle Cybersecurity
8. Crashworthiness
9. Post-Crash ADS Behaviour
10. Data Recording
11. Consumer Education and Training
12. Federal, State, and Local Laws

These were among the original 15 aspects of the previous SAL approach; two particularly controversial parts of the last version – ethics and consumer privacy – were removed. Each of these aspects has design and / or testing guidance assigned to it, some key points of which are summarised below.

The design and validation process should include hazard analysis and risk assessment for the automated driving system, for the vehicle as a whole, and where applicable for the broader transport ecosystem. This must describe redundancies in the system and the strategies for safely handling system malfunctions. Significant emphasis should be placed upon software development, verification and validation, and the ODD should be specified to cover at least:

- Roadway types (interstate, local, etc.) on which the automated driving system (ADS) is intended to operate safely
- Geographic area (city, mountain, desert, etc.)
- Speed range
- Environmental conditions in which the ADS will operate (weather, daytime/night-time, etc.)
- Other domain constraints

Entities are expected to have a documented process for the 'assessment, testing and validation' of the system's OEDR (Object and Event Detection and Response) capabilities, and the system is expected to be able to detect and respond to other vehicles, pedestrians, cyclists, animals, and any objects that could affect safe operation. The OEDR should also include the ability to respond to foreseeable encounters such as emergency vehicles, construction zones or police manually directing traffic.

Entities are also expected to have a documented process for the assessment, testing and validation of a variety of 'behavioural competencies', i.e. the ability to operate within typical traffic conditions, and for crash avoidance capabilities in an emergency. Based on the ODD, an ADS should be able to address applicable pre-crash scenarios that relate to control loss; crossing-path crashes; lane change/merge; head-on and opposite-direction travel; and rear-end, road departure, and low-speed situations such as backing and parking manoeuvres.

Entities are encouraged to have a documented process for transitioning to a minimal risk condition when a problem is encountered; a minimal risk condition will vary according to the type and extent of a given failure. Adherence to best practice for the Human Machine Interface (HMI) design and for cyber security should be applied and documented.

Prior to on road testing, entities are encouraged to consider how much simulation and track testing is required. The occupant protection system on the vehicle should maintain its original performance level in the event of a crash, and methods to return the AV to a safe state immediately after a crash should be considered. It should be documented how the manufacturer intends to account for all applicable laws.

For each safety element laid out by the Voluntary Guidance, entities are encouraged to include an acknowledgment within the Voluntary Safety Self-Assessment that indicates one of the following:

- This safety element was considered during product development efforts for the subject feature; or
- This safety element is not applicable to the subject product development effort

The above only provides a brief summary of the full guidance; please see the original document for further information.[45]

State Legislation

There are currently 12 states that have legislation that permits testing without a driver either enacted or in progress, and 25 states where the legislation permits or will permit testing only where a driver is present – the remaining 13 states have no legislation referring to AVs (although no states explicitly ban AVs, making testing something of a grey area in these remaining states).

In general there are many common themes in the regulations; for example:

- The requirement for proof of insurance / self-insurance of at least $5 million,
- For drivers / remote operators to have correct license for that vehicle category,
- For clear HMI to indicate whether the vehicle is in automated or manual mode,
- Means to get to a minimal risk condition in the event of a fault (via safety driver or automated control via redundancy in the system), and
- Reporting requirements (typically accidents reported within ten days, and an annual report detailing mileage, accidents and disengagements due to system faults or driver override).

There are, however, many outliers; California is particularly interesting as they have a bill in progress with far more detailed requirements than other states, and some states have a particularly laissez-faire approach (e.g. Florida, Georgia, Nevada and Texas have legislation that allows commercial deployment of AVs, whereas other states only allow deployment for research and development purposes).

A summary of each state is provided below, along with links for more information.[45]

States Allowing Tests Without a Safety Driver in the Vehicle

Arizona permits the use of AVs on public roads via an Executive Order signed by the State Governor and allows testing where the operator is not present in the vehicle, provided that they monitor the vehicle and have the ability to intervene if necessary. [46]

California currently allows testing with a safety driver, and has passed bills allowing trials without a driver within a limited area for a limited duration, subject to a maximum speed of 35 mph. However, a draft regulation is being worked on that is expected to be finalised by the end of 2017 and approved in early 2018, which aims to free up the testing of AVs in order to regain ground perceived to have been lost to other states.

[45] https://www.nhtsa.gov/automated-vehicles/vision-safety
[46] http://azgovernor.gov/file/2660/download?token=nLkPLRi1

The new regulations will allow testing with or without a safety driver, and will allow a remote driver to provide a safety backup. The regulation is particularly detailed relative to other states, providing a lot of useful information, which is summarised below: [47]

- Allows testing with safety driver in vehicle or remote safety driver
- The manufacturer must conduct the testing themselves
- Insurance/ self-insurance of $5,000,000 required – may be insurance certificate, a surety bond or a certificate of self-insurance
- The manufacturer must have applied for and been granted a permit
- The manufacturer must provide the DMV (Department of Motor Vehicles) with make/ model/ year, vehicle identification number and license plate
- Testing must be carried out in a controlled space before progressing to public roads (no mention of how many miles are required or what evidence is provided)
- No trailers, motorcycles, or vehicles over a mass threshold are allowed
- If no driver is in the vehicle, the manufacturer must provide details of the following to local authorities: the ODD, a list of roads used, date test begins, date and time when test will be on public roads, number of vehicles, contact info
- The manufacturer must certify that they'll assume liability for any collisions where the AV technology is at fault
- If the vehicle is monitored remotely, it must have two-way communication and the possibility to intervene
- The manufacturer must provide information to emergency services on how they can communicate with the remote operator, how to remove the vehicle from the roadway, how to recognise when in automated mode (and disengage it if possible), description of ODD, any other info the manufacturer deems necessary
- The manufacturer must maintain training program for remote operators and certify that each operator has received sufficient training. The syllabus must be provided to the DMV.
- The manufacturer must disclose to any passenger that is a member of the public what information will be collected on them and how it may be used
- Any collisions must be reported using an official form within 10 days, including details of all persons involved and description of how the collision occurred
- The manufacturer must monitor disengagements from the moment permit is issued, and provide annual report including location, automation mode, description of facts, party that initiated disengagement (vehicle, driver, passenger, remote operator). This report must also include total automated mileage for each vehicle each month
- If a vehicle is not equipped with manual controls, the manufacturer must provide evidence of exemption that has been approved by NHTSA

Florida's legislation, passed in 2012 and updated in 2016, declared the intent to encourage AV development and rules that the state does not prohibit or explicitly regulate the testing or operation of AVs. There are no requirements limiting testing on public roads or requiring the presence of a driver in the vehicle (the requirement for a driver in the vehicle was removed in the 2016 update), and any driver only has to have a valid driver's license. The vehicle must obey all traffic laws. [48]

Georgia allows regular operation as well as testing, with or without a driver present, and no longer even requires a driver's license for the operator. If operating without a driver, the vehicle must be capable of reaching a minimal risk condition in the event of a failure within the system. [49]

[47] https://www.dmv.ca.gov/portal/wcm/connect/f0a611ed-9579-44a3-ac0b-85d9508f53d9/15DayExpressTerms.pdf?MOD=AJPERES
[48] https://www.flsenate.gov/Session/Bill/2016/7027/BillText/er/PDF
[49] http://www.legis.ga.gov/Legislation/20172018/170801.pdf

Louisiana is currently considering a bill to allow AVs with or without a safety driver. The vehicle must be capable of reaching a minimal risk condition in the event of a failure and of operating in compliance with road traffic laws. The manufacturer must certify that the vehicle was in compliance with all FMVSS standards at the time of manufacture other than where exemptions are granted and must provide proof of insurance or self-insurance. Each vehicle must be registered as an AV with the state. [50]

Michigan has passed legislation to allow the use of AVs with or without a driver for research testing. Before conducting tests, the manufacturer must provide proof of insurance, and it must be possible for an operator to monitor the vehicle and intervene where necessary; this operator must hold a driving license and must be employed, contracted or authorised to operate the vehicle by the manufacturer. [51]

Nevada allows autonomous vehicles for testing or normal operation, with or without a driver present. This legislation was passed in June 2017 and contains provisions for registering vehicles, reporting accidents (within 10 days if accident involves personal injury or property damage in excess of $750, and allows AVs to be used for commercial purposes subject to certain requirements being met. [52]

North Carolina allows the operation of a fully autonomous vehicle without a driver present provided that the vehicle is able to reach a minimal risk condition. Operators are not required to hold a driving licence. An adult must be present in the vehicle if there are any passengers under 12. The act, which will become effective in December 2017, would allow use for testing or general use. [53]

Pennsylvania has hosted a significant amount of AV testing in Pittsburgh through Uber and Carnegie Mellon University. An act was passed in 2016 to allow testing where the safety driver monitors and is able to control the vehicle remotely. Companies wishing to test must enter into a contract with the state and must provide proof of insurance. The bill gives the Department of Transportation powers to establish more detailed requirements later, e.g. technical requirements or restrictions of geographical area. Any accidents must be reported within 10 days, and an annual report on AV testing must be provided. [54] [55]

Tennessee introduced an act in June 2017 that allows testing without any driver supervision, subject to certain conditions, including the ability to bring the vehicle to a minimal risk condition in the event of a failure. The act also allows manufacturers (but not other companies) to undertake projects involving making the vehicles available to the public. Manufacturers must provide proof of insurance up to $5 million, and any non-manufacturers doing testing must have insurance for far higher amounts (dependant on claim type). [56]

Texas allows use of AVs for testing or commercial deployment. Operators are required to have a valid licence, but the owner of the vehicle will be considered liable regarding compliance with local traffic laws – the law doesn't required manufacturers to test the vehicles, and the state's DOT and local authorities are prevented from requiring any special permit. The vehicle must be capable of complying with local traffic laws, able to respond to system failures, equipped with a recording device, insured, and registered in accordance with state laws. The act was passed in September 2017. [57]

Washington allows testing of pilot programs for AVs on public roads, with or without a safety driver on board. There is no requirement for remote monitoring/ control, only that the vehicle must be capable of reaching a safe condition in the event of failure and the vehicle must be able to operate in compliance with state vehicle laws. Companies developing AVs are required to provide proof of financial responsibility and to self-certify compliance with the requirements. This is the result of a June 2017 Executive Order. [58]

[50] http://www.legis.la.gov/legis/ViewDocument.aspx?d=1031238
[51] https://www.legislature.mi.gov/documents/2015-2016/publicact/pdf/2016-PA-0332.pdf
[52] https://www.leg.state.nv.us/Session/79th2017/Bills/AB/AB69_EN.pdf
[53] https://www.ncleg.net/Sessions/2017/Bills/House/PDF/H469v7.pdf
[54] http://www.legis.state.pa.us/CFDOCS/Legis/PN/Public/btCheck.cfm?txtType=PDF&sessYr=2015&sessInd=0&billBody=S&billTyp=B&billNbr=1268&pn=1835
[55] http://www.penndot.gov/ProjectAndPrograms/ResearchandTesting/Documents/AV%20Testing%20Policy%20DRAFT%20FINAL%20REPORT.pdf
[56] http://wapp.capitol.tn.gov/apps/BillInfo/Default.aspx?BillNumber=SB0151
[57] http://www.legis.texas.gov/tlodocs/85R/billtext/pdf/SB02205F.pdf
[58] http://governor.wa.gov/sites/default/files/exe_order/17-02AutonomouVehicles.pdf

States that have Passed Legislation Related to AVs that Doesn't Allow Testing without a Safety Driver Present

Alabama has established an executive committee via executive order, as of May 2017), to examine the possibilities for testing AVs within the state. There is no legislation yet. [59]

Arkansas has legislation to facilitate truck platooning but no further automated driving legislation.

Colorado allows testing with a human present provided that the vehicle complies with all traffic laws. Approval is needed if the vehicle is unable to comply with any state or federal laws.

Connecticut has passed a bill allowing fully autonomous vehicles to be tested, but specifically requires that a trained safety driver must be present in the vehicle and ready and able to intervene. This was introduced in June 2016. [60]

Delaware has an Advisory Council to investigate and make recommendations upon the introduction of AVs, as per an Executive Order from the governor in September 2017. [61]

Hawaii has passed an act requiring authorisation for an AV testing program no later than January 2018 and an application and approval process to be in place by January 2019. At a minimum, manufacturers will be required to provide evidence of: safety features (including a manual override), ease with which the operator can activate and deactivate the autonomous system, the applicant's safety record and the applicant's insurance or financial bond. [62]

Idaho is debating a bill to allow testing of AVs with a safety driver present. The driver would have to be employed/ contracted by the manufacturer or testing organisation, at least 18 years old, hold a valid license, be seated in the driver's position, and ready and able to take control if needed. The ACS must be able to be engaged and disengaged easily and give clear feedback to indicate its current status, must give a warning to the driver in the event of a technical failure, and must be able to be overridden by inputs to the brakes, accelerator or steering wheel. All roads may be used unless specifically prohibited due to safety concerns (e.g. schools, construction works). [63]

Illinois has passed an act to prevent local authorities from prohibiting the use of AVs. There are no provisions to allow vehicles without a driver and no specifications for what qualifications a safety driver should possess; the act contains very little detail.

Maryland has passed an act (July 2017) that will allow the Motor Vehicle Administration (MVA) to introduce regulations relating to AVs. The MVA is therefore expected to provide further information in future; the act passed contains do further details. [64]

Massachusetts allows AVs but requires a safety driver to be present. A working group has been set up to further investigate AVs. This is the result of an Executive Order from the Governor in October 2016. [65]

Minnesota was considering a bill to investigate possible legislation for AVs in 2013. However, no progress appears to have been made since then. It is thought (see second reference) that AVs are likely to be legal in the state under pre-existing laws, in the absence of any specific legislation, but there is a lack of clarity, which may explain why it isn't a major test location. [66] [67]

Nebraska is currently considering a bill to allow AV testing, and debating what level of regulation is appropriate. The state currently does not allow testing of AVs. [68]

New Hampshire is currently considering a bill to allow testing of AVs, which as drafted would require an operator inside the vehicle with a means to easily engage or disengage the autonomous system. [69]

[59] http://alisondb.legislature.state.al.us/ALISON/SearchableInstruments/2016RS/PrintFiles/SJR81-enr.pdf
[60] https://www.cga.ct.gov/2017/ACT/pa/2017PA-00069-R00SB-00260-PA.htm
[61] https://governor.delaware.gov/executive-orders/eo14/
[62] http://www.capitol.hawaii.gov/session2017/bills/HB1596_.htm
[63] http://legislature.idaho.gov/sessioninfo/2015/legislation/S1108/
[64] http://mgaleg.maryland.gov/webmga/frmMain.aspx?pid=billpage&stab=01&id=SB9&tab=subject3&ys=2017rs
[65] http://www.mass.gov/governor/press-office/press-releases/fy2017/exec-order-signed-on-automated-driving-technologies.html
[66] https://www.revisor.mn.gov/bills/bill.php?b=House&f=HF1580&ssn=0&y=2013
[67] https://conservancy.umn.edu/bitstream/handle/11299/172963/9%20MJLST_v162_Peck_843-878.pdf?sequence=1&isAllowed=y
[68] https://www.manufacturing.net/news/2017/03/auto-industry-urges-caution-nebraska-autonomous-car-bill
[69] http://www.gencourt.state.nh.us/bill_Status/bill_status.aspx?lsr=0411&sy=2017&sortoption=&txtsessionyear=2017

New Jersey is considering an act that would allow the use of AVs for testing only, and a driver holding the appropriate license must be present in the driver's seat and ready to take control. The manufacturer must provide insurance/ self-insurance/ a surety body of $5,000,000. Testing is not permitted until an application has been submitted and approved – this application must include certification that the technology can be easily engaged and disengaged by the driver, that there is clear indication of the status of the system (on/ off), that the vehicle can either alert the driver or safely stop itself in the event of a technology failure, that the vehicle will allow the operator to take control by multiple means (at least brake, accelerator, steering wheel), that the vehicle with the automated technology complies with federal and state law applicable at the time of the vehicle's model year, and that an Event Data Recorder is fitted and able to store at least 30s of data prior to a collision event. [70]

New York will allow testing of AVs, following an announcement from the state's governor in May 2017. However, the requirements are comparatively restrictive; tests will have to be overseen by the police (with the manufacturer having to pay for the police to attend), manufacturers will have to submit detailed reports to the state, a $5,000,000 insurance policy will need to be in place, and tests are prohibited in near to schools or construction works. A person holding a valid driver's license must be present in the driver's seat at all times, and the test must follow a pre-arranged route. [71]

North Dakota passed an act in January 2017 requiring further study on how to support the introduction of AVs into the state. Legislators believe testing AVs is not prevented by the existing laws, and felt a study was a better way to indicate to manufacturers that they're open for testing, rather than risking stifling innovation through regulations. [72]

Oklahoma is considering a bill to allow operation of AVs on all highways within the state; this bill requires the Department of Public Safety to adopt regulations to set a minimum standard for the vehicles and their operation, together with insurance requirements. It is therefore unclear at this point whether a driver will be required to be present. [73]

Oregon is considering a bill to allow the operation of AVs with an operator in the driver's seat ready to take control. This operator must have the correct class of license. It must be possible for the operator to easily engage or disengage the automated system, with visual indication provided to show the current status. In the event of a system failure, the vehicle must alert the driver, and must bring the vehicle to a stop if the driver does not take immediate control. The vehicle must meet all federal and state standards applicable to its model year, and must have an EDR that backs up at least 30s of data. [74]

South Carolina has an act allowing AVs, but requires an operator to be present in the vehicle, monitoring the test, and ready and able to intervene if necessary. This operator must be certified by the manufacturer and must have a special license endorsement from the state to cover AV testing. The vehicle must contain lettering of a minimum size signifying that it is autonomous. The bill has been at the committee stage for a long time now, and it's unclear when and if progress will be made. [75]

South Dakota has tabled a bill for AV testing; however, no progress appears to have been made since 2014. [76]

Utah passed an act in March 2016 requiring a study to further evaluate appropriate regulatory strategies, safety standards and best practices for AVs. Further regulations may therefore be expected in the future. [77] [78]

Vermont has passed an act requiring the Department of Transportation to convene a meeting of stakeholders with expertise in AVs and to make recommendations upon future legislation.

Virginia will only allow testing within specific "Virginia Automated Corridors", and has no provisions for testing without a safety driver. Virginia passed an act in January 2016 to allow visual displays of moving images to be displayed while a vehicle is in autonomous mode. [79]

[70] http://www.njleg.state.nj.us/bills/BillView.asp?BillNumber=A3745
[71] https://www.governor.ny.gov/news/governor-cuomo-announces-autonomous-vehicle-testing-begin-new-york-state
[72] http://www.govtech.com/transportation/Lawmakers-opt-for-study-not-regulation-of-unmanned-vehicles.html
[73] http://www.oklegislature.gov/BillInfo.aspx?Bill=SB202&session=1700
[74] https://olis.leg.state.or.us/liz/2017R1/Measures/Overview/HB2461
[75] http://www.scstatehouse.gov/sess120_2013-2014/bills/4015.htm
[76] http://sdlegislature.gov/Legislative_Session/Bills/Bill.aspx?Bill=139&Session=2014
[77] https://le.utah.gov/~2016/bills/static/HB0280.html
[78] https://le.utah.gov/interim/2016/pdf/00004126.pdf
[79] http://lis.virginia.gov/cgi-bin/legp604.exe?ses=161&typ=bil&val=hb454&submit=GO

Washington D.C. allows the testing of AVs provided there is a driver in the control seat who is prepared to take control at any moment. The act limits liability upon manufacturers of original vehicles that have been converted, and states that vehicles must be no more than 4 years old at the time of conversion, or of a model year 2009 or later, whichever is nearer. [80]

Wisconsin has created (via executive order) a steering committee to advance the testing of AVs in the state (as of May 2017), but has no legislation as yet.

OTHER NATIONS

Australia

Australia is active in encouraging AVs, including altering regulations where necessary. This is led by the NTC (National Transport Commission), who have produced well-structured documentation, including a policy paper[81] "Regulatory reforms for automated road vehicles" as well as candidate guidelines for AV trials. However, prior to new legislation being enacted, the NTC position is that the driver remains responsible for the actions of a highly-automated vehicle, and it will not be possible to test without a driver present until the legislation changes.

AVs cannot operate legally in highly or fully automated modes, and therefore testing organisations require state or territory road transport agencies to provide exemptions or permits. These agencies have a responsibility for road safety and must therefore ensure that safety is managed appropriately and incidents are investigated. Entities are required to follow the guidelines in order to gain an exemption, but merely 'encouraged' to follow the guidelines if no exemptions are needed.

The guidance covers aspects such as clearly mapping the exact trial route and any traffic management plans, infrastructure requirements etc., providing a high level description of the technology being tested, demonstrating appropriate insurance, and providing a safety management plan created with reference to applicable standards such as ISO 26262. The safety management plan should include:

- Cyber security
- Risks to other road users (especially vulnerable road users)
- Risks to road infrastructure, system failure/ fallback options
- Transition processes into and out of automated states
- Whether a human driver is present in the vehicle (a specific exemption would be needed to test without a human)
- Pre-trail testing (e.g. at a closed track)
- Training provided for the driver/ operator
- Fitness for duty of the driver/ operator
- Whether the vehicle will be identified as an AV to other road users (e.g. signage)

Canada

Like the US, law-making responsibilities in Canada are split between federal and local (provincial and territorial) authorities. The federal government has produced a document on AVs, covering the status of the technology and key policy issues, and has started to develop a regulatory framework for AVs. Legal authority for trials and deployments of AVs rests with the provinces and territories, and so far, Ontario is the only one that has an AV test framework. As well as defined requirements for a license for on-road trials, the province has already granted three licenses to AV operators. [82] [83]

[80] http://lims.dccouncil.us/Download/26687/B19-0931-SignedAct.pdf
[81] http://www.ntc.gov.au/roads/technology/automated-vehicles-in-australia/
[82] http://www.mto.gov.on.ca/english/vehicles/automated-vehicles.shtml
[83] http://canada.autonews.com/article/20160216/CANADA/160519825/pilot-program-allows-autonomous-testing-in-all-10-provinces-but-...

Ontario requires:

- A human driver ready to take over
- The driver must hold the appropriate license for the vehicle being tested
- $5,000,000 of insurance
- The vehicle to be manufactured/ equipped by an approved applicant
- The vehicle to comply with SAE Standard J3016 and the Motor Vehicles Safety Act
- The driver and owner to be liable for all applicable penalties under the Highway Traffic Act

Further details are provided at the links below.

China

The Chinese Government halted trials of AVs on public roads in August 2016, stating it wants to issue new regulations, which will ensure the safety of the public, before allowing trials to start again. Manufacturers are keen for the government to draft these new regulations as soon as possible. In the meantime, China has designated a 5km square 'pilot zone' to test their regulations; this zone could expand to 100 square km within a few years. [84]

India

In contrast to efforts by other nations to encourage the testing and deployment of AVs, the Indian government has announced it will ban AVs in order to protect jobs. Testing may be possible in the interim, before legislation to prohibit it can be introduced, but no manufacturers have shown any interest as the Indian road infrastructure is particularly challenging for AVs, and would need improving for testing to be possible with the current state of the art of AVs. [85] [86]

Japan

Japan has non-regulatory guidelines for testing AVs without needing prior approval. They require a driver and an ACS-monitoring passenger to be in the vehicle, and suggest an iterative approach starting with private facilities, and using quieter public roads before moving to busier and/or more hazardous environments.

No permission is needed before tests can take place. However, partner vehicles should accompany the test car with a sign attached to inform other road users of the tests. The driver must confirm in writing that they accept liability for any accident.

The Japanese Prime Minister has targeted making the 2020 Tokyo Olympics a showcase for AVs; this would require changes to current legislation if SAE level 3 or above is to be used, as the current requirement for constant monitoring of the system is consistent with level 2. [87]

Japan is pushing for regulation of AVs to be done internationally via harmonised UN standards, and is concerned about the USA's current policy of creating legislation nationally as it gives them an opportunity to gain an advantage commercially and means that other nations might find themselves forced to develop their AV regulatory approaches in line with the USA. [88] [89]

[84] https://jalopnik.com/chinas-ban-on-autonomous-vehicle-testing-on-highways-co-1784066702
[85] https://www.autocarindia.com/industry/nitin-gadkari-states-no-autonomous-vehicles-for-india-405503
[86] https://www.motoring.com.au/india-to-ban-autonomous-cars-108231/
[87] https://www.theglobeandmail.com/globe-drive/culture/commuting/japan-aims-to-show-off-autonomous-vehicles-at-2020-summerolympics/article36971226/
[88] http://www.autonews.com/article/20161106/OEM06/311079960/japan-inc.-steps-up-autonomous-drive-push
[89] https://www.japantimes.co.jp/news/2016/04/11/national/self-driving-vehicle-tests-wont-need-permission-to-use-public-roads-say-npa-guidelines/#.Whf5TUlvjIW

New Zealand

While New Zealand has not yet had any AV trials on its territory, it has a very supportive framework in place to allow for tests. The government has published a brochure on testing AVs in New Zealand, pointing out that existing laws cover AV tests anywhere in the country, and do not require the operator to be in the vehicle. However, there is uncertainty around liability in the event of a crash.

The Ministry of Transport considers that, between the Police's general powers to ensure public safety, and the specific powers of the New Zealand Transport Agency to place conditions on the operation of vehicles (when the vehicles need permits to operate on our roads), there are sufficient controls in New Zealand to ensure the safety of testing of AVs on public roads.

Testing can potentially take place on any road within the country. Anyone undertaking testing should hold appropriate levels of public liability and professional indemnity insurance to protect against the risks associated with testing. The driver must hold the appropriate class of license and the vehicle must conform to New Zealand's Land Transport Rules. It is recommended that a safety management plan is submitted to the NZ Transport Agency containing at least the following: [90] [91]

- A description of the technologies being tested
- A description of testing already undertaken and test performance
- The testing plan, schedule and methodologies
- Safety management accountabilities, lines of responsibility, and fail-safes
- Risk and hazard identification, and planned management actions
- Completed and planned staff safety training and drills
- An incident register, and exception reporting methodologies

Further information is provided at the links below.

Singapore

Singapore's Land Transport Authority (LTA) has supported at least two trials of AVs in the city-state, and amendments to the road traffic act (passed Feb 2017) will allow the LTA flexibility to adapt to evolving technology. These new laws allow authorities to exempt drivers from responsibility for the actions of an AV while the ADS is engaged.

The Minister for Transport will now be allowed to create new rules which can place time and space limits on the AV trials, set standards for the design of the AV equipment, and impose requirements to share data from the trials.

The regulations are only valid for five years, after which the ministry will consider enacting more permanent legislation or extending the term of the current legislation. [92] [93]

Developers must:

- Demonstrate basis roadworthiness by passing safety assessments before the vehicles are allowed on the road
- Have robust accident mitigation plans – this could include use of a safety driver with the necessary license, but the need for a safety driver can be waived if the AV competency has been satisfactorily proven
- Start on lightly used roads; once competence has been demonstrated, the test can move on to more complex environments
- Log travel data for accident investigation/ liability purposes

[90] http://www.transport.govt.nz/ourwork/technology/specific-transport-technologies/road-vehicle/autonomous-vehicles/
[91] http://www.transport.govt.nz/assets/Uploads/Our-Work/Images/T-Technology/Testing-Autonomous-Vehicles-in-New-Zealand.pdf
[92] http://statutes.agc.gov.sg/aol/search/display/view.w3p;page=0;query=DocId%3Aba3acbce-2ce4-4b3f-8011-5bfae19cfbbc%20%20Status%3Ainforce%20Depth%3A0;rec=0#pr6C-he-.
[93] http://www.channelnewsasia.com/news/singapore/regulations-in-place-to-ramp-up-driverless-vehicle-trials-in-sin-7622038

South Korea

South Korea has an active programme of AV tests, supported by new legislation defining the parameters required for trials. These include mandating two drivers in the vehicle, adequate closed-road testing, technical requirements including a speed limiter and incident recording equipment, and evidence of insurance. Recent amendments have enabled trials to no longer be limited to specific areas, and can take place in all areas other than 'safety zones'.[94][95]

[94] http://english.molit.go.kr/USR/BORD0201/m_28286/DTL.jsp?id=eng0301&cate=&mode=view&idx=2632
[95] https://www.forbes.com/sites/elaineramirez/2017/02/07/how-south-korea-plans-to-put-driverless-cars-on-the-road-by-2020/#19d266cf448f

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