Written evidence submitted by the University of Warwick (SDV0046)

INTRODUCTION

About me

Dr Siddartha Khastgir CEng MIMechE

I am the Head of Verification & Validation, Connected & Automated Vehicles, WMG, University of Warwick, UK and a member of the Department for Transport's Science Advisory Council (SAC) [1].

I have a diverse portfolio of industrial experience in the automotive sector in different parts of the world: India at Tata Motors, Germany at FEV GmbH and now in the UK, leading multi-cultural teams to deliver large commercial projects successfully.

I am currently the lead researcher for WMG various collaborative research and development projects related to Self-Driving vehicles. (Including - DfT LSAD GB Assurance work package 2 and 3, Transport Canada funded validation of simulation, StreetWise, OmniCAV, SAVVY, and UKIERI funded - Safety of AI).

In September 2019, I received the UK Research and Innovation (UKRI) Future Leaders Fellowship. My Fellowship is titled - "Enabling a Novel Evaluation Continuum for Connected & Autonomous Vehicles (CAV)" and was on Forbes 30 Under 30 2018 Europe – Industry list.

Organization: **WMG, University of Warwick, UK**

About WMG, University of Warwick, UK

The University of Warwick is a world leading university with the highest academic and research standards. The University is consistently ranked in the top 10 universities in the country and in the top 50 internationally. WMG is an academic department at Warwick focused on applying research and skills to the challenges of our industry and social partners. We are a leading international role model for successful collaboration between academia and the public and private sectors, driving innovation in science, technology and engineering. In the last Research Excellence Framework (2021) which assesses quality and impact, 93% of WMG's research is world leading/internationally excellent. As WMG is particularly focused on Real World Impact, over 60% of our impact submissions have received the highest rank of 'world-leading'.

WMG has a significant portfolio of research in Intelligent Vehicles, and we are considered the centre of excellence for connected and automated vehicle research. Our multidisciplinary approach, including cooperative driving systems, connectivity, human factors and verification and validation, enables a full understanding of the practical applications that will help shape the future of transport mobility.

Are you responding to this consultation in a personal capacity or on behalf of your organization?

In a personal capacity.

As a member of Department for Transport's Science Advisory Council (SAC) and Head of Verification & Validation, Connected & Automated Vehicles, WMG, University of Warwick, UK.

Our Response

Our response focuses on the following aspects of the consultation:

- **safety and perceptions of safety**
- **the regulatory framework**
- **the role of Government and other responsible bodies**

Background

The scale of the opportunity of Self-Driving Vehicles (SDVs) is a question of projections, dependent on assumptions about the speed to market deployment, the potential for service-related sales, impact on the overall vehicle market, regulatory controls and other limits.

For this reason, projections for the economic impact of SDVs can also vary significantly, with McKinsey (2016) suggesting an increase of 30% in global automotive revenue by 2030[2], with new services representing a global $1.5 trillion dollar market, while the UK's own self-driving vehicles strategy projects a global £750 billion market by 2035, with a UK market share of 6% representing £42 billion and creating up to 38,000 new jobs in the sector[3]

Given that these projections depend on a number of unknowables about future market performance and uptake, and often vary in their definition of which technologies and markets are included in the study, it may be wiser to look at a range of projections for the future market development of automated vehicles rather than making a single projection.

A useful summary of the current range of projections can be found M. Alonso Raposo et al, (2022)[4], which collects together a number of studies looking at the impact of self-driving and automated vehicles, and taking their analyses as a whole. The scale of the opportunity varies dependent on a high or baseline uptake is projected, but the opportunity is measured in the hundreds of billions for the Automotive and data sectors, and in the tens of billions for the electronics and software sectors. In addition, the authors project a decline in insurance market revenues, driven by the expectation that self-driving vehicles will be safer, and therefore less expensive to insure, than the driver-operated vehicles and fleets of today.

1. Safety and Perception of safety

Safety remains the biggest challenge for commercialization of the self-driving vehicle (SDV) technology [5, 6]. Safety or perceived safety of self-driving technology has a correlation with the development of trust and acceptance in the technology [7]. This has been demonstrated by a variety of studies in the UK and internationally [8,9], suggesting the country agnostic nature of the impact of perceived safety on public acceptance.

Thus, in order to unlock the huge commercial potential of the self-driving technology (mentioned earlier), it is essential that the government and the SDV ecosystem focusses on answering the safety challenges of the technology.

However, if we are serious about the **safe** introduction of SDVs, then all stakeholders in the self-driving technology field (self-driving technology developers, vehicle manufacturers, fleet service providers, regulators, policy makers etc.), **need to focus on:**

- **Setting high standards for safety assurance**
- **Not competing on safety of self-driving vehicle technology**

The **UK has a potential to demonstrate global leadership** in both these aspects by creating and **sharing exemplar approaches** for both.

The UK has historically had a strong collaborative approach to new technology development.
For SDV technology, it is critical that all methods and data related to safety, or which can help improve safety of the technology are shared across the ecosystem. There already exist some case studies where industry (in the UK and internationally) are collaborating in this way. The Safety Pool™ Scenario Database [10] (developed by WMG and Deepen AI), is the world's largest public store of scenarios and aims at creating an ecosystem where organisations share test scenarios. It has also been presented at the UNECE VMAD forum for consideration as a global database [11], demonstrating UK's global leadership.

1.1. Safety: Building blocks

In order to prove that self-driving vehicle (SDV) technology is safe, research and regulation is needed in three key areas:

- **Test Scenarios**: A test scenario illustrates the situations a SDV will experience during its deployment in real world. Understanding of these situations is key to designing a safe SDV.
- **Test Environment**: A test environment is the platform in which the SDV software undergoes testing. Test environments can be a combination of hardware, software, real-world infrastructure, and data. They can be wholly computer based, or a constrained real-world setting like a test track, or in an unconstrained real-world environment.

- **Safety argument**: A safety argument provides the link between safety evidence and the safety claim (i.e., the system is safe to use). The safety evidence is obtained by executing the test scenarios in the test environment. The collected evidence can be used to create the safety argument proving that the self-driving system is a safe system. This will entail comparing against ***"defined safe behaviour"*** and ***"defined safety benchmarks"***.

1.2. ODD

One of the fundamental steps in assuring the safety of self-driving vehicles (SDV) is to define their **"Operational Design Domain" (ODD)** [12]. ODD means establishing in which conditions a SDV is intended to be competent to operate. (e.g., type of roads, weather conditions etc. it can safely operate within). In simpler words, ODD defines the capabilities and limitations of the SDV. ODD definition therefore influences each of the three elements (scenarios, test environment and safety argument) needed to prove that the system is a safe system, as it defines both the conditions in which a system is intended to be self-driving, and those conditions in which manual control will be required.

The UK has demonstrated global leadership in the area of ODD in both the research and standardization. BSI PAS 1883 [13], one of the initial publicly available specification released by the British Standards Institution under the Centre for Connected & Autonomous Vehicles (CCAV) funded Programme, went on to become the de-facto global standard for ODDs and has been the foundation of an on-going ISO standard on ODD definition[14]. WMG is proud to have led both these initiatives.

As ODD definition is fundamental to the safety assurance of SDVs, we recommend that the Department for Transport and its ALBs, mandate a minimum level of detail in an ODD definition from SDV developers.

1.3. Perceptions of safety

We believe that safe deployment of self-driving vehicles (SDVs) will be a combination of **safety technology** and ensuring **safe use of technology**.

Research has shown that users of self-driving technology need to develop an accurate understanding of the system's capabilities and limitations to enable them to use the technology in a safe manner. We call this ***"informed safety"*** [15]. Having *informed safety* enables users to create an accurate mental model on how to ***safely use*** the technology. It is the responsibility of the SDV developers to impart this knowledge on to the users. This will include an accurate understanding of the ODD of the SDV by the user which suggests that the ODD needs to be defined in an accessible manner for the end user.

There are instances in industry where naming of current driver assistance systems can be misconstrued as a "self-driving" system e.g., Autopilot, Highway pilot etc. Misrepresentation of the capabilities of automated systems has popularly been referred to as ***"autonowashing"*** [16].

Along with the SDV developers' responsibility to educate the user, we believe the government also has a role to check and promote consumer awareness. We fully support the Law Commission's recommendations on Automated Vehicles (now adopted by CCAV), which explicitly mentions the misrepresentation of automated vehicle capabilities as a *"criminal offence"* (Recommendation 34) [17].

CCAV through their AV-DRiVE initiative and together with SMMT have published guiding principles on marketing and representation of self-driving technologies.

However, we believe more elaborate guidance and robust checking mechanisms are needed to prevent *autonowashing* in the UK. We recommend a minimum level of detail be mandated about system capabilities and limitations from SDV developers, which needs to be presented in an accessible manner to the end user.

1.4. Cross domain learnings

In addition to self-driving vehicles (SDVs), the UK has also had a major focus on introducing automated transport solutions in aviation and maritime sectors, e.g., the Future Flight Programme [18] and the marine autonomy programme [19].

Every transportation domain (marine, aviation, and land) in their introduction of automation-based solutions (e.g., SDVs, aerial drones and automated ships) is facing, and will face the same set of safety challenges [20]. Concept of ODD (initiated in land) are now being adopted by EASA (European Union Aviation Safety Agency) for aviation [21] and in marine. Furthermore, the qualification process of virtual test environments used in aviation is now being adopted in the land domain as part of the UNECE VMAD's credibility assessment framework [22]. Marine and aviation have long had an accident investigation boards, and this is now being adopted by land with the announcement of the UK's new Road Safety Investigation Branch [23].

We recommend the government should create an industry-academia-government body responsible for safety assurance of automated transport systems as a cross-domain activity, leveraging learnings from land, aviation and marine.

2. Regulatory framework

We believe that policy and regulatory decisions can be used as **both interventions as well as enablers for introducing self-driving vehicles (SDVs)** safely for public benefit. For SDV technologies, it is imperative that DfT checks unsafe introduction of technology to ensure public trust.

2.1. CAVPASS

On 18 Aug 2022, HM Government released its Connected & Automated Mobility 2025 roadmap illustrating the government's plans to creating the UK's regulatory framework for self-driving framework by 2025 [24]. It talks about the CAVPASS programme [25] which is supposed to create technical standards and regulations to ensure safe and secure deployment of SDVs. The 2025 roadmap mentions about the Law Commission's recommendations being taken onboard and the timelines for primary and secondary legislation for SDVs.

However, most of the Law Commission's work has focused on primary legislation. We believe that from an industry and deployment perspective, **more certainty and maturity is needed on the secondary legislation and the subsequent creation of the technical requirements for the SDV** developers to follow.

The UK is currently lagging behind on publishing the technical requirements for SDVs as other regions and organisations have already come up with theirs. The European Commission adopted its EU Act for Automated Driving Systems on 5 Aug 2022 [26]. France has also been working on its set of technical requirements based on the EU requirements [27].

We recommend, in the near-term, the Department for Transport and its Arm's Length Bodies (ALBs) need to publish technical guidance on the requirements for SDVs (and the approach being taken to create them).

2.2. UK's international influence and leadership on regulations

The UK plays an active role at the United Nations Economic Commission for Europe (UNECE)'s World Forum for Harmonization of Vehicle Regulations (WP.29) which created the UN Regulation 157 [28] for Automated Lane Keeping System.

However, the UK historically lags the translation of research outputs from various Collaborative R&D projects [29] into policy or regulatory technical requirements.

This is slowly changing through the work led by the DfT's International Vehicle Standards (IVS) who commissioned research work on LSAD Type Approval Scheme. Outputs from this activity have already influenced and been adopted at the UNECE working groups. These include the work on ***codification of the rules of the road*** [30] and an ***ODD based method for scenario generation***.

We recommend that the DfT and CCAV take a more pro-active role in translating research outputs into UK national standards and using them as foundations for international standards and regulation. Thus, demonstrating UK's global influence.

3. Role of Government and other responsible bodies

Self-driving vehicle (SDV) is a complex system with emergent behaviour. Furthermore, policy creation for SDVs need to consider the interconnected systems within the SDV ecosystem. This requires a *systems thinking* approach to both development of the SDV technology and the policy creation for it.

Unfortunately, most systems thinking activities tend to restrict the system boundaries to the technology itself. If we aspire for SDV technologies to have a positive impact on our lives and deal with climate change issues, **it is essential we consider the "user", i.e., the public as a part of the system**. Moreover, if we adopt a true systems thinking approach, inclusive and accessible products and services will automatically get created, rather than being an afterthought.

As Chair of ITS UK's User-Behaviour Forum, we are advocating the need for the ITS (Intelligent Transportation Systems) community to adopt a true systems thinking approach. For strong and robust policy creation, the government workforce needs to be equipped with the right skills. The **Government Office for Science has published a *"systems thinking for civil servants"* toolkit** in May 2022 [31] which provides systems thinking guidance (tools and methods).

We recommend the DfT and other responsible bodies (including ALBs) be upskilled on application of system thinking methods and need to take a true systems thinking approach (with user, i.e., public, as a part of the system) for safe and secure deployment of SDVs.

4. Our recommendations

In summary, our recommendations to the committee are the following:

- Safety of self-driving vehicles needs to be **pre-competitive**.
- Take a **cross domain (land, marine and aviation) approach** to safety
- Focus on creating ***Informed Safety*** and preventing ***autonowashing***
- **Strengthen UK's global leadership on setting strong regulations** by taking a proactive approach to creating strong home-grown regulation and using them as foundations for international standards and regulation.
- **True system thinking approach** to safety of self-driving vehicle technology

In case you would like to have further clarification or information, please do not hesitate to contact us.

August 2022

Endnotes

---

[1] Department for Transport's Science Advisory Council: https://www.gov.uk/government/groups/dft-science-advisory-council

[2] McKinsey, https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/disruptive%20trends%20that%20will%20transform%20the%20auto%20industry/auto%202030%20report%20jan%202016.pdf

[3] Connected and Automated Vehicles: market forecast 2020, Connected Places Catapult (2021). https://www.gov.uk/government/publications/connected-and-automated-vehicles-market-forecast-2020

[4] María Alonso Raposo, Monica Grosso, Andromachi Mourtzouchou, Jette Krause, Amandine Duboz, Biagio Ciuffo, 2022. Economic implications of a connected and automated mobility in Europe, Research in Transportation Economics, Volume 92, 2022, 101072, (Accessible here: https://doi.org/10.1016/j.retrec.2021.101072)

[5] Koopman, P. and Wagner, M., 2017. Autonomous vehicle safety: An interdisciplinary challenge. IEEE Intelligent Transportation Systems Magazine, 9(1), pp.90-96.

[6] Rezaei, A. and Caulfield, B., 2020. Examining public acceptance of autonomous mobility. Travel behaviour and society, 21, pp.235-246.

[7] Khastgir, S., Birrell, S., Dhadyalla, G., & Jennings, P. (2018). Calibrating trust through knowledge: Introducing the concept of informed safety for automation in vehicles. Transportation research part C: emerging technologies, 96, 290-303.

[8] Stilgoe, J., 2021. How can we know a self-driving car is safe?. Ethics and Information Technology, 23(4), pp.635-647.

[9] Körber, M., Baseler, E. and Bengler, K., 2018. Introduction matters: Manipulating trust in automation and reliance in automated driving. Applied ergonomics, 66, pp.18-31.

[10] https://www.safetypool.ai/

[11] https://wiki.unece.org/download/attachments/161841516/VMAD-SG1-23-03_20220516_SafetyPool_VMADSG1_SUBMITTED.pdf?api=v2

[12] https://www.sae.org/standards/content/j3016_202104/

[13] https://www.bsigroup.com/en-GB/CAV/pas-1883/

[14] HM Government, 2022. Connected & Automated Mobility 2025: Realising the benefits of self-driving vehicles in the UK

[15] Khastgir, S., Birrell, S., Dhadyalla, G. and Jennings, P., 2018. Calibrating trust through knowledge: Introducing the concept of informed safety for automation in vehicles. Transportation research part C: emerging technologies, 96, pp.290-303.

[16] Dixon, L., 2020. Autonowashing: The greenwashing of vehicle automation. Transportation research interdisciplinary perspectives, 5, p.100113.

[17] Law Commission of England and Wales, Scottish Law Commission, 2022. Automated Vehicles: joint report

[18] https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/future-flight/

[19] https://www.gov.uk/government/consultations/future-of-transport-regulatory-review-maritime-autonomy-and-remote-operations

[20] Cross Domain Safety Assurance Framework for Automated Transport Systems: https://warwick.ac.uk/newsandevents/pressreleases/new_report_outlines/

[21] EASA Concept Paper: First usable guidance for Level 1 machine learning applications A deliverable of the EASA AI roadmap: https://www.easa.europa.eu/sites/default/files/dfu/easa_concept_paper_first_usable_guidance_for_level_1_machine_learning_applications_-_proposed_issue_01_1.pdf

[22] https://wiki.unece.org/display/trans/VMAD-31st+SG2+session

[23] https://www.gov.uk/government/speeches/road-safety-investigation-branch-launches

[24] HM Government, 2022. Connected & Automated Mobility 2025: Realising the benefits of self-driving vehicles in the UK

[25] CAVPASS: https://www.gov.uk/guidance/connected-and-automated-vehicles-process-for-assuring-safety-and-security-cavpass

[26] Regulation (EU) 2019/2144: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12152-Automated-cars-technical-specifications_en

[27] https://www.ecologie.gouv.fr/en/automated-vehicles

[28] UN Regulation 157: https://unece.org/sites/default/files/2022-05/ECE-TRANS-WP.29-2022-59r1e.pdf

[29] The Centre for Connected & Autonomous Vehicles has invested over £200 M in research and test-bed facilities in the UK

[30] https://wiki.unece.org/download/attachments/161841375/FRAV-27-06.pdf?api=v2

[31] https://www.gov.uk/government/publications/systems-thinking-for-civil-servants