Centre for Accident Research
& Road Safety - Queensland
(CARRS-Q)
Queensland University of Technology
130 Victoria Park Road
Kelvin Grove QLD 4059 Australia

Phone **+61 (0)7 3138 4905**
Fax +61 (0)7 3138 7532
Email carrsq@qut.edu.au
Twitter @CARRS_Q
Facebook www.facebook.com/carrsq130
ABN 83 791 724 622 | CRICOS 00213J

CARRS-Q is a joint venture initiative of the Motor Accident Insurance Commission and Queensland University of Technology

Mr Paul Retter AM

National Transport Commision

Level 3/600 Bourke Street

Melbourne VIC 3000

Dear Mr Retter

Since 1996 the Centre for Accident Research and Road Safety Queensland (CARRS-Q) has grown to become one of the world's leading institutions in road safety research and the premier trainer of road safety researchers and practitioners. Through its high-quality research, training and advocacy, CARRS-Q has had a major impact on road safety policies and practices at state and national levels, through both government and industry linkages.

CARRS-Q is a joint venture initiative of the Motor Accident Insurance Commission (MAIC, QLD) and Queensland University of Technology (QUT), and is conducting major research in the area of Connected and Automated Vehicles.

CARRS-Q is part of a new European Union funded project (H2020) directly relevant to this consultation. The project, called Levitate, aims to prepare a new impact assessment framework to enable policymakers to manage the introduction of connected and automated transport systems, in order to maximise the benefits and utilise the technologies to achieve societal objectives. Knowledge from the Levitate project will help Australia to forecast impacts of ADS and form new evidence-based approaches to policy-making.

As researchers involved in the legal, regulatory and social issues related to connected automated vehicles, we are very pleased to have an opportunity to make a submission to the NTC's Consultation Regulation Impact Statement (RIS) on Safety Assurance for Automated Driving Systems.

The following members of the academic staff at Queensland University of Technology (QUT) have contributed to the submission by QUT

- Professor Sébastien Glaser – Professor in Intelligent Transport Systems, CARRS-Q
- Professor Andry Rakotonirainy – Professor in Intelligent Transport Systems, CARRS-Q
- Dr Andy Bond – Director Future Mobility, CARRS-Q

Please find enclosed the CARRS-Q response to the RIS.

Yours sincerely

Brisbane 11/07/2018

A. Raky

Professor Andry Rakotonirainy – Acting Director, CARRS-Q

Introduction

Red flag laws were road safety laws enacted in the 19th century in the US and UK. This law required early adopters of automobiles to not exceed 5km/h and have a pedestrian to precede all "horseless carriages" waving a red flag as a safety precaution.

The policy makers of that time had certainly the best of intentions to assure the safety of its citizens. Looking back, with the safety knowledge we have today, such laws might not have a high cost-benefit ratio. However, the situation that they had in the 19th century is not different to the Automated Driving System (ADS) policy issues we are facing today. Authorities in charge of transport are constantly challenged to understand the implications of new technology on mobility and safety policies with the view to identify the most effective measures to achieve wider societal objectives; minimizing harm while we embrace the future. New evidence-based approaches to policy-making are necessary. However, as ADS are not yet in widespread use then there is no readily available data and knowledge upon which to construct such evidence-based approaches. ADS are disruptional; therefore future impacts cannot be determined from historic patterns. Furthermore, projections of future impacts of ADS may be based on forecasting approaches such as simulation, yet there is currently no agreement over the methodologies or baselines to be used to validate such approaches.

How best to achieve safety of all road users in an environment featuring a mix of human and semi/highly automated vehicles is a complex research question. Fully automated ADS vehicles (SAE[1] Level 4 or 5) are a reality within a well constrained setting. Their profitability will depend on consumers' perception, opinions and attitudes. ADS technology, and the knowledge about how road users interact with ADS is not yet mature, preventing ADS stakeholders from accurately assessing potential safety risks. There is currently an underwhelming number of Field Operational Test (FoT) studies involving ADS. Most of the FoT studies focus on ADS at SAE level 2 or 3.

ADS will disrupt mobility models[2]. It is widely predicted that ADS (SAE level 4, 5) will cause a shift away from personally owned vehicles due to financial and convenience reasons. The real impacts of ADS may come from the integration of ADS within a broader transport service called Mobility as a Service or MaaS[3]. In such a scenario, most of the ADS are likely to be owned by fleet managers and rented to individuals. As such, the safety assurance management procedures will likely be different from privately owned vehicles as hypothesised in this RIS. For example, safety assurance will be simpler and more affordable to manage at the corporate level compared to at the privately owned, individual level. In a scenario where MaaS would be the norm, safety policy in general, and safety assurance in particular, might be taken out of the hands of regulators and monopolised by private MaaS operators. Note that the direction toward a specific scenario (privately owned or shared vehicle with ADS) still depends on public awareness and on the trust in automation.

CARRS-Q considers that Option 4 in the RIS is the best option, as it is the one that provides the highest safety benefit. Safety assurance for ADS should be sustainable. It should strike the right balance between protecting our community from harm/injury, providing fair access to ADS to everyone, catering for uncertainty of ADS development, catering for the uncertainty around human machine interactions, and catering for uncertainty around road user's acceptance and trust of ADS.

The future adoption and deployment of ADS is fraught with uncertainty, and more agile planning and policy can help properly contend with this fact. Most importantly, acknowledging such uncertainties, safety assurance should

[1] Society of Automotive Engineering, J3016, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

[2] Future Cities: Navigating the new era of mobility. Michigan Economic Development Corporation, Center for Automotive Research, 2017

[3] KiM - Paths to a self-driving future: Five transition steps identified - Netherlands Institute for Transport Policy Analysis = 2015

not be too restrictive and discourage technological innovation and early adopters. Safety assurance should also adopt the safe system principles as described by the National Road Safety Strategy.

Responses to consultation questions

2. What other factors should be considered in the problem statement?

Problem 1: ADS must be inclusive and provide a benefit for all

To ensure a high level of safety, the modern ADS architectures rely on hardware (dedicated data buses, engine control unit) and software redundancy. Different sensor technologies (radar/ lidar/ camera) are used. It is expected that the initial price of a fully automated ADS (SAE level 4 or 5) by about 2025, will add up to $13,000 to the price of a non-automated vehicle[4], and will decrease at a rate varying from 4% to 10% per year. Moreover, the road and digital infrastructure must evolve to support ADS (accurate mapping, V2I communication support, lane marking …) to improve ADS performance and reliability. ADS cannot be completely autonomous. It will require a mechanism to cooperate with the environment and the other road users in order to share the road safely. Given the cost of deploying such technology, the ADS may not bring the expected benefits as it will not be financially viable for the population most in the need of such a system (e.g. older drivers, children, the disabled).

Problem 2: ADS generates new technological risks that are not yet known or managed

The Vienna convention states that "Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive." ADS will replace a set of driving functions or will replace them completely in the case of Level 5 automation. Therefore, the hardware and software in the ADS should be subjected to the same "fitness" requirements in performing driving tasks. Hence, ADS should be "fit" to sense the environment and have the "intelligence" to make decisions and perform safe path planning tasks. This sensing mechanism introduces new safety related risk during the lifecycle of the vehicle. The safety assessment criteria to determine whether an ADS is deemed fit to be on the road is not comprehensively addressed in this RIS.

ADS will feature highly sensitive/fragile sensors and actuators. They will require continuous monitoring including self diagnostic and self healing mechanisms. The different scenarios (p.19) describe safety risks that could arise from deploying ADS. In the full suite of vehicle operation, several important scenarios are missing and highlight these requirements for continuous self diagnosis and self healing:

- Scenario 4 may be extended with the following one: after a crash resulting in minor vehicle damage (scratches), what appears to be cosmetic damage could actually result in sensors' (e.g. camera) loss of calibration/ decrease of performance that cannot be detected by current ADS. This could deteriorate the safety performance of the ADS.
- Scenario 7: Mechanical parts in the sensors (e.g. Lidar) may move due to vibrations during its lifecycle. As a result, the calibration of the sensors deteriorate slowly over time and may result in a large discrepancy when fusing signals between sensors.

Data fusion is acknowledged as the core approach to build new Safe architectures[5]. The quality of data relies on the type and characteristics of sensors (e.g. LIDAR sensors are accurate in distance measurement, Cameras perform

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[4] Xavier Mosquet, Thomas Dauner, Nikolaus Lang, Michael Rüßmann, Antonella Mei-Pochtler, Rakshita Agrawal, Florian Schmieg, "Revolution in the Driver's Seat: The Road to Autonomous Vehicles", 2015, https://www.bcg.com/publications/2015/automotive-consumer-insight-revolution-drivers-seat-road-autonomous-vehicles.aspx

[5] Ömer ¸Sahin, Stefan Hörmann, Bernd Schäufele, and Florian Kuhnt, "Automated Vehicle System Architecture with Performance Assessment", 2017 IEEE 20th International Conference on Intelligent Transportation Systems (ITSC)

well in obstacle identification, …). The accuracy of ADS also relies on the calibration of sensors[6]. Variations of the extrinsic parameters for the calibration may result from vibrations, small collisions or even road conditions such as potholes. Slow variations of these parameters are even difficult to estimate as they may be within the range of the error of one of the fused sensors. At long range, the variation in the extrinsic parameters may generate mis-understanding, for instance by merging the road lanes, detected by a camera, and the position of possible obstacles from a radar.

The full lifecycle of the ADS must be managed and clearly addressed in the safety assurance, along with an estimate of the cost related with the maintenance of such systems. Given the lifetime of a car, the ADS and related components such as sensors and specifically software, will face several technological evolutions, rapid obsolescence and harsh operational conditions. The ADS and its components must be able to self-diagnose, and be calibrated at a regular interval. The experience in other domains where the equivalent of ADS has been used over a long period, such as aeronautic, may be investigated.

4. To what extent have the community and industry expectations of a regulatory response been accurately covered?

The expectation of the research community is not well covered by the RIS, with regard to access to the data (see our response to question 7 below). Issues related to fairness in access to ADS and associated services are also not covered. It has been shown that the access to ADS and associated services (e.g. Mobility as a Service, MaaS) might provide societal and economic advantages. ADS will provide major public health benefits, by preventing crashes, optimizing mobility and reducing emissions. It will provide a new form of mobility independence to a demographic who could not have had access to such a service in the past (e.g. people without a driving license). Given that ADS deployment will require significant investment in infrastructure and vehicles, its access will be gradual. Such a transition period could potentially introduce inequality. Each community might have access to ADS with different levels of sophistication, resulting in different degree of mobility, safety and comfort benefits. There is a risk that only privileged users and/or communities could afford them. Rural and remote communities are unlikely to be the early beneficiaries of ADS.

Human factors issues are not adequately addressed by the RIS. Research and discussion about ADS is focused on the technology (e.g. level of SAE automation). Technological approaches to operations and safety issues are well documented. However, there is a need to examine how the human is incorporated in this ecosystem as the technology advances. For example, how rules, training and road users' interaction issues should be adjusted as the market penetration of highly automated systems in all modes of transportation increases. A safety assurance system based on a mandatory self-certification approach is a good step forward, however the current RIS heavily focuses on the vehicle itself and there is a need to have a broader "safe system" approach.

To illustrate this assertion, one of the most prestigious international conferences in this field, Transportation Research Board, had only 21 articles related to human factors and human machine interaction out of 204 articles related to Connected Automated Vehicles. These 21 articles mostly cover topics such as:

- Driver interaction: situation awareness, Human Machine Interface,
- Recognition of vulnerable road users: detection and tracking,
- Use of the ADS: implication in term of mobility and economy,
- ADS behavior: path planning and optimal control

[6] Koyel Banerjee, Dominik Notz, Johannes Windelen, Sumanth Gavarraju and Mingkang He, "Online Camera LiDAR Fusion and Object Detection on Hybrid Data for Autonomous Driving", 2018 IEEE Intelligent Vehicles Symposium (IV), Changshu, Suzhou, China, June 26-30, 2018

Only six articles address the problem of interaction (detection, decision) between road users and ADS. This is even worse for technical high level conferences as IEEE Intelligent Vehicle where only 25 articles out of 346 are related to human factors (mostly for the driver monitoring and recognition of vulnerable road users) and less than 2% address the problems of interaction (detection, decision) between road users and ADS. Human related factors such as acceptability, trust and future use are still poorly tackled by the ADS research community.

ADS is still perceived as science fiction because they are not widely available for public scrutiny. Furthermore, recent media coverage has focused on a few high profile automated car crashes that exacerbate the public perception that ADS are inherently unsafe and not to be trusted.

5. Are the four options clearly described? If not, please elaborate.

The extent of the primary safety duty requires further clarification. Section 3.5.3 stated that it is administered by a national body and triggered by an accident, near miss or other behaviour. How a national body (e.g. Police) is called upon after a crash event is clear. However, the mechanism to trigger it when a near miss or other behaviour occurs requires further explanation. For example, how do we define "near miss and other behaviour", and also how will national bodies be notified of, and manage, such an event?

Moreover, the concept derived from the Workplace Health and Safety (WHS) will ensure that safety standards increase over time as technology and practice improve, but does not highlight the impact on the existing users/early adopters (maybe as an extension of scenario 6, page 19).

6. Are the proposed safety criteria and obligations on ADSE[7]s (detailed in chapter 4 and Appendix C) sufficient, appropriate and proportionate to manage the safety risk?

Safety risks are not yet well understood due to the uncertainty of the future of ADS.

7. Are there any additional criteria or other obligations that should be included?

When SAE level 4 and level 5 crashes occur, the main concerns are to identify and understand the succession of events (similar to black box in aviation). Looking at the architecture of ADS, a failure may occur at the (i) sensing, (ii) understanding, (iii) deciding or (iv) controlling level. The low-level control of the actuators is not in the scope of this RIS as it is already managed at the level of the vehicle platform. For level (i) to (iii) it must be possible to ascertain the signals and specific processing that have led to the action/s from the ADS. Then, all the high-level understandings of the environment and also the low-level signals must be stored and be made explicit in the data recording.

Data recording is essential, not only for crash investigation but also for the whole research community (robotics, human factors, road safety …) to progress the field of ADS. Data recording must be comprehensive (and transparent) enough to explain the workflow from sensing to decision.

From the research community point of view, driving behaviour data is also essential to train machine learning algorithms. Machine Learning algorithms is a section of Artificial Intelligence (AI) where we let machines learn from data. Machine learning algorithms will play a major role in future ADS architectures (e.g. google cars). A large amount of data (Big data) is necessary to properly train deep learning algorithms which is increasingly being used in vehicles to detect hazards and to react to them. The driving behaviour dataset and the associated machine

[7] Automated Driving System Entity

learning will be used to improve ADS safety, provided that there are clear criteria establishing that the algorithm has correctly learned relevant and safe driving behaviour.

14. Are there any specific regulatory costs to industry that we have not considered?

As an extension of the above mentioned remark (Access to ADS could potentially contribute to inequality), the RIS does not capture the cost of each option to the public. The safety benefits and the design, organisational and operational risks (Appendix A) of ADSE cover a wide range of issues in this RIS, but have major methodological limitations. The identified risks are learned from past exposure making their predictability dependent on past experience. As of today, we do not have sufficient information about actual ADS deployment. In such an uncertain condition, it is hard to make accurate predictions on regulatory requirements and associated cost.