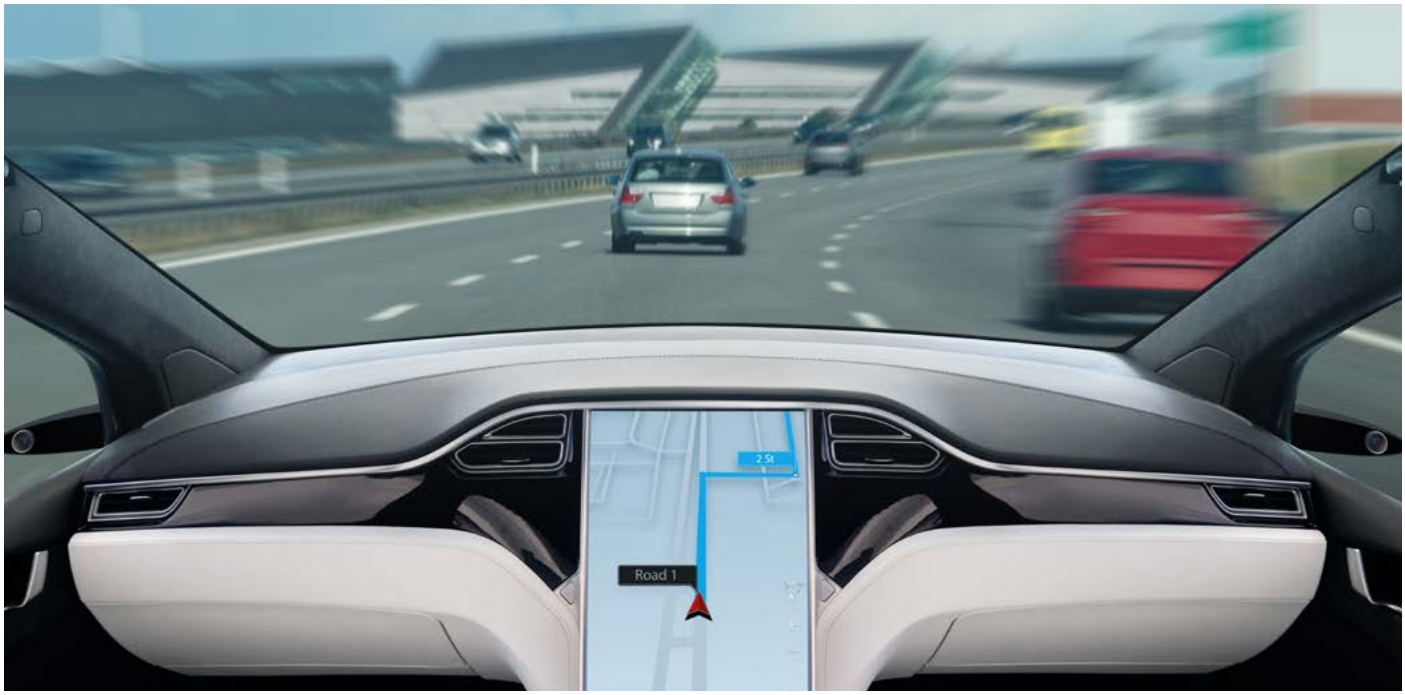
Failing to prepare, is preparing to fail: Adopting a safe systems approach for the approval of automated vehicles

By Dr Phil Martin



AVs – a challenge to established Safe System thinking?

The Safe System approach to road safety recognises that people will make mistakes and that the primary causes of crashes are failures of the road system as a whole. It promotes the principle of collective responsibility for building safe and forgiving road systems to ensure the limits of human vulnerability are never exceeded, even when mistakes result in a crash.

To minimise risks of death or serious injury, the Safe System approach actively encourages all parts of the road system to be strengthened in combination. This is addressed through six essential components, known as the Safe System 'pillars', which taken together build in the resilience to the system needed to break the chain of events that lead to a crash.

The future deployment of fully approved automated vehicles (AVs) on our roads, however, presents a significant challenge to the established thinking associated with the Safe Systems approach and leads us to the question:

Should fully approved AVs ensure mistakes are very rarely, if ever, made in the future; will investment in the other safe system pillars continue to be required?

With the promise of fully approved AVs representing the pinnacle of vehicle safety, then this presents a fair challenge as to whether there is any need to consider the remaining Safe System pillars. For example, it doesn't take much to imagine that should AVs eradicate run off the road crashes, then the significant capital and operational expenditures required to install and maintain vehicle restraint systems (i.e. crash barriers) can be all but eliminated.

However, while early AV commentators hailed the rapid transformation of our transport system, it is fair to say that progress since then has been rather more modest. It has become increasingly clear that AVs will need to integrate with existing road systems and that mixed human and machine-operated vehicles will likely be needed for the foreseeable future.

This mix of conventional and automated vehicles therefore presents a significant challenge in technical complexity and funding. It is clear that the future design of our road systems must be forgiving to both AVs and conventional vehicles, at least in the near-term. As we trend towards greater dispersion of AVs through the fleet, the established ways we view the pillars of the Safe Systems approach, and the focus of the funding efforts for road safety interventions, will therefore also need to evolve.

So what needs to be done to anticipate and prepare for the transformational changes to our transport system driven by the future integration of fully approved AVs? The following sections consider this question in the context of the Safe Systems approach, focusing on the preparations needed to pave the way for fully approved AVs across the remaining Safe System pillars.

Preparing roads infrastructure for AVs

Changes to accommodate AVs must not come at the expense of the safety of other road users.

It is certain that, in the near- and medium-term, AVs will need to use and share existing road infrastructure with conventional vehicles, and so optimising their integration within the current system must be the primary focus. This must not come at the expense of the safety of other road users, including vulnerable road users such as cyclists and pedestrians.

While AV developers are creating vehicles with the intention of deploying them on existing physical road infrastructure - and there are no calls for special-purpose infrastructure - their operational effectiveness can be benefitted by improving the maintenance of existing roads, which should in turn benefit other road users. This can be through "self-explaining roads" (the provision of clear road markings and signs) and reliable road surface quality. Standards for ensuring such maintenance meet the minimum levels of performance compatible with the needs of AV systems are, however, not yet available and remain a key industry need.

Further limiting the development of such requirements is a lack of evidence supporting the definition of what "good" design and operation of roads infrastructure looks like when placed in the context of AVs. Until such requirements are much clearer, it will be a challenge to demonstrate value in investing in upgrades to the existing physical roads infrastructure.

Developing the digital infrastructure that AVs require may provide a much better case for action, however. This includes ensuring reliable and continuous access to communication network connectivity, high-definition maps, live operational data and reference standards, digital architectures and operational concepts. This will support vehicles with being more aware of their road environment and the traffic situation, while enabling additional safety critical functions such as remote operations.

Evidence for and development of design standards and standard operational procedures are urgently required.

While this will clearly benefit AVs, there are also wider benefits for conventional connected vehicles in general. Developing such digital infrastructure offers greater opportunities to drive nearer-term safety benefits, without the need for major infrastructure upgrades. As these "invisible" digital infrastructures will more often than not be privately operated, any future strategies must therefore focus on providing cross-sector leadership and a consistent framework within which service providers, network operators and connected vehicles can all cooperate.

The provision of standardised digital infrastructures for AVs is an imperative, as it will offer greater benefits in less time than physical infrastructure upgrades.

Preparing road users for AVs

Road user behaviours and interactions on the road are governed by a range of norms, rules, laws and infrastructure. The integration of fully approved AVs on our roads will, without doubt, disrupt these behaviours by creating new cultural norms. For example, drivers of conventional vehicles may mirror the shorter headways that would be possible for AVs. This may ultimately require changes to the rules of the road to account for new behaviours observed with the integration of AVs and the digital code on which they will depend.

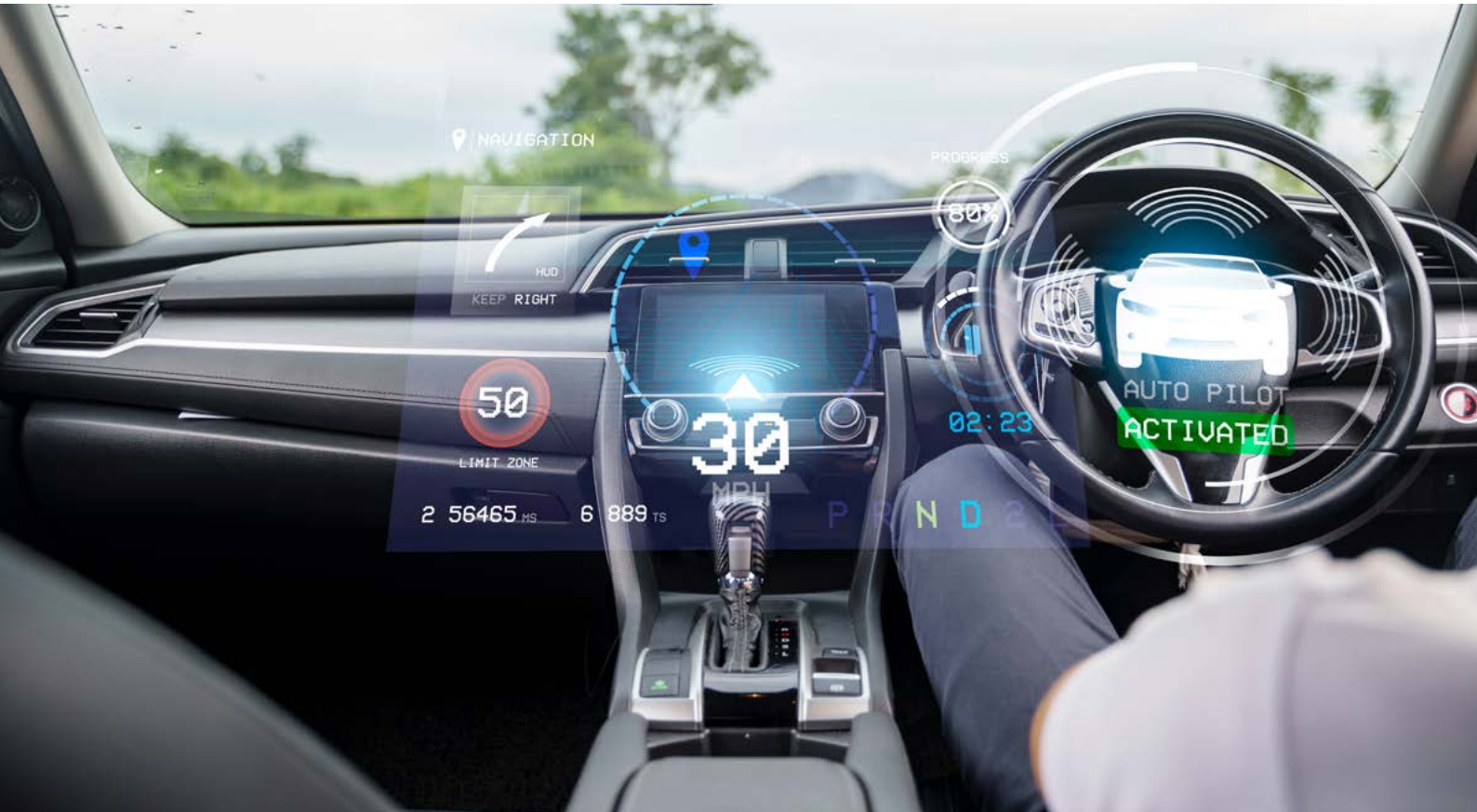
For AVs to cooperatively follow the rules of the road, it is widely accepted that these rules must be "machine-readable" and comprise of a complete set of traffic laws, codes and local conventions – a Digital Highway Code, as some have dubbed it. The digitisation of these rules for AVs also offers an opportunity to better specify and possibly even correct some of the hazards that inherently characterise mobility

Will the digitisation of the rules of the road ultimately define the boundaries of what "careful and competent" means to a fully approved AV?

The implementation of such a digital ruleset, however, could result in a new regime of behavioural norms on our roads. This may harden rules and conventions that were previously soft, while standardising the previously nuanced differences between road types, places and jurisdictions. Similar to how the advent of the motor car disrupted the social norms of the time, privileging some and burdening others in the process, a similar societal adjustment may be on the horizon as a result of AVs on our roads.

It is critical that the price of adjusting our socio-behavioural norms to accommodate fully approved AVs on our roads is balanced against the impacts these changes will have on the safety, inclusivity and sustainability of mobility. Deliberate debate is therefore called for to ensure the technical requirements for fully approved AVs recognise and actively consider their intended and unintended impacts on the system as a whole.

The impacts of digitising the rules of the road for AVs must be understood, and a democratic decision reached about the potential trade-offs.



Preparing post-collision responders for AVs

The post-collision response is perhaps the least considered pillar of the safe system in our preparations for the deployment of fully approved AVs on our roads. The interactions between AVs and emergency responders and the role that collision investigators have in understanding the root cause of incidents have only been explored at a high level, with very little published work on how such interactions should be incorporated into AV regulations.

Emergency responders will need to interact with AVs across several common operational scenarios. These scenarios include responding to incidents, securing scenes, stabilisation and extrication, traffic direction and control, traffic stops and checkpoints and investigating abandoned and unattended vehicles.

These interactions will, however, be very different to the standard operating procedures that currently govern how emergency responders interact with conventional vehicles in similar scenarios. For example, how should AVs be disabled and stabilised at a collision scene and how will AVs react to the conducting of traffic control measures at a scene?

It is clear that a consistent approach to these interactions between emergency responders and AVs in these common scenarios would lead to safer and more efficient responses to road collisions. A better understanding of how the introduction of AVs may affect current interactions is first needed, before considering how these can be incorporated into AV regulations and standard operating procedures for emergency responders.

Safe interactions between emergency responders and AVs must be a key requirement for future AV regulations and emergency responder standard operating procedures.

Understanding the root causes and contributing factors of collisions involving AVs will be critical to the evidence-based evaluation and amendment of AV regulations and to the allocation of responsibility for the collision. Rapid access to the data collected by AV automated driving systems, with the support of in-depth collision investigations, will present many opportunities for the high-fidelity reconstruction of collisions involving AVs.

Data from the radar, LiDAR and camera sensors, basic messages from V2X communications and driver/operator monitoring systems could all provide key information for reconstructing collisions. This could include driver/operator state, automation status, location, objects and people in the immediate area, AV performance and diagnostic data, environmental factors, and so on.

To manage these emerging AV collision investigation data sources, AV regulations must define the minimum dataset recorded by AVs during a collision. These requirements must be proportionate to the needs and capabilities of the collision investigators and the ability of AV manufacturers to collect, and provide access to, the data. Any gaps in the necessary capabilities or barriers to accessing the minimum dataset should be met with a national capability development plan.

AV regulations must specify a minimum dataset to be collected by AVs during a collision to ensure effective investigations of incidents and collisions.

Gaining access to such data in a standardised format and timely manner is a major barrier to realising the full benefits this data to the future development of AV regulations. Using AV regulations to establish industry-wide requirements will be an important lever for removing this barrier. For this, one can look to the ongoing efforts within UN WP.29 (the World Forum for Harmonization of Vehicle Regulations), which have begun to address such issues through developing technical requirements for the Event Data Recorders (EDRs) and Data Storage Systems for Automated Driving (DSSAD) regulations.

There are, however, many challenges to overcome with collecting such data, including data privacy, commercial sensitivity and public perceptions of surveillance. Any AV regulation must consider how it will address these concerns in a proportionate way, while recognising the critical need to collect collision data to better understand how AVs behave and comply with approval regulations in the real world.

There must be clear and coherent responsibilities for ensuring AVs operate within a Safe System.

To ensure safety, clear and coherent responsibilities will need to be defined, and continually re-defined, between AV developers, AV operators, enforcement agencies, roads authorities, infrastructure managers and network operators to ensure each organisation maintains their legal liability for their undertakings and actions over time. New roles for agencies and institutions will clearly be required and these must combine with the existing structures to provide a cohesive system that assures the safety of AVs on our roads.

A single body will therefore likely be required to take on the responsibility of understanding and managing these interactions at a strategic level. While this organisation may be new or pre-existing, it needs to have the relevant skills and expertise to understand and react to the unique challenges that integrating AVs into society will bring. Supporting the development of new skills and capabilities right across the AV ecosystem will also be essential to their successful integration.

National and international cooperation will be a key accelerator to adoption of AVs.

Public engagement and outreach will be a critical tool to winning the hearts and minds of the people. Establishing a collaboratively built communications strategy, that involves the public at its core and is consistently followed by all in the AV ecosystem, will be needed to ensure the benefits to both society and individuals are understood in a way that generates future trust in AVs. Without this trust, it is very unlikely AVs will reach their full potential.

Fostering global collaboration will also enable the development of standardised approaches that encourage innovation while maintaining safety standards. The open sharing of best practices and lessons learned, the harmonisation of approaches and the facilitation of knowledge exchange will all be crucial aspects to accelerating the integration of AVs. It is very important that such knowledge, particularly knowledge relating to safety, is not kept for commercial gain – the safety of citizens should not be up for sale.

What next?

Industry and policy-makers must be proactive in considering and managing the evolving road safety landscape associated with AVs. Without greater focus on understanding how to prepare for AVs across all the Safe System pillars, there will be substantial challenges and unintended consequences associated with integrating AVs safely within our road system. TRL calls on industry and policy-makers to consider all Safe System pillars when developing the AV approval process. A comprehensive and inclusive approach is absolutely essential to ensure the successful and safe integration of autonomous vehicles into our road system.

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Phil is a transport safety research consultant with nearly 15 years' experience in applying Safe System principles to all surface transport sectors. Holding a PhD in Biomechanics and Master's degree in Integrated Engineering, Phil is a Chartered Engineer and Member of the Institute of Mechanical Engineers. Focusing on evidence-led research and consultancy, his track record includes leading projects for public and private sector clients, both nationally and internationally, to develop local and national road safety strategies, vehicle regulations and standards, advise on procurement policies and to demonstrate, monitor, evaluate and appraise the impacts of transport safety policies and innovations. He is an active member of several international working groups, expert panels and government committees, has authored several high impact peer-reviewed journal publications and has presented his research at numerous national and international road safety conferences.