Automation in transport

Leading the UK to a driverless future

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Contents

> "Success cannot be achieved without action and it is only through taking bold steps that collectively, we will be able to accelerate technology development, prepare for a fully automated transport system, drive safety improvements and secure a global leading position in automation for the UK"

1. Introduction

Success is not linear. Success is not about getting it right all of the time. Its about progressing, learning from set-backs, overcoming the challenges and moving towards a shared vision.

The development and deployment of automated vehicles is no different. The vision is to have a connected and automated transport system that enhances quality of life by:

1. Improving road safety by reducing the risk of collisions
2. Reducing fuel consumption and the associated emissions
3. Increasing capacity of the road network
4. Improving access to transport
5. Reducing transport costs
6. Building the economy
7. Enhancing communities

Success is meeting this vision and enabling the projected benefits.

Since 2015, the UK government has invested £200 million to support this vision and although the vision has not yet been met, progress has been significant. Technology is continually evolving and advancing. As an industry, we understand more about simulation and the use of this in the validation process, we have designated test facilities that enable progression and innovation under varying levels of environmental control, we have developed safety standards, and we are planning for the future including advanced trials, deployment, approval and regulation.

However, the gap between technology development and automated vehicle deployment has been underestimated and the challenges involved with meeting this vision and delivering autonomy have been far greater and more complex than first envisaged.

Challenges include the development and reliability of the technology as well as the validation and approval of the automated driving system (ADS). How can you ensure that decisions made through machine learning are safe? How do you approve a vehicle – or system – that is continually being updated and learning? How do you ensure that vehicle behaviour is appropriate, reliable and safe?

1.1 Fundamental requirements for success

TRL is working with our customers and our partners and customers to shape and implement a safe and predictable automated transport system that meets the needs of the consumer and that ultimately benefits society, the economy and the environment. We are reactive to new challenges and emerging priorities whilst predicting and understanding what needs to be developed and implemented to enable future deployment.

TRL believe the following activities are key enablers in achieving this position:

1. Develop a flexible and responsive UK regulatory system that enables the safe and secure deployment of automated vehicles in the future. Effective regulation is based on industry good practice, has requirements that are proportionate to the risk posed and does not stifle innovation through the creation of unnecessary bureaucracy.
2. Provide a simple, consistent but robust approach to assuring safety during trials and testing to enable and facilitate trials across all UK locations and environments.
3. Develop and implement a UK safety monitoring and investigation unit to monitor safety, analyse data, investigate incidents and provide timely feedback and recommended actions. Implementing this unit now and undertaking in-depth investigations for collisions with assisted driving functions will prepare for an automated transport system in the future and enable a more reliable, proactive approach to be adopted.
4. Enable more advanced trials to be undertaken in the UK where the boundaries of the technology are extended and solutions to the identified challenges are explored without compromising safety. This can be done through conducting advanced testing in designated test beds with appropriate risk management systems and intelligent, connected safety monitoring infrastructure.
5. Accelerate the adoption and safe implementation of automated vehicles for off-highway activities and minimise worker exposure to high risk environments and working practices within the UK and globally.

2. Regulation and approval for deployment of automated vehicles

Requirement: Develop a flexible and responsive regulatory system that enables the safe and secure deployment of automated vehicles in the future.

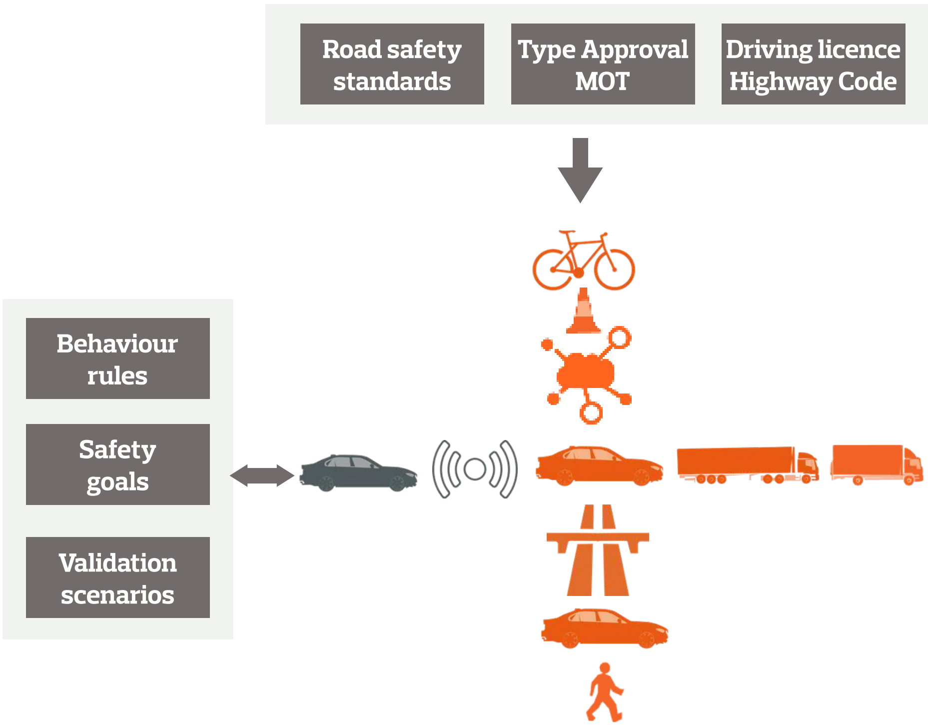
Regulation is key to unlocking the promise of vehicle automation, but the development of regulation highlights the move from separate elements in a transport system towards an integrated transport system with significant dependencies. Currently vehicles, drivers and road infrastructure are approved and managed separately with the intent to create a safety system. Regulation also has to mandate in-use safety monitoring and the sharing of data to provide continued validation of the system following changes to hardware, software or ADS behaviour.

Basic vehicle safety requirements are developed at the UN and adopted by countries all over the world. This harmonisation standardises performance and minimises compliance costs for industry. Automation is no different. UN WP.29 has a broad programme of work to develop regulations to ensure the safety and security of automated functionality on vehicles, and the first three UN regulations have already been agreed:

1. Cyber security and cyber security management systems (UN Reg No. 155)
2. Software updates and software update management systems (UN Reg No. 156)
3. Automated lane keeping systems. (UN Reg No. 157)

These ground-breaking regulations mean that the milestone of the first automated series production vehicles is expected to be realised this year and is already happening in Japan.

This sets standards at the global level, but national standards are also important to support development of new vehicle and service types, and to check real-world performance of type-approved systems at the local level. For example, it is important to verify that national infrastructure (signage, road markings, road layouts) is understood, and UK driving norms are handled safely. Finally, most AVs are being developed in countries that drive on the right; it is not a given that vehicle will be exactly as competent if used on the left-hand side of the road.



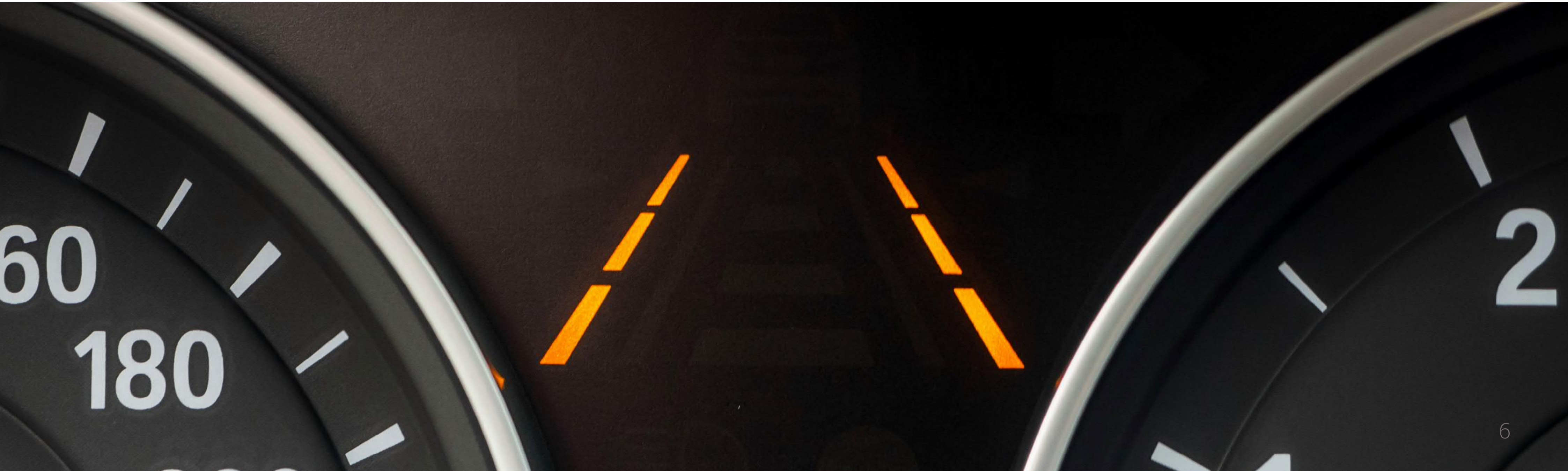
> “Connected and automated vehicles create a need to approve these elements together as one system because there are significant, safety critical dependencies between them”

2.1 Navigating the regulation landscape

Our commitment to road safety, experience of CAV safety assurance and knowledge of the regulatory process makes us an integral part of the safe deployment of CAVs at scale. Since 2015, TRL have done extensive work with the European Commission's DG GROW on updates to the General Safety Regulations and enabled them to set the future European priorities for legislative vehicle safety requirements and develop new test protocols. From this experience, TRL understand that regulation for new technologies needs to ensure that it does not stifle innovation. Indeed, regulation should achieve the opposite.

A flexible and responsive regulatory system can enable innovation by streamlining entry into emerging markets and lessen the initial regulatory burden on developers and manufacturers. Our recent work for DG GROW has resulted in the update of the General Safety Regulation (GSR), to include 10 new and developing technologies. The developments have enabled the deployment and innovation of new technologies such as Emergency Lane Keeping Systems (ELKS), Event Data Recorder and Driver Drowsiness and Distraction Recognition (DDR) within Europe.

> "It is important to verify that national infrastructure is understood, and UK driving norms are handled safely"



3. Safety Assurance for trials and testing

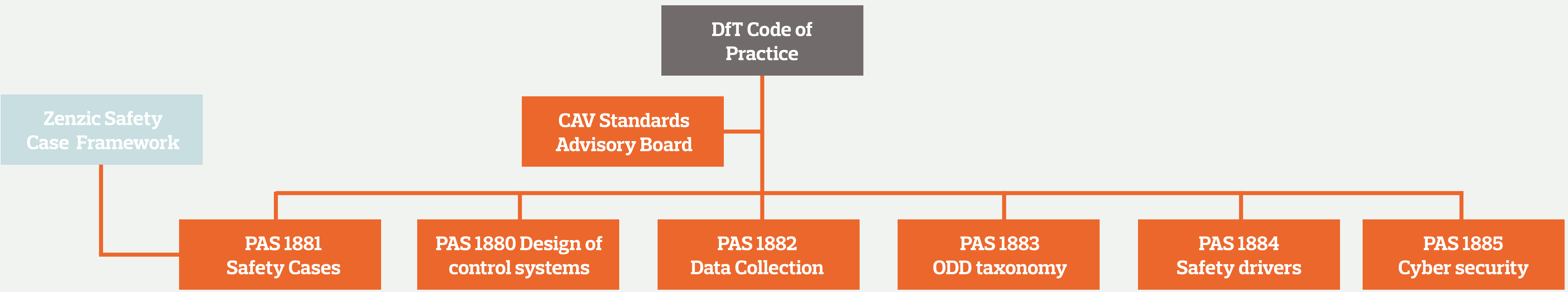
Requirement: Provide a simple, consistent but robust approach to assuring safety during trials and testing to facilitate trials across all UK locations and environments.

3.1 GATEway: a benchmark for good practice

TRL's initial automated vehicle trial was for the GATEway project in 2015, which saw driverless pods navigating their way between leisure sites and residential locations around the Greenwich peninsular, automated urban deliveries, and remote teleoperation demonstrations. The aim was to understand more about the challenges and barriers to adopting automated vehicles, but ultimately TRL needed to ensure safety during the trials and be able to demonstrate that risks had been appropriately managed to a tolerable level. This presented TRL with a challenge and an opportunity. The challenge was that, at the time, there were no standards, other than the high-level requirements included within the DfT Code of Practice 'The Pathway to Driverless Cars' (2015), and no established good practice to draw upon. The opportunity was for TRL to set the benchmark for safety and develop a robust approach to managing the risks associated with automated vehicle trials and testing.

3.2 Evolution of standards

The operational safety case framework developed in GATEway was based on well-established risk management methods with risk assessment and evaluation being central to the approach and effective controls implemented to reduce risks as low as reasonably practicable. The approach was developed and refined during subsequent automated vehicle trials including DRIVEN and StreetWise and ultimately Helm UK, where Highways England's safety governance requirements were integrated. It is important that any standard reflects industry good practice, so significant stakeholder engagement was conducted, and learning used by TRL to technically author BS PAS 1881, which sets out the requirements for an operational safety case. The BS PAS 1881 is part of a suite of documents that support and enhance the requirements in the latest version of the DfT Code of Practice 'Automated Vehicle Trialling' (2019). TRL has also worked extensively with Zenzic and CAM test bed UK ecosystem to develop supporting guidance that is specific to test beds and enables interoperability and consistency between the different testbeds.



3.3 Preparing for large-scale trials of advanced systems

When BS PAS 1881 was developed the focus was on operational safety – testing organisations needed to demonstrate that the vehicle would reliably 'hand back' to the safety driver and that the safety driver could intervene and safely resume full control of the vehicle. Advanced trials, with the safety driver either not present in the vehicle or less alert require the safety of the vehicle systems to be demonstrated and documented. TRL have developed a high-level systems safety case as part of the ServCity trial with the systems safety case being developed by Nissan.

3.4 Building confidence via a consistent approach

The DfT CoP (2019) requires trialling organisations to develop 'a detailed safety case before conducting trials which demonstrates that the trial activity can be conducted safely'. There is also a requirement for 'those planning a trial' to 'engage with all relevant organisations with responsibility for the trial areas'. The 'relevant organisation' may be a road authority, landowner, local authority or test bed. Although not an explicit requirement, the relevant organisations are typically wanting assurance that the trial or test is safe to proceed as part of that engagement process.

The approach to this varies and ranges from a high-level overview to in-depth safety case review or the requirement to follow specific safety governance. This inconsistency can provide a barrier to testing in multiple locations or avoiding areas with more stringent requirements.

There are three key options that can be used individually or as combined approaches:

1. Safety Case Review
2. Process Review
3. Safety Assurance

Connected and Automated Vehicle Guidance

UK Government Requirements

- DfT Code of Practice: Automated Vehicle Trialling

Localised Requirements/Guidance

- TfL Connected and Autonomous Vehicles: Guidance for London Trials
- Highways England GG-104: Requirements for safety risk assessment

Industry Guidance

TRL Assuring the safety of connected and automated vehicle trials:
- Local authorities
- Trialling organisations
- Insurers

- DG Cities Autonomous and Connected Vehicle: Trials on the Public Highway

Zenzic Safety Case Framework Guidance Edition
- Safety case creators
- Safety case reviewers

Standards

- BS PAS 1880
- BS PAS 1881
- BS PAS 1883
- BS PAS 11281
- ISO 26262
- BS PAS 1882
- BS PAS 1884 (new)

Safety Case Review

The most appropriate method for reviewing safety cases depends on the objective of the review. A safety case is a live document and the operational safety elements should be specific to a defined trial scope including test location, vehicles, use case and test objectives. If the objective of the review is to determine whether that specific trial is safe to proceed, a full review of the safety case may be appropriate. It is likely that this would need to be done by a team of experts including those with operational safety, systems safety, vehicle safety and cyber security expertise. The challenge with this is ensuring that there is consistency in the review process. The suite of PAS standards can assist with this for operational safety and the ODD but systems safety requirements are still largely undefined. It is also important to note that the review is only valid at a given point in time and for a specific trial – safety assurance throughout the trial is also important. If the trial changes (location, vehicle, test objectives) it cannot be assumed that the safety case is still sufficient. A review would need to be conducted for each trial.

Process Review

A complimentary approach is to look at the processes used to develop a safety case, for example, the method for identifying hazards and evaluating risks, route assessments, driver training scope, safety monitoring, incident reporting and continuous improvement process. This would provide assurance the testing organisation has the appropriate management system and processes in place as well as appropriately competent people to develop a sufficient safety case. This could enable trialling organisations to self-certify for individual trials. The outcome from the review process could be valid for a defined period of time, in line with other safety management audits/ certification processes.

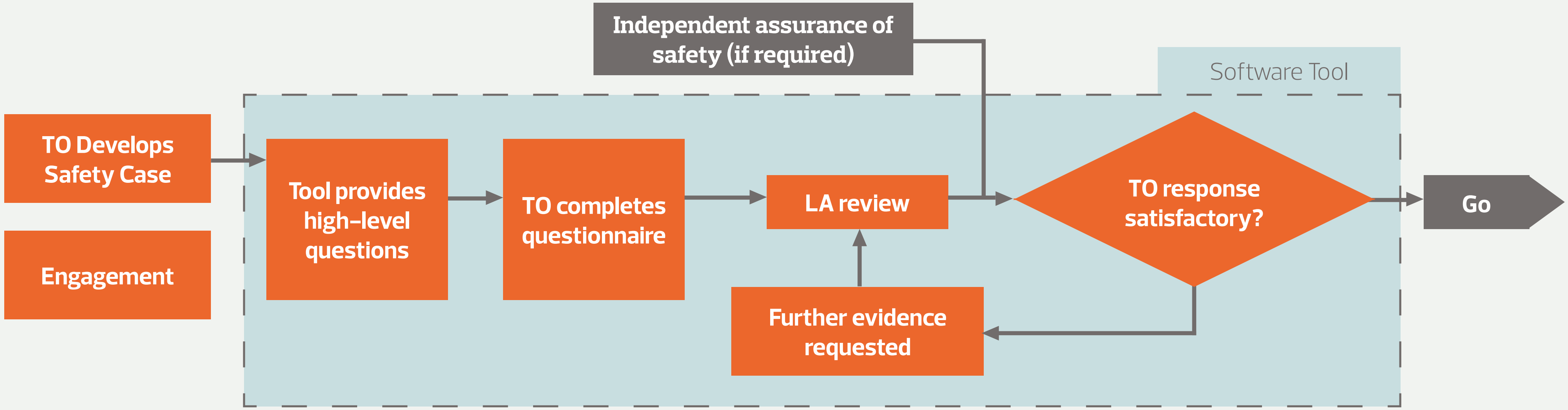
Self-service safety certification

As part of the Innovate UK Endeavour project, TRL has engaged with a range of key stakeholders involved in automated vehicle trials and testing including testing organisations, local authorities, road authorities, test beds and insurers. The aim of the engagement was to explore the necessary requirements for tools and services that could support stakeholders in order to ensure a more consistent and simplified approach to safety assurance.

Based on the feedback gathered, TRL is developing a software tool that could be used to guide and support stakeholders when engaging with trialling organisations.

The specifications for the software were drawn specifically from the challenges identified during the stakeholder consultations. The software aims to:

- Create a consistent method for sharing evidence for safety assurance of automated vehicle trials and testing
- Assure safety against established good practice
- Provide an intermediate solution prior to the implementation of a regulated CAV
- approval process
- Reduce the burden on trialling organisations whilst still providing stakeholders with sufficient safety assurance
- Remain aligned with recognised good practice through periodic and immediate updates



4. Safety monitoring and investigation

Requirement: Develop and implement a safety monitoring and investigation unit to monitor safety, analyse data, investigate incidents and provide timely feedback and recommended actions.

4.1 Pro-active approach to road safety

Historically road safety is managed reactively. There is a collision, it is investigated and through the analysis of accident data, measures are identified and implemented to minimise the risk of the collision type either at a specific location or more broadly across the road network. Measures focus on the road design, vehicle speed and passive safety measures implemented on the vehicle that reduce injury severity (e.g. air bags, seat belts). A more proactive approach to road safety is being adopted through 'the safe system approach' and routes are being assessed for hazards and categorised in the International Road Assessment Programme: iRAP. In line with the safe systems approach, where all stakeholders have a responsibility to improve road safety, vehicles increasingly have active safety measures that reduce the risk of collisions occurring through assisting drivers and reducing human error (e.g. AEB, lane departure warning).

However, automated and connected vehicles provide the opportunity to accelerate this proactive approach. Through monitoring and analysing vehicle behaviour whilst the vehicle is in use, unsafe behaviours can be identified, collisions predicted and interventions implemented to prevent a collision from occurring. This approach mirrors traditional workplace risk management where near misses are reported, investigated and mitigations implemented to prevent the incident from being realised. The term 'near miss', however, can create confusion and often leads to a debate about the definition and what events should be reported within this category. A number of industries have renamed the term as a 'near hit' or a 'good catch' but this still does not provide the clarity needed for consistent, accurate and effective reporting, evaluation and learning.

> "Through monitoring and analysing vehicle behaviour whilst the vehicle is in use, unsafe behaviours can be identified, collisions predicted and interventions implemented to prevent a collision from occurring"

4.2 In depth collision investigation to inform future safety monitoring

Instead, through in-depth collision investigations (RAIDS) and extensive research on collision causal factors, TRL can identify behaviours that are likely to lead to a collision and use these behaviours as 'lead indicators', 'safety surrogates' or 'collision precursors'. The lead indicators could be monitored using in-vehicle data and supplemented with environmental and location data from intelligent infrastructure. The success of this approach, however, relies on the lead indicators being reviewed, refined and updated as our understanding about causal factors for automated vehicle collisions develops.

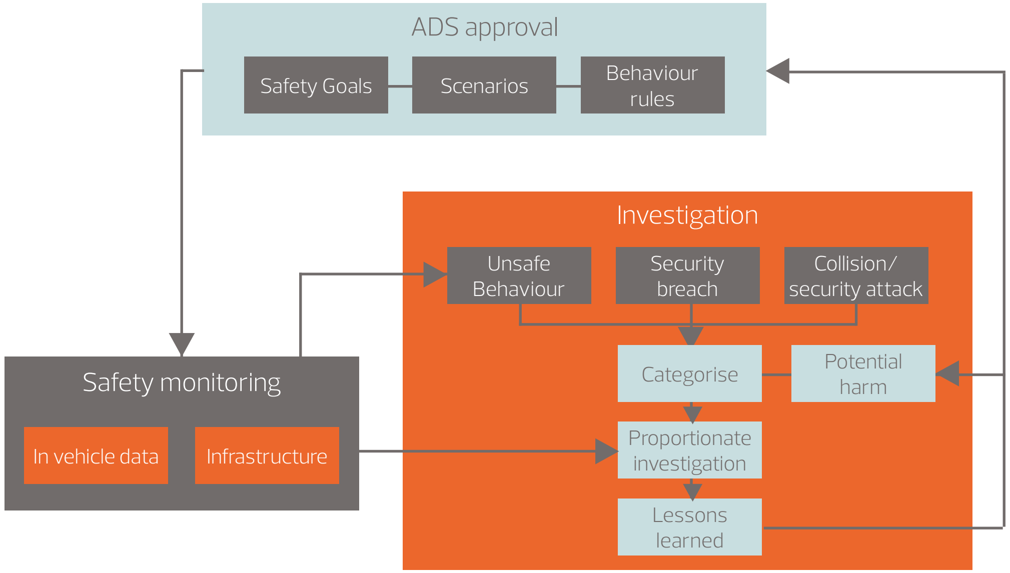
TRL recommend that in-depth investigations of collisions involving vehicles with automated or assisted driving functions should be conducted now to strengthen understanding about causal factors and refine the lead indicators that need to be monitored when automated vehicles are in use.

> "This proactive approach would drive safety improvements, promote continuous improvement, accelerate innovation and development and make Vision Zero a more realistic and achievable target"

4.3 Continuous improvement of the regulatory approval process

Ideally it would be and beneficial and efficient to have a single UK safety monitoring and investigation that initially focuses on collision investigation but expands to include in-use safety monitoring and evaluation in the future. The unit would provide a central hub to monitor safety, analyse data, investigate incidents, and provide timely feedback and recommended actions. Implementing this unit now and undertaking in-depth investigations for collisions with assisted driving functions will prepare for a more automated road network in the future and enable a more reliable proactive approach to be adopted. Learnings from monitoring and investigations would also feed into the CAV regulatory approval process including the refinement of safety goals and desired ADS behaviours as well as the real-world scenarios generated for validation.

This proactive approach would drive safety improvements, promote continuous improvement, accelerate innovation and development and make Vision Zero a more realistic and achievable target.



5. Advanced trials and testing

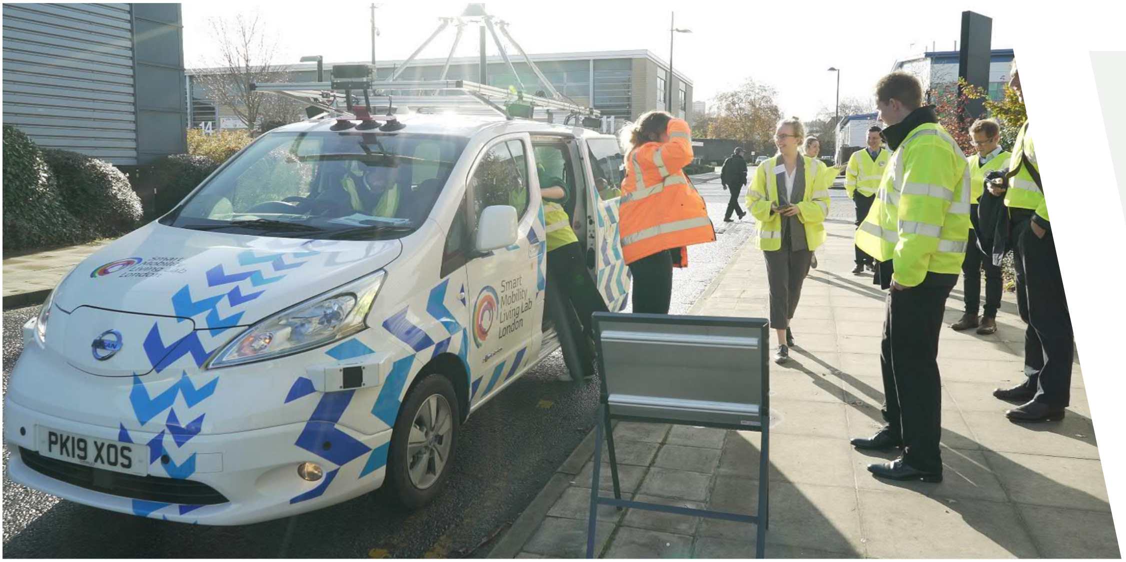
Requirement: Enable more advanced trials to be undertaken where the boundaries of the technology are extended and solutions to the identified challenges are explored without compromising safety.

There have been significant technological and testing developments since the GATEway project bought automated vehicle technology onto the public roads and into public awareness in 2016, and as a result, connected and automated vehicle trials are becoming increasingly advanced and complex.

The purpose of advanced trials is to progress technology, overcome challenges and understand future infrastructure requirements, with the ultimate goal of deploying self-driving technology on the UK road network. This opens the debate about the terms 'self-driving' and 'remote operation'. Is a vehicle self-driving if there is reliance on a remote operator? Is it safe for a remote operator to have any safety critical function or perform even parts of the dynamic driving task?

London's Smart Mobility Living Lab (SMLL) provides a unique real-world test facility to conduct advanced tests and validate vehicle behaviour performance, sub-system performance, V2X and urban connectivity integration performance.

SMLL is part of CAM Test Bed UK and provides over 24 km of instrumented routes within the Royal Borough of Greenwich and Queen Elizabeth Park. SMLL provides a wide range of features, complexities and environments to test, simulate and innovate.



"Through testing in a real-world environment and monitoring performance using cooperative infrastructure, we can accelerate learning and technology progression"

5.1 Remote operation

As part of TRL's role in Project Endeavour we have undertaken an extensive literature review and stakeholder engagement to understand more about the role of the safety driver, and the in-vehicle safety engineer to determine which elements of the roles could be performed remotely. We have also identified the technical challenges with remote operation and explored whether these can be overcome to enable any parts of the dynamic driving task to be conducted remotely. The findings from this study and an associated road map will be published in September 2021.

At a high level, the key remote operation roles are:

Remote control: This describes continual oversight of an automated vehicle's operation by a remote operator and performing a potentially safety critical role. This may include a requirement to intervene and could range from pressing an emergency stop button (remote intervention) to performing the full dynamic driving task (remote driving).

Remote vehicle assistance: . Remote vehicle assistance is likely to be intermittent and assistance from the operator to ensure safety is not time critical. Assistance is provided in response to a request from the automated vehicle once an issue has been encountered and the minimum risk condition achieved. Assistance may include providing an ADS with instructions to 'nudge or manoeuvre' an automated vehicle around an obstacle, providing approvals or permissions to facilitate trip continuation. This does not include fleet management tasks or providing instruction regarding selection of destinations or trip initiation timing.

Remote user/passenger services: This describes a range of services that can be provided by a remote operator to support the welfare of the user/passenger of an automated vehicle, including answering occupant queries, or providing guidance in the event of an emergency. This is similar to the concierge service already provided by a number of OEMs including BMW and Hyundai.

"By advancing the capability and reliability of the automated driving system we can minimise or eliminate the need for human intervention or control, therefore removing some of the concerns."

5.2 Is remote operation ever appropriate?

TRL's concern is that through retaining any level of human control over an automated vehicle, there is still the potential for human error and the projected safety benefit is less likely to be achieved.

The level of risk posed will depend on a number of factors including the complexity of the task being undertaken, the environment, how time critical the task is, communications, data reliability and operator workload and situational awareness.

We are optimistic that remote control may be suitable for low-speed operations within controlled environments where interactions with other road users are minimised or or where remote control can reduce the level of risk posed to affected parties.

To enable any level of remote control on public roads, communications need to be uninterrupted and the network sufficient to transmit large amounts of simultaneous, high quality data. Latency is also critical to enable operator response in sufficient time to avoid an incident. The situational awareness of the operator and their workload also need to be addressed to ensure sufficient attention is retained and appropriate, safe and timely actions are taken.

By advancing the capability and reliability of the automated driving system we can minimise or eliminate the need for human intervention or control, therefore removing some of the concerns.

Advanced technology trials are currently being undertaken within SMLL to progress this solution and improve the accuracy of vehicle positioning, reliability of vehicle decisions, improve vehicle perception and generate scenarios for validation that represent the complexities of the real-world urban environment.

5.3 Advanced research to validate performance in real world conditions

Advanced technology trials are currently being undertaken within SMLL to improve the accuracy of vehicle positioning, reliability of vehicle decisions, improve vehicle perception and generate scenarios for validation that represent the complexities of the real-world urban environment.

Can the accuracy of vehicle position be improved through correction technology?
Global Navigation Satellite System (GNSS) will play a big role in determining the position of automated vehicles. However, the urban environment provides a significant challenge to GNSS accuracy and this is exacerbated by communication latency. The effect of the urban environment of vehicle positional accuracy is being analysed within SMLL and new technologies that are more suitable for complex urban environments are being tested.

Can Cooperative infrastructure be used to assist and enhance vehicle decisions?
Cooperative infrastructure is relevant to connected vehicles as well as automated vehicles. As part of the ServCity trial with Nissan, SMLL are validating the use of CCTV, edge computing and message transmission to detect objects using roadside cameras and communicating them to the ego vehicle. If this is a valid approach, the hardware and software requirements need to be understood to determine whether it is practicable for wider roll out across the UK road network and what the impacts could be.

How can the accuracy and reliability of vehicle perception systems be improved?
Data fusion is key for all perception requirements including vehicle location, object detection and reading the road layout. Data fusion also adds a layer of redundancy to the ADS decision making. Testing within SMLL aims to validate a perception-based system fusing multiple sensors including cameras, inertial navigation system, and GNSS.

How can validation scenarios be captured that more realistically reflect the urban environment?

Initially validation scenarios can be generated by combining vehicle behavioural competencies, ODD attributes and the Highway Code rules. However, it is important that this is supplemented with real world data to ensure unexpected, non-standard or challenging scenarios are captured. StreetWise was one of the largest initial tests of automated vehicles on public roads and as part of that project TRL developed a toolchain for the extraction of scenarios from the national road safety data (STATS-19) and learnings from in depth collision investigation (RAIDS). TRL demonstrated the concept of parametric scenario generation through generating 1,000 iterations of a selected scenario in the CARLA simulation platform.

Findings from in-depth collision investigations, such as RAIDS and TFL fatal collision databases can supplement the higher-level detail recorded in STATS-19. For example, Figure 1 shows an incident scenario generated during the StreetWise project. STATS19 recorded the case as a fatal collision between a vehicle and pedestrian at a junction. A review of the matching RAIDS case revealed that the presence of a bus, and the blind spot it created, was actually the primary contributor to the collision. The bus was not detailed in STATS19. Incident databases such as STATS19 and RAIDS can only enable scenarios to be generated from events that have already happened and have resulted in injury.

There is, however, the opportunity to accelerate learning and technology development by evaluating events or behaviours that could have resulted in a collision. The connected and instrumented environment at SMLL provides a unique opportunity to capture and analyse events or 'safety surrogates' using footage from the 276 CCTV cameras.

TRL have conducted this as part of a project for the SMLL Innovation Community and extracted scenarios which were imported into the CARLA simulation platform. Figure 2 shows an example of a scenario captured by SMLL infrastructure, where a pedestrian crosses the road, from behind a parked heavy goods vehicle at a T-junction, as an automated vehicle approaches the junction. As part of the ServCity project, TRL is expanding this capability and developing an automated image detection process for extracting the positions of road users involved in these events, for use in scenario generation.

Figure 1: Example of a real-world validation scenario

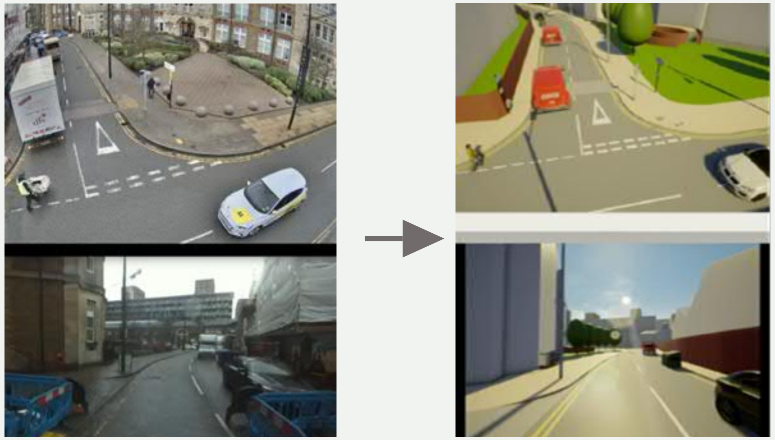


Figure 2: Example of scenario capture through infrastructure from a UK CAM Testbed - SMLL

6. Off-Highway Automation

Requirement: Accelerate the adoption and safe implementation of automated vehicles for off-highway activities in the UK and minimise worker exposure to high risk environments and working practices.

The off-highway vehicle industry is broad and diverse and includes the following sectors:

- Agriculture, forestry and ground care
- Quarrying and mining
- Construction
- Road works
- Military
- Materials handling – including ports and airports, warehousing etc.
- Leisure

Off-highway vehicles operate across a very broad range of terrains, from hard paved surfaces, both indoors and out, through an array of fully and partially prepared roads and tracks, to entirely unprepared terrain including mud, snow, sand and rocks.

Some sectors of the off-highway industry have been early adopters of automated and remotely operated vehicle technologies. In particular the agricultural, materials handling, mining and military sectors have all been operating fully or partially automated vehicles on a commercial basis for more than a decade.

6.1 Widespread off-highway automation

The off-highway environment offers a number of advantages for the deployment of automation, not least the fact that many operating scenarios permit automated vehicles to be isolated from other traffic and pedestrians thus reducing the burden placed on collision avoidance systems. However, the off-highway environment brings with it a number of additional challenges including the complexity of vehicle-terrain interactions, the often less structured operating environment, and the lack of traffic rules.

The key drivers for the adoption of automation in the off-highway industry have been safety and the removal of operators from dangerous or harmful environments, reducing human errors, availability and competency of the operators and efficiency through improved accuracy or productivity.

Automation has also permitted the re-imagining of some vehicle types, for example, allowing fleets of smaller vehicles to replace a single large one when driver productivity is no longer a consideration. These smaller, lighter vehicles offer potential benefits like the reduction of soil compaction, the ability to operate in more marginal terrains and the opportunity to optimise material flow. Automation also enables electric vehicles to be adopted off highway. Electric vehicles are typically size-limited and historically a fleet of smaller vehicles would also mean more drivers, who are already in short supply.

However, automation has also led to some unintended consequences, for example, most automated agricultural vehicles are only partially automated, requiring a driver in the cab to operate some controls and perform some manoeuvres. Crucially these drivers retain responsibility for collision avoidance but are, for the most part, no longer engaged in the driving task. Incidents due to distraction, inattention and drowsiness are therefore relatively common.

6.2 Development of best practice

As part of an Innovate funded project on Automated Off-highway Vehicles, TRL has developed and published a draft Code of Practice providing guidance to operators of automated vehicles in all sectors of the off-highway industry. The document focuses on the ways in which working practices should be adapted to ensure that the adoption of automation is as smooth and safe as possible.

However, further steps are needed to fully integrate automation off highway and ensure safety, process efficiency and to promote continuous improvement.

Innovation, trials and testing

As a developing technology, automation in the off-highway sector also requires development support services. TRL has been at the forefront of automated vehicle trials and testing on public roads and can apply learning from this to off highway trials and testing:

- It is important that proposed innovations are reviewed in line with business and customer priorities and objectives
- In the absence of relevant standards, safe systems and safe operations should be demonstrated in a safety case
- Monitoring and evaluation throughout a trial provides the evidence required to robustly demonstrate that the innovation meets safety objectives and business requirements

Safety monitoring and investigation

Automated vehicles should be monitored whilst in use and any undesired behaviours identified and investigated. Learning from investigations, combined with learnings from in depth investigations of any automated vehicle collisions should be fed back into vehicle design and the safety management system. If investigations are conducted by an independent body and in line with investigations for on highway vehicles, safety critical information can be shared between and across industries to accelerate innovation, technology development, efficiency and safety.

TRL recommends that RIDDOR – Reporting of Injuries, Diseases and Dangerous Occurrences 2013 is updated to mandate the reporting and investigation of unsafe automated vehicle behaviours and collisions as well as the sharing of safety critical information.

6.3 Guidance for regulators and operators

There is currently very little sector specific guidance for the use or design of automated off-highway vehicles. Examples could include sector specific codes of practice, an automated vehicle equivalent of the HSE's HSG136 Guide to Workplace Transport or design guides for the manufacturers of automated off-highway vehicles. Currently there is a lack of specific regulations that apply to automated off-highway vehicles. Regulators are beginning to consider automation within the regulatory frameworks for off-highway vehicles, e.g. The European Commission have tendered a project to update Regulation (EU) No 167/2013 – Type Approval Regulations for Agricultural and Forestry Machines, which includes as one of its objectives the development of regulations for automated vehicle systems.

6.4 Process improvement to maximise efficiency

In order to fully realise the benefits of automation, operators often need to reconsider their working practices at a holistic level. There may be a tendency for operators to seek like-for-like exchanges of manual vehicles for automated equivalents, but this approach often fails to realise the full economic and productivity potentials of adopting automated technology. TRL is well placed to act as a source of independent advice and guidance to operators of off-highway vehicles on the most economically effective ways in which they could incorporate automated technologies into their operations.

6.5 Training

New technologies can only be fully integrated safely and embedded into the work culture if the new working practices and technology capabilities, limitations and associated risks are fully understood. Appropriate training might include:

- Process optimisation through automation for operations managers or directors
- Safe management of automated vehicles for site managers
- Safe working practices around automated vehicles for all workers

6.6 Risk management and site safety

The management of risks associated with automated technology should be integrated into existing safety management systems and workplace transport management. Automated technology may need to operate in a workspace shared with manually driven vehicles and pedestrian workers. Site layout and safe working practices need to be carefully designed to ensure the safe movement of vehicles and pedestrians. TRL has significant experience within both workplace transport site safety as well as automated vehicle technologies so is well placed to advise and support organisations to ensure risks are managed to a tolerable level.

TRL's Strategic Themes

TRL is strategically investing, producing disruptive research and delivering innovation linked to these strategic themes:

Environment & Decarbonisation

Transport solutions that protect the natural environment. The primary challenge is the decarbonisation of transport.

Transport Safety

Safe systems incorporating safe roads, safe speeds, safe vehicles, safe road users

Transport for Sustainable Development

The role of transport in driving sustainable development, with a focus on low to middle income economies.

Automation in Transport

What automation will enable, and how it will be applied to transform the transport domain.

Digitisation of Transport

Data and connectivity enabling new journey capabilities; this also includes digital roads and developing efficiencies for lifecycle asset management, including road design, construction, condition monitoring and maintenance.

New Mobility

New ways of moving people & goods, including active travel, and new business models and on-demand services to promote inclusivity and ease of use.

For more information on these themes, visit: www.trl.co.uk/strategy

About TRL

Our mission: Creating clean, efficient transport that is safe reliable, and accessible for everyone

TRL is a team of expert scientists, engineers and specialists working together with our clients and partners to create the future of transport.

We publish software that helps the world's largest cities, and many smaller towns too, reduce pollution, carbon footprint and congestion with advanced traffic management, better road design and good asset management.

We conduct leading edge research into infrastructure, vehicles and human behaviours which enables safer, cleaner, more efficient transport.

We deliver detailed incident investigation, structural survey and other high value field services to help clients to improve the service they give their customers.

We work with universities and other partners to invest in basic and applied research that will underpin future needs.

We have built, with partners from government and industry, the Smart Mobility Living Lab: the world's first physical and virtual testbed in a global megacity (London) that lets companies test new mobility products and services safely on live public roads.

Established in 1933 as the UK government's Road Research Laboratory, the renamed TRL was privatised in 1996 and today has more than 1000 clients in many countries. Our headquarters are in Crowthorne House, near Bracknell, and we have offices in Birmingham, Edinburgh, London, Germany and India.

Transport Research Foundation (TRF)

The TRL group of companies is owned by the Transport Research Foundation: a non-profit distributing company that enables our experts to give independent advice without influence from shareholders or finance companies.

Executive summary

The gap between technology development and automated vehicle deployment has been underestimated and the challenges involved with delivering autonomy have been far greater and more complex than first envisaged. TRL believe that the following activities are key in overcoming these challenges:

1. Develop a UK regulatory approval system that enables the safe and secure deployment of automated vehicles in the future.

A flexible and responsive regulatory system is needed that can enable innovation by streamlining entry into emerging markets and lessen the initial regulatory burden on developers and manufacturers.

2. Provide a simple, consistent but robust approach to assuring safety during trials and testing to enable and facilitate trials across all UK locations and environments.

The approach to safety assurance varies between stakeholders and this inconsistency can provide a barrier to testing in multiple locations or avoiding areas with more stringent requirements. TRL is developing a software tool that could be used to guide and support stakeholders when engaging with trialling organisations.

3. Develop and implement a UK safety monitoring and investigation unit to monitor safety, analyse data, investigate incidents and provide timely feedback and recommended actions.

TRL can identify road user behaviours that are likely to lead to a collision. These behaviours could be monitored using in-vehicle data and supplemented with environmental and location data from intelligent infrastructure. This proactive approach would drive safety improvements, promote continuous improvement, accelerate innovation and development and make Vision Zero a more realistic and achievable target.

4. Enable more advanced trials to be undertaken in the UK where the boundaries of the technology are extended and solutions to the identified challenges are explored without compromising safety.

London's Smart Mobility Living Lab (SMLL) provides a unique real-world test facility to conduct advanced tests and validate vehicle behaviour performance. Through testing in a real-world environment and monitoring performance using cooperative infrastructure, we can accelerate learning and technology progression.

5. Accelerate the adoption and safe implementation of automated vehicles for off-highway activities and minimise worker exposure to high risk environments and working practices within the UK and globally.

As part of an Innovate funded project on Automated Off-highway Vehicles, TRL has developed and published a draft Code of Practice providing guidance to operators of automated vehicles in all sectors of the off-highway industry.

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