HOW CAN AN OPERATIONALLY SAFE ENVIRONMENT BE ASSURED IN THE TRANSITION TO AN AUTOMATED ENVIRONMENT?

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WHILST AN ENVIRONMENT WHERE ALL VEHICLES ARE FULLY AUTONOMOUS IS CURRENTLY ENVISAGED AS THE END GOAL, TECHNOLOGICAL ADVANCES ARE EXPECTED TO BE DELIVERED INCREMENTALLY CREATING A SPECTRUM OF AUTONOMY.

THE STRATEGIC ROAD NETWORK IN THE UNITED KINGDOM HAS SEEN INITIAL LEVELS OF AUTONOMY INTRODUCED OVER PREVIOUS YEARS BUT A VARIETY OF CONSIDERATIONS ARE REQUIRED TO ESTABLISH HOW NETWORK OPERATORS REACT FROM THE PRESENT SITUATION THROUGH THE NEXT PHASES, EVENTUALLY LEADING TO FULL AUTONOMY (TRANSITIONAL PHASE).

THIS PAPER IDENTIFIES AND REVIEWS THE OPERATIONAL SAFETY CONSIDERATIONS THAT ARE APPLICABLE TO THIS TRANSITIONAL PHASE AND CONSIDERS HOW CHALLENGES CAN BE MITIGATED AND MANAGED. RECOMMENDED NEXT STEPS FOR NETWORK OPERATORS ON HOW TO REACT TO THESE SIGNIFICANT FUTURE VARIATIONS ARE PROVIDED.

Introduction

The move from present day to a fully autonomous road environment can be split into stages, this spectrum of autonomy is becoming clearer to network operators however how to react and manage the transition is not yet fully defined.

Expected benefits of full automation is relatively clear, an example is the prediction of a 90% reduction in road traffic collisions through the removal of driver error[1]. The operational performance is expected to improve, through an increase in average speeds and reduced congestion, all attributed to the consistent and efficient traffic management brought by autonomous systems. Benefits realised through the transitional phase between the current situation and a fully autonomous environment are not as clear. It is expected that the combination of automated and traditional driver controlled vehicles is likely to introduce risks with mitigations required to manage, what these look like is not yet clear.

As the transition across the spectrum is underway, there is a need for network operators to assess and proactively work to ensuring operation in an acceptably safe manner is facilitated and maintained.

It is expected that considerations surrounding the stages of autonomy will vary across local and strategic roads, this paper considers the challenges and considerations required on the UK strategic road network. The SRN accounts for only 2% of the road network in England, however it is the most heavily used part, carrying one third of all traffic and two thirds of all freight[2]. Its strategic importance is not only applicable to the UK economy but has wider benefits for the European Union through a number of trans-European routes.

AIMS AND OBJECTIVES

Autonomy has become the long-term focus of the transportation sector. Challenges likely to be faced have not fully been considered by SRN operators and maintainers, these will need to be clearly considered in order for the transition to be successful.

The aim of this paper is to:

- Consider the operational safety challenges and opportunities that could be faced by network operators between current situation and full autonomy (transitional phase)
- Review how can these potential challenges be mitigated and managed and how opportunities can be realised
- Recommend next steps for network operators to start planning for the transition.

What is Operational Safety?

To provide an introduction to the parameters being used for consideration of challenges and opportunities, a summary of operational safety is documented below. This subject can be split into four areas:

SAFETY MANAGEMENT

An important aspect of the work carried out by Network Operators is the management of safety risk which needs to be undertaken through cost effective and appropriate means. Safety risk can be defined as being the combination of the likelihood and the consequence of a specified hazard being realised. All schemes, projects, programmes, operational activities, policies and other initiatives undertaken by Network Operators should be implemented with an appropriate level of safety governance in order that safety risk is identified, mitigated and managed.

OPERATION OF THE STRATEGIC ROAD NETWORK

Operation of the SRN, in a way that results in compliant driver behaviour and reliable journeys, relies on effective management of congestion and incidents in a safe, sustainable and politically acceptable manner. The operating regimes that are put in place will be key to achieving the scheme objectives but just as important is how Network Operator manages these operating regimes. The management of incidents, roadworks, weather, and other heightened situations that impact the operation of the scheme is essential to ensuring that the SRN is operated in the most effective and efficient way.

MAINTENANCE STRATEGY FOR THE SRN

The maintenance strategy provides assurance that the necessary maintenance activities can be carried out while ensuring that the risks to road workers are kept as low as reasonably practical. The strategy should also determine the likely impact on network availability, identify any specific resource requirements and highlight any safety issues for road users and operatives.

A strategy needs to demonstrate that a design for maintenance approach has been followed throughout the design and construction of the road, roadside assets, and any associated technology. This is to enable maintenance to be carried out safely and cost effectively while ensuring that any future maintenance interventions which expose road workers to risk are minimised.

Stakeholder Management and Engagement

Stakeholders need to be managed in different ways depending on the likely impact a scheme will have on them—the level and type of engagement will vary. Stakeholders can be major allies, and building their views and feedback into a design process can have significant long-term benefits. The natural starting point for any stakeholder will often be to reject change, but by making the stakeholder part of that change and showing how it will benefit them can lead to support from the start. Operationally speaking, their experience can also be a major contributor to the success of a scheme on the SRN. Identification of key stakeholders is not always simple, but on a highway, is likely to include the network operators, maintainers and emergency services as a minimum.

Each of these subject areas considers transport challenges from a different perspective however if considered and managed collectively ensure an operationally safe environment for any given scheme or concept.

Automated Environment and How This Looks on the SRN

The automated environment is largely being driven by enhancements to in-vehicle systems, this is shown in the spectrum of automated driving shown in Figure 1 below. A number of levels have been identified showing the progressions from no automation through to a future vision of full automation.

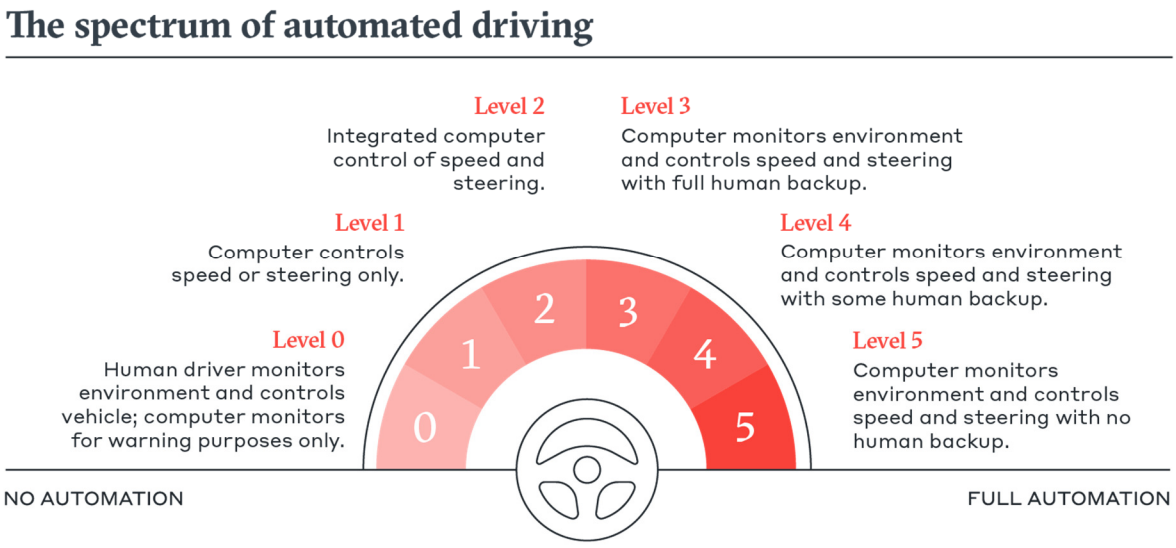

Figure 1: The spectrum of automated driving[3]

The spectrum of autonomy has quite broad implications which differ across varying road types, our view of the context on the SRN is summarised in Table 1 below.

Level	Context in relation to SRN
0	The current situation for the majority of users across the SRN, little to no input from any automated systems.
1	This level is becoming more apparent in various models of vehicles, its use on the SRN is more appropriate due to the clearer speed limits and direction of travel.
2	Some vehicles are beginning to be used on the SRN with features linked to level 2, this is limited however the SRN provides the most likely environment for these systems to be used first.
3	Very limited number of vehicles are currently being used across the SRN with level 3 features.
4	Some vehicles have the capability to operate at level 4 but legislative restrictions typically prevent recognised use beyond level 3.
5	No vehicles are being used by the general public operating at level 5, this will require significant legislative changes and will impact on the infrastructure of the SRN.

Table 1: Context of spectrum of autonomy across the SRN

Whilst an environment where all vehicles are fully autonomous is currently envisaged as the end goal, advances can be divided into two groups. As defined in WSP's White Paper[3]: New Mobility Now: A Practical Guide.

The first approach is being brought to market by several manufacturers, where everyday driving speeds are not compromised by increasing levels of on-board automation. In 'self-driving' mode, these vehicles are now able to navigate without substantial driver intervention under defined conditions. But at no time does the driver give up legal or practical control of the vehicle, and none are able to operate on the road beyond SAE Level 3.

The second approach to the development of fully autonomous (Level 4/5) operation is based around slow speed fully driverless pods. As one example, a series of UK-based pilot trials are now live, generally on footways and in defined pedestrianised areas. These trials are more focused on 'any condition' driving at speeds where the safety-related risks are low. They are also providing insight into how these vehicles are perceived and accepted by the public. The use of level 4/5 vehicles is not yet being applied to the SRN.

As identified in the above, it is assumed that transitional phases cover the move from level 2 to level 5 of autonomy. This is the transitional phase through which there will be a significant mix of autonomous (at vary levels) and standard vehicles. According to the Secretary of State, fully autonomous vehicles could be on the UK roads as early as 2021, meaning the transitional phase, whilst already having begun between some levels is close upon us.

Transitional challenges and opportunities

The following sections identify the considerations that should be given to ensuring an operationally safe environment during this integrated mix of autonomous and standard vehicles.

OPERATIONAL SAFETY

Factor	Challenges	Opportunities
Level of complexity for safety decisions	Moving through the spectrum increases the reliability on technology. How do we then define the appropriate level of complexity for safety decisions?	To fully develop a detailed safety approach which gives confidence through the spectrum.
Safety baseline and objectives	With new technology emerging, how do we establish the safety baseline and objectives for different populations?	To learn from other technology schemes such as Smart Motorways to develop suitable and appropriate baselines and objectives.
Risk assessments	Obtaining accurate data and evidence that will provide a robust and conclusive risk assessment.	To undertake trials and gather evidence at an early stage through the development of autonomous vehicles.
Defining mitigations to manage safety performance	Agreement of appropriate mitigations.	Close liaison with stakeholders will help to ensure appropriate mitigations are fully considered and developed.

Table 2: Operational safety challenges and opportunities

As shown in Table 2, the challenges at present relate to many unknowns in the applications of technology and systems to support automation. This does however provide various opportunities to consider approaches to safety management. Early definition of methodologies for assessment, along with learning from previous applications of

'new' technological advances such as Smart Motorways will provide operators with clearer expected outcomes and enable future ready changes to ways of working and highway operation.

NETWORK OPERATIONS

Factor	Challenges	Opportunities
Journey time, traffic speeds, free-flow conditions	Consideration will be required in order to set appropriate scheme objectives and targets through the spectrum noting that there will be a mix of vehicles on the network (autonomous vehicles and standard).	To comprehensively understand the performance benefits of autonomy and how the future will look when the road is operated as an autonomous environment.
Operational components and assessments	How will the network operator manage the network where there are autonomous vehicles and standard vehicles?	To reduce requirements on the network operator which will reduce operating costs and improve safety.
Compliant driver behaviour (human factors)	How will compliance be achieved with a mix of different vehicles? What technology is required and how should it be operated to achieve acceptable levels of compliance.	To put in place 'softer' operational measures to improve compliance such as education and encouragement.
Controlled environment	A controlled environment provides the driver (road user) with the right (i.e. relevant, timely and accurate) information, at the right location at the right time; thereby promoting appropriate and intuitive driver behaviour. How do we ensure that through the spectrum these key requirements are delivered to all road users (autonomous vehicles and standard)?	To consider the use of road side technology and infrastructure and the use of in-car technology. There may be an opportunity to reduce roadside infrastructure. We can better understand how drivers behave in an autonomous environment.
Driver information	With autonomous vehicles eventually reaching Level 5, there is a need to understand what information is actually required as we move through the spectrum.	To reduce the level of information from network operators presented to road users. Technology and other infrastructure can be removed if not required.

Table 3: Network operations challenges and opportunities

The introduction of autonomous vehicles will bring differing changes at each stage, the expectation is that benefits will be significant in areas such as reducing journey times and increasing average traffic speeds. Whilst this vision is shared, subtle changes to existing ongoing challenges is likely as detailed in Table 3. These ongoing challenges do provide opportunities, the delivery of a controlled environment will be more complex with the reliance on technology and reliance on software settings within vehicles, however this can be more easily controlled and adapted than the actions of human drivers at present.

MAINTENANCE STRATEGIES

Factor	Challenges	Opportunities
Designing for maintenance and applying the Eliminate, Reduce, Isolate and Control (ERIC) principles	That the risks to road workers are kept as low as reasonably practical and that design for maintenance approach has been followed throughout the design and construction of the road, roadside assets, and any associated technology.	To reduce the level of risk for road workers.

Table 4: Maintenance strategy challenges and opportunities

Without clarity on various operational aspects as noted in the previous section, it will be difficult for network operators to consider the implications on maintenance. A highway that has a significant amount of roadside equipment to enable safe operation (i.e. a Smart Motorway) will require a maintenance strategy that consists of a wide range of considerations. Where the technological control is in-built within the vehicles that use it, it will be subject to a maintenance strategy that centres around the surface and existing local features (i.e. bridges, vegetation) that enable or interact on transiting of vehicles using the section. One consistent aspect will be the need to reduce risk as low as reasonably practicable and opportunities to minimise maintainable assets is expected to be a benefit as transition occurs.

STAKEHOLDER ENGAGEMENT AND MANAGEMENT

Factor	Challenges	Opportunities
Communication planning	Early liaison with stakeholders is key to the transition to autonomy.	To work closely with stakeholders as early as possible so that any concerns can be mitigated.
Stakeholder engagement	Ensuring that all stakeholders are bought into the approach to autonomy and that agreement can be reached that risks are appropriately mitigated.	Enable a comprehensive approach to be in place so that network operators, vehicle manufactures, core responders and other key stakeholders work through issues and risks together.
Management of relationships and messages	That all stakeholders have the same goals, objectives and timescales. What are the messages to be delivered to all road users (autonomous vehicles and standard)?	Working more closely with the customer – the travelling public so that they understand the autonomous transition on the SRN.
Education, encouragement, engineering and enforcement (4 Es)	These factors (4 Es) are key to the transition. The required level of each factor would need to be established through each phase of the spectrum and also for the different mix of vehicles on the SRN.	To work closely with all stakeholders to agree the approach to delivery of the 4 Es. This will ensure that a suitable level of each factor is provided to road users at the appropriate time.

Table 5: Stakeholder management and engagement challenges and opportunities

Early and ongoing engagement with stakeholders will be essential to achieving successful outcomes with automation however at the development stage of a concept this can be a challenge to achieve. A reluctance to share

information and openly engage on developments, that may risk commercially sensitive information passing to competitors, may reduce involvement of manufacturers. This information being shared with network operators would however, likely improve the ability to adapt to changes in vehicle fleet capabilities and enable opportunities to improve operational safety performance across most populations (i.e. road users and workers, etc.).

Recommendations for network operators

As identified in the sections above there are a significant number of ongoing challenges and opportunities through the spectrum of autonomy. Building on these a number of next steps could be considered by network operators to adapt to the changing environment brought by autonomy and enable a successfully managed transition.

Considerations should have operational safety as the focus with various recommendations summarised below:

Operational safety – determination of a future vision for the safety performance of the road network allows for a more targeted definition of safety baselines and objectives. Undertaking preliminary safety risk assessments will begin to identify new and existing hazards that will require mitigation, this in turn will begin to help shape future policy and procedures.

Network operations – understanding of and input to software developments across the automated fleet will help shape the strategy for operation of the SRN. Determining appropriate means of information provision to users at varying stages of the transition will be challenging and development of an early operational strategy will assist in mapping out this approach.

Maintenance strategies – maintenance strategies are impacted primarily by the approach to infrastructure, clear understanding of the requirements of autonomous vehicles will enable application of ERIC principles at an early stage to make sure that future network enhancements have 'designing for maintenance' at the forefront and that mitigations introduced for the transitional phase do not disproportionately adversely affect maintenance workers as a population.

Stakeholder management and engagement – early and ongoing engagement with key stakeholders will be essential to increasing knowledge with developments.

Conclusion

This paper has reviewed the operational safety considerations that are applicable to this transitional phase and considered how challenges can be mitigated and managed. Enabling an operationally safe environment during the transition to autonomy will be a challenge, however it unearths various opportunities for Network Operators. Being proactive, adaptive and retaining longer-term visions will provide a basis for assuring safe design and operation. If these approaches can be taken forward then this can only support the successful transition to an environment where all vehicles are fully autonomous and a high performing network is operated in a safe, efficient way.

References

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