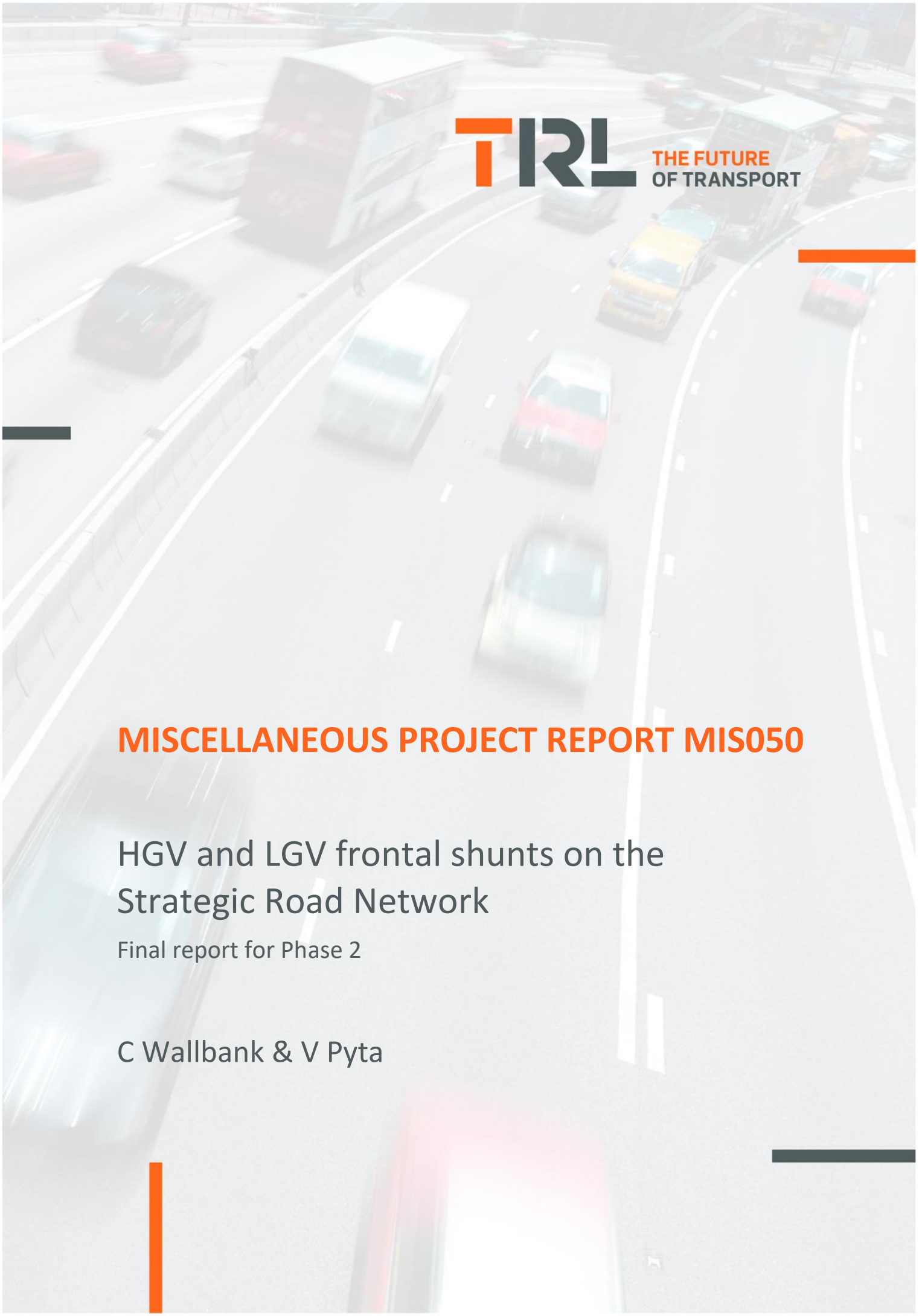

THE FUTURE OF TRANSPORT

MISCELLANEOUS PROJECT REPORT MIS050

HGV and LGV frontal shunts on the Strategic Road Network

Final report for Phase 2

C Wallbank & V Pyta

Report details

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Executive Summary

Highways England has an aspirational long-term vision that by 2050 no one should be harmed while travelling or working on the Strategic Road Network (SRN). To monitor progress towards this vision, Highways England has a Key Performance Indicator (KPI) to reduce the number of killed or seriously injured (KSI) casualties on its network by 50%. The Commercial Vehicle Incident Prevention (CVIP) programme, which aims to identify risks associated with commercial vehicles and drivers and the design and evaluation of interventions to prevent incidents involving these vehicles, will deliver measurable impact against this KPI, and contribute to the wider outcomes and objectives outlined in the strategy.

One of the most common collision types identified for commercial vehicles on the SRN is frontal shunt collisions, where the front of the commercial vehicle impacts the rear of another vehicle. These collisions account for around a third of collisions involving HGVs and LGVs on the SRN and thus reducing these figures could make a significant contribution to achieving Highways England's targets.

This project aims to understand the root causes of these collisions (Phase 1) and identify countermeasures or interventions which could help to prevent them in the future (Phase 2 – this report). This report explains how a list of 26 countermeasures were generated to address the causes identified in Phase 1 (Wallbank *et al.*, 2021), documents the output of a workshop with stakeholders to prioritise these countermeasures and makes recommendations for which countermeasures Highways England should pursue further.

The following points provide a summary of the recommended course of action in relation to each of the countermeasures; further details are presented in Section 4.2 of this report:

1. Review where media campaigns aimed at the general public which cover the following topics might fit within Highways England's portfolio:
    - The performance limitations of HGVs
    - The importance of addressing vehicle warning lights and maintaining a roadworthy vehicle, specifically improved maintenance of vehicle rear-lighting
2. Pursue the following through engagement with operators (e.g. through Driving for Better Business (DfBB) or other communication channels):
    - Develop and communicate guidance and/or a checklist on what training for fleet drivers should cover
    - Promote INDG382 guidance (and forthcoming web-based replacement) to operators, specifically the parts related to the uptake of technologies[4] and health, safety and wellbeing policies
    - Engage with Operators to understand current use of electronic systems whilst driving to inform discussions with vehicle manufacturers about improvements and fitment of voice control systems
    - *Lower priority: Promote guidance on maintaining the roadworthiness of LGVs/HGVs*

- *Lower priority: Review guidance provided on mobile phone use and technologies to prevent these devices being used whilst driving*

3. Identify areas of the network where the following might be beneficial and carry out a cost-benefit analysis to understand whether to pursue installation:
   - Average speed cameras
   - Increased use of MIDAS
   - Increased use of Variable Speed Management
4. Identify potential funding routes for the following activities:
   - Development of materials for HGV/LGV driver hazard perception training
   - *Lower priority: Review training provided through CPC and engage with training providers to improve this*
   - Creation of a Road Collision Investigation Bureau or alternatively, Highways England In-depth investigations framework
5. Monitor progress with the following technologies and engage with the development/regulation process as necessary:
   - Improvements to AEB regulations
   - Driver monitoring systems including sudden sickness, distraction/attention and fatigue/drowsiness monitoring systems
   - Vehicle-to-vehicle (V2V) technology, specifically that related to automated queue warning solutions
6. Carry out further research to re-evaluate sites where two second chevrons are installed to understand the long-term effectiveness of this countermeasure.

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1 Introduction

Highways England has an aspirational long-term vision that by 2050 no one should be harmed while travelling or working on the Strategic Road Network (SRN). To monitor progress towards this vision, Highways England has a Key Performance Indicator (KPI) related to the number of killed or seriously injured (KSI) casualties on its network. In the second period of the Road Investment Strategy (RIS2), which runs to 31 March 2025, the KSI target requires a 50% reduction from the 2005-09 baseline. The Commercial Vehicle Incident Prevention (CVIP) programme, which aims to identify risks associated with commercial vehicles and drivers, and design interventions to prevent incidents involving these vehicles, will deliver measurable impact against this KPI, and contribute to the wider outcomes and objectives outlined in the strategy.

One of the most common collision types identified for HGVs on the SRN is frontal shunt collisions, where the front of the HGV impacts the rear of another vehicle. There were 472 of these incidents in 2018 and 466 equivalent collisions involving LGVs. As a result, reducing these figures could make a significant contribution to achieving Highways England's targets. This project aims to understand the root causes of these collisions (Phase 1 (Wallbank *et al.*, 2021)) and identify countermeasures or interventions which could help to prevent them in the future (Phase 2 – this report).

1.1 Report structure

This report is structured as follows:

- Section 2 presents a summary of the causes identified in the form of Ishikawa (or cause and effect) diagrams. These diagrams present a hierarchy of the strength of evidence for each cause (from strong to weak), based on the prevalence of the cause in the data and whether the same cause was identified across multiple sources. It is not however possible to attribute a numerical figure to the prevalence of each cause.
- Section 3 summarises the methodology used to generate the countermeasures suggestions for the identified causes. It also presents the full list of countermeasures taken forwards to prioritisation.
- Section 4 summarises the results of the prioritisation of countermeasures and makes recommendations for which countermeasures Highways England should pursue further.

2 Conclusions from Phase 1

The findings from the phase 1 analysis are presented in Figure 2-1 the form of an Ishikawa diagram (also called 'cause and effect' or 'fishbone' diagrams). These are designed to show the possible causes of an event, in this case why HGV/LGV frontal shunts are occurring on the SRN. The right-hand side of the diagram also provides a summary of the circumstances for these collisions, information which might be useful in designing and implementing countermeasures.

The left-hand side of the diagram contains the key causes identified from the analysis of Stats19, HE Fatals and the driver engagement tasks carried out in Phase 1. These causes are grouped under the three safe system pillars of behaviour (for both the HGV/LGV driver and other road users), roads/environment and vehicles. Two additional categories are included: one to reflect the organisational factors identified and another to list factors which increased the collision severity.

The ordering of causes within each of these groups reflects the strength of evidence for that cause (from strong to weak), based on the prevalence of the cause in the data and whether the same cause was identified across multiple sources. Where relationships were evident between different causes, these have been indicated by a dotted line.

This diagram enables common themes and areas where system performance may be weaker to be identified. The Phase 1 report concluded that:

- A large proportion of the causes seem to relate to the HGV/LGV drivers' behaviour[1], and a lot of these causes were shown to be interrelated.
- Road/environmental factors were also relatively common in these collisions, with queuing traffic being the biggest cause identified for frontal shunts. This linked to behavioural factors for other vehicle drivers including "cutting in" and "sudden braking".
- Issues with vehicle technology featured within the causes in the vehicle group, including:
    - Technology not working as expected, sometimes because there were issues with identifying which vehicles had active technologies/warning systems.
    - Unintended consequences due to the technology (e.g. increased glances away from the road).

[1] It should be remembered that the Ishikawa diagrams present a list of all the causes identified from the data analysis and attributed to each road user in the collisions; they should not be used to draw conclusions on the relative levels of blameworthiness for these collisions.

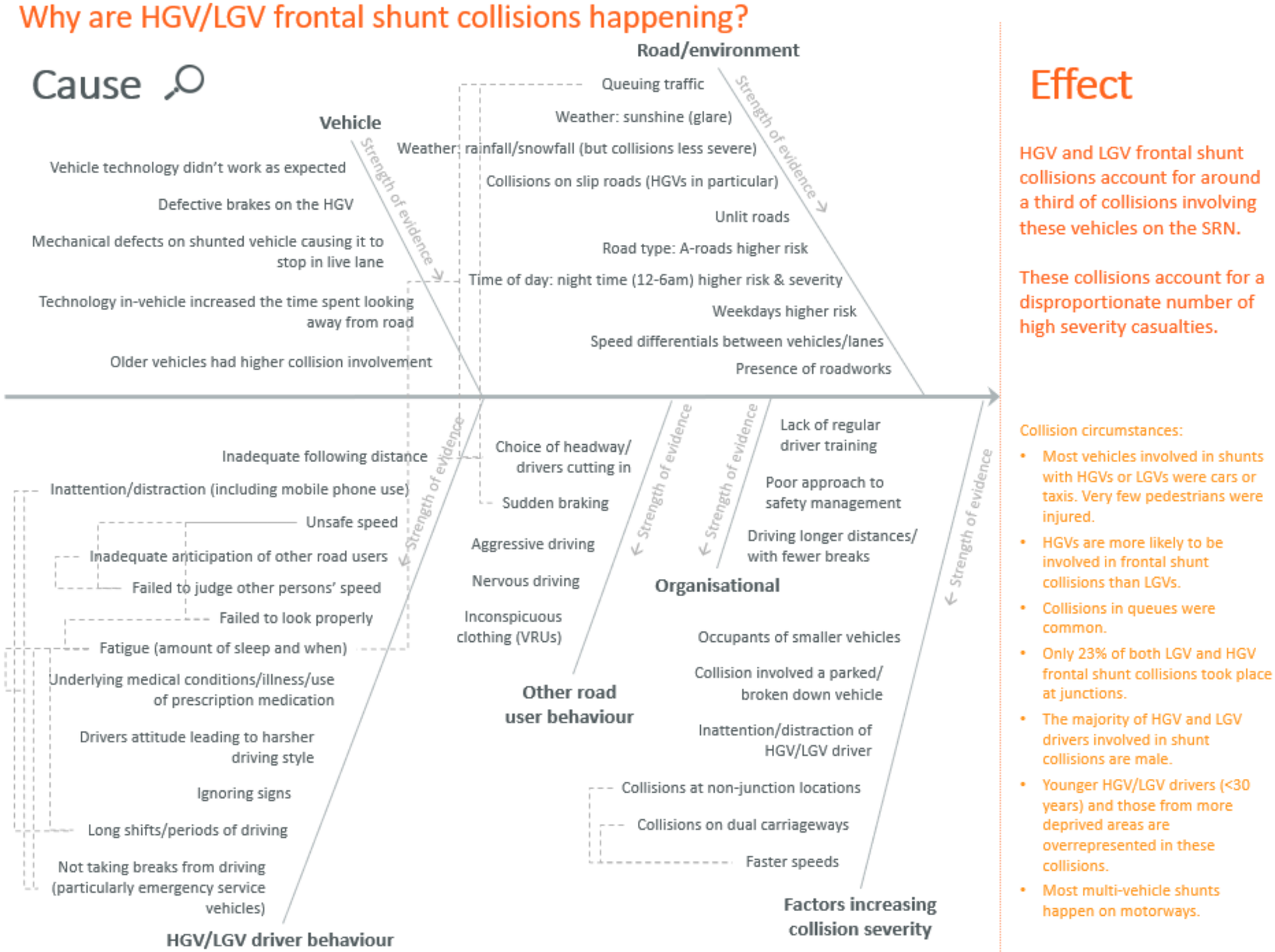

Figure 2-1: Ishikawa diagram for causes and effects relating to shunt collisions on the SRN (Wallbank *et al.*, 2021)

Note: strength of evidence is decreasing as you go down the page for each spine

3 Countermeasure suggestions

Figure 3-1 presents an overview of the process for generating countermeasure suggestions. This is described in more detail in the following sections.

Figure 3-1: Method for countermeasure generation

Appendix A summarises a number of other countermeasure suggestions that were made in the expert workshop but were not taken forward to prioritisation. The reasons for these omissions are documented.

3.1 Method for expert workshop

An internal workshop with TRL experts from a range of disciplines (road safety, speeds, collision investigation, vehicle standards, road user behaviour, commercial vehicle fleets, roadside infrastructure, and human factors) was used to collate a list of potential countermeasures. The purpose of the workshop was to identify a list of potentially effective countermeasures to address the causes identified in the Phase 1 work and to take forward to the evidence review (see Section 3.2) and then to prioritisation (see Section 4).

A week in advance of the workshop, participants were given a 30-minute briefing on the purpose and what they would be asked to do. This briefing included a summary of the project outputs from the earlier tasks, including the literature review, analysis of STATS-19 and Fatals data, and consultation with HGV/LGV drivers and managers. The Ishikawa diagram (shown in Figure 2-1) was presented and participants were provided with a spreadsheet containing a summary of the evidence behind each of the causal factors identified.

Each expert was asked to complete a spreadsheet in advance of the workshop with countermeasure suggestions they felt would be effective at addressing the identified causes based on their subject matter expertise. For each countermeasure, the experts recorded the following:

- How/why should this work?
- Feasibility of implementation on the SRN
- Possible unintended consequences
- Timeframe for implementation (Short = could be done in less than a year, Medium = 1-5 years, Long = 5+ years)
- Timeframe of effect on the casualty numbers and whether the effect is likely to be constant/increase/decrease
- Evidence for effectiveness and likely costs and benefits (noting that a full cost benefit analysis was not within scope for this project)

During the workshop, each expert was asked to give a brief verbal summary of the countermeasures they had proposed and this was followed by a discussion around the feasibility of implementing these solutions on the SRN, and the potential timescales for implementation/effect on the casualty numbers (i.e. short, medium or long term).

In addition to their own knowledge base, each expert was assigned to one of the groups listed below and instructed to consider and discuss the countermeasures from these perspectives:

- HGV drivers
- Emergency service vehicle / Traffic officer service / Recovery vehicle drivers
- LGV and other delivery drivers (e.g. Uber, Amazon)
- Specific other groups like new drivers, motorcyclists
- Those who might need to implement countermeasures (e.g. fleet managers, vehicle manufacturers)
- Highways England

The aim of this task was to ensure that as many perspectives as possible were considered at this early stage, to ensure that the countermeasures taken forward were likely to be feasible and effective solutions.

3.2 Review of countermeasure suggestions from Phase 1

A short list of additional countermeasures for consideration was collated from the results of Phase 1 (Wallbank *et al.*, 2021). The literature review noted any countermeasures mentioned in the papers reviewed, and the drivers and managers involved in the engagement task were also asked for any suggestions that they believed would help to reduce these collisions.

Twenty-three potential countermeasures were identified through this route, and these were assessed in the same way as those identified by the TRL experts.

3.3 Gap analysis (rapid evidence review)

The aim of the rapid evidence review was to fill in any gaps in knowledge following the expert workshop and countermeasure review from Phase 1, to ensure that the countermeasure suggestions taken forward for prioritisation were likely to support Highways England to reduce frontal shunt collisions.

Some of the questions posed and answered in the review were:

- Is there any evidence specifically for the effectiveness of average speed cameras at reducing shunt collisions?
- What evidence is there around the effectiveness of better 'size' cues from rear lights on vehicles?
- Voice controls and head up displays – what is the evidence for/against these? Any specific findings for use in HGVs?

- What is the evidence that training interventions (both skill/knowledge based, and attitudes/behaviour based) for LGV/HGV drivers can be effective?
- What evidence is there of the effectiveness of media campaigns to educate the whole driving population?
- Is there any evidence of hazard perception training being implemented and having a positive effect on safety in experienced professional drivers?

The results were collated, along with the information on each countermeasure provided by the experts and the discussion from the expert workshop (see Section 3.1, and summarised in the following section.

Following the review, some countermeasures were deemed as out of scope, not feasible for implementation, not considered to be effective at reducing shunt collisions or already being considered by Highways England. For completeness, these are documented in Appendix A.

3.4 Countermeasures for prioritisation

Table 3-1 summarises the list of countermeasures taken forward to prioritisation (see Section 4).

Table 3-1: Summary of the countermeasures taken forward to prioritisation

No.	Category of countermeasure	Cause	Countermeasure suggestion	How/Why should this work?	Strength of evidence for reducing shunt collisions	Feasibility of implementation	Can Highways England implement this directly?	Known potential unintended consequences	Implementation timeframe	Timeframe of the effect on the casualty numbers
1	Data – Improving understanding of causes	Most factors would be covered to some extent	Full Road Collision Investigation Branch (RCIB)	Independent investigation, evidence base, actionable intelligence and systematic change to safety. This is a combination of coordinated investigation techniques to capture the evidence and programmes to convert into the necessary intelligence to inform systematic change down to target interventions. This countermeasure could benefit all collision types, not just shunts.	Medium	A full national RCIB is challenging – this requires multi-agency coordinated approach, which Highways England would be part of. Highways England can start lobbying for an RCIB and can also take steps towards this (see 'Highways England in-depth investigations framework' countermeasure suggestion).	No	Move to a centralised body responsible for learning about collisions could slow down the speed at which Highways England learns and is able to make improvements. Highways England should be heavily involved as a stakeholder to prevent that, but also can take on its own activities to supplement and mitigate.	Medium	Depends on interventions that arise but likely needs 3+ years before enough evidence for systemic changes is available. Effect should only increase though.
2	Data – Improving understanding of causes	Most factors would be covered to some extent (but would focus on factors that are easier to identify than an RCIB)	Highways England In-depth investigations framework	This countermeasure works by using Highways England's existing infrastructure and network of personnel to collect key information from collision and incident scenes – to enhance existing understanding and data capabilities. It would involve creating an investigation framework, training and support programme and potentially some equipment (e.g. cameras) for Traffic Officers to use at the scene of incidents to capture in-depth data. Essentially 'on-scene lite by proxy'. Similar to how Transport for London use Notification and Investigation of Major Incidents (NIMI) and Ministry of Defence with the Defence Accident Investigation Branch (DAIB). Still needs independent investigation, evidence base, actionable intelligence and systematic change to safety, but at a different scale to a full RCIB. Highways England Fatals database is a start but represents a single aspect and has limitations (but good demonstration of how a powerful dataset can be built up relatively quickly).	Medium	Estimate it would take 1 year for Highways England to conduct a feasibility study and develop framework and training. Then a further year to start rolling out.	Yes	Risks to safety – should be covered in training and feasibility. Poor quality of information gathered – framework should allow layperson to collect useful info.	Medium	Allow 1 year for adjusting to the process, but analysis for interventions and additional intelligence could begin almost immediately.

				This countermeasure could benefit all collision types, not just shunts.						
3	Data – Improving understanding of causes	D1-12	Promote uptake of dashcams with proactive monitoring to identify appropriate interventions for the behaviours observed	This countermeasure works through better data to understand the involvement of human factors and behaviour on collisions. it could be achieved through encouraging fleets and commercial vehicle operators to install devices that monitor drivers - e.g. dashcams. Human factors and behaviours are the most difficult part of a collision to identify and evidence, usually being reliant on witness statements. Through accessing these types of data, it will be possible to build the evidence base with which we can make informed decisions on which countermeasures should be implemented at a system level. Proactive monitoring or reporting could also provide more targeted interventions at an organisational level (e.g. stop requiring your drivers to complete a certain form after delivery because CCTV shows they are all doing it while on the way to the next job) down to targeting individual drivers (obvious challenges with this and 'Big Brother').	Medium	Easily technologically, more difficult to encourage drivers/organisations to do it. Highways England could lobby for this approach. Key part of the message would be it is for learning purposes, however, how would you stop the police taking it in a criminal investigation?	No	Manipulation, tampering, disabling the device. Police take data, undermining trust that it's there for learning not to keep an eye on the drivers and prosecute them if they do something wrong.	Short	Delayed by time to implement in large number of vehicles.
4	Driver – monitoring technology	V4, E10, D2, D11, ORU2, S3	Distraction or attention monitoring	This is a driver monitoring system that monitors the drivers' attention to the road scene and warning them when they are visually distracted. This would encourage the driver to keep their eyes on the road whilst driving reducing the accidents related to visual distraction and inattention.	High	To prevent visual distraction-related crashes, Regulation (EU) 2019/2144 mandates the implementation of Advanced Distraction Recognition (ADR) systems on M1, M2, M3, N1, N2 and N3 vehicles from July 2022 (new types) and July 2024 (all new vehicles). This will likely be delayed and effectiveness in the UK depends on DfT adopting the EU regulations. Highways England can't implement this directly, but they could lobby for regulation.	No	If the system is not sufficiently robust, the driver may get false-positive and false-negative warnings which could cause lack of trust in the system, unnecessary distraction and/or driver frustration. If the system is not sufficiently robust, it may result in the driver performing more risky behaviour than prior to implementation, and as such, increase accident risk. However, the effectiveness of these systems needs to be demonstrated by the manufacturer to obtain type-approval which mitigates the risk of badly designed systems being brought to market. Over time, these systems will improve.	Medium	Delay due to time it takes technology to infiltrate the fleet but for vehicles that are fitted, if the system is robust then an immediate effect likely. Effect will likely increase with advancement in technology capabilities.

								Moreover, according to current draft regulations, the driver can switch these systems off if needed.		
5	Driver – monitoring technology	E7, D7, D8, D11, D12, O3, S3	Fatigue and drowsiness monitoring	Current systems monitor the drivers' alertness through vehicle system analysis and warn the driver when they are too drowsy to drive safely. Future system will likely comprise a camera which monitors the driver eyelid behaviour in conjunction with vehicle system analysis to determine the driver's drowsiness level, warning them when they are too drowsy to drive safely. This system would encourage the driver to take a break and educate them on driver drowsiness.	High	To prevent fatigue-related crashes, the revised General Safety Regulation (EU) 2019/2144 mandates the implementation of Driver Drowsiness and Attention Warning (DDAW) systems on M1, M2, M3, N1, N2 and N3 vehicles from July 2022 (new types) and July 2024 (all new vehicles). This will likely be delayed and effectiveness in the UK depends on DfT adopting the EU regulations. Highways England can't implement this directly, but they could lobby for regulation.	No	If the system is not sufficiently robust, the driver may get false-positive and false-negative warnings which could cause lack of trust in the system, unnecessary distraction and/or driver frustration. If the system is not sufficiently robust, it may result in the driver performing more risky behaviour than prior to implementation, and as such, increase accident risk. However, the effectiveness of these systems needs to be demonstrated by the manufacturer to obtain type-approval which mitigates the risk of badly designed systems being brought to market. Over time, these systems will improve. Moreover, according to current draft regulations, the driver has the ability to switch these systems off if needed.	Medium	Delay due to time it takes technology to infiltrate the fleet but for vehicles that are fitted, if the system is robust then an immediate effect likely. Effect will likely increase with advancement in technology capabilities.
6	Driver – monitoring technology	D8	Sudden sickness monitoring	This system, which is still under development (some Tier 1 suppliers have a system), monitors the driver health state. It is currently a requirement for Level 3 and 4 Automated Vehicles to monitor this state whilst the Automated Driving System is engaged, taking action when the driver is too unwell to drive safely. It is envisaged that this system will eventually be implemented in conventional vehicles to warn drivers when they are too unwell too drive (or even to act if needed). Euro NCAP has recommended this to be monitored by all vehicle types – this is part of their scoring system. If implemented in vehicles, including HGVs and LGVs, it could prevent accidents relating to the onset of ill health.	Medium	Driver Availability Monitoring Systems for Level 3 and 4 Automated Vehicles are required to monitor sudden sickness, along with other states such as drowsiness, driver presences, attentiveness, secondary task engagement etc. It is expected that once this technology is developed and these types of systems are brought to market, the sudden sickness element can be transferred into conventional vehicles. Highways England can't implement this directly, but they could lobby for regulation.	No	If the system is not sufficiently robust, the driver may get false-positive and false-negative warnings which could cause lack of trust in the system, unnecessary distraction and/or driver frustration. If the system is not sufficiently robust, it may result in the driver performing more risky behaviour than prior to implementation, and as such, increase accident risk. However, the effectiveness of these systems needs to be demonstrated by the manufacturer to obtain type-approval which mitigates the risk of badly designed systems being brought to market. Over	Long	Delay due to time it takes technology to infiltrate the fleet but for vehicles that are fitted, if the system is robust then an immediate effect likely. Effect will likely increase with advancement in technology capabilities.

								time, these systems will improve.		
7	Driver – monitoring technology	E1, E9, D1, D3	Driver behaviour monitoring	This uses vehicle telematics and forward-facing cameras to assess the driver's driving behaviour i.e. following distance and harsh braking etc. Currently used by insurance companies and some fleet companies to identify risky driving behaviour. There have been some apps developed aimed at improving risky driving behaviour by presenting feedback and advice to drivers in real-time or in a report. In-app/report-based feedback has been shown to diminish in effectiveness over time but if coaching/feedback from a manager also included then this has shown to be more effective in the longer term. If used effectively, this type of monitoring can improve driving performance over time and assist in helping identify drivers who drive unsafely. It is recommended that drivers who are identified as unsafe are not penalised but rather trained or educated on what they are doing wrong and how to improve it (i.e. a preventative blame-free culture). Holding drivers accountable (except of course in extreme cases) could cause conflict in the working environment. Moreover, a risky behaviour such as sudden braking may not be due the HGV/LGV driver but rather the other road user driving badly (e.g. cutting in), as such, incidents of identified risky behaviour should be fully investigated. This countermeasure aims to reduce risky driving behaviour and hence reduce frontal shunts.	Medium	This should be feasible to implement as technology already exists and there are systems already on the market. However, not all LGV/HGV operators have adopted this approach, and as such, Highways England could lobby to increase uptake (supported by guidance on how this should be applied to be most effective and/or a cost-benefit analysis to demonstrate the potential benefits).	No	If drivers are punished/penalised for risky driving they may resist such technology. Behaviour which is identified as risky may be due to other road users driving badly and not due to the LGV/HGV driver. Thus, caution should be taken when interpreting the findings from these data.	Medium	In-app/report-based feedback has been shown to diminish in effectiveness over time, but coaching/feedback from a manager more effective in the longer term (Pyta *et al.*, 2020)
8	Driver – training / education	V1	Training for fleet drivers	The aim of this countermeasure is to train the drivers better on what to expect from each new vehicle they drive, before they drive. This could involve additional training session on new types, driving with an instructor, information sheets, knowledgeable contact person for help and questions.	Low	Some evidence from the driver engagement task that some organisations already do this but not consistent. Highways England can't implement directly but can lobby for these activities with fleets and/or FORS.	No	Incorrect training if the trainers or training materials are not relevant/up to date.	Medium	Delayed by time to implement. Effect will decrease unless audit/inspection scheme to ensure this training is of good quality and carried out across all fleets.

9	Driver – training / education	D1 - D12, O1, O2	Drivers involved in frontal shunt incidents required to undertake relevant CPC training (using behavioural change techniques)	Every year HGV drivers are required to undertake 7 hours of professional training – the Driver Certificate of Professional Competence (Driver CPC) [modules usually taken annually but requirement for review of CPC every 5 years]. This training is provided by professional trainers who are registered to do so. The particular courses taken are chosen by the company organising the drivers' training (employer) but the latest guidance suggests organisations should "encourage training programmes that better align with drivers' specific work". If a driver is involved in an incident, or if they have a near miss, the idea is that their next CPC training could be orientated to training to prevent these incidents in the future. Behavioural change techniques could be used to deliver the content, raising awareness of common LGV/HGV driver behaviour factors in theses collisions and the consequences of these, educating them on other road user behaviour and what to be aware of, and providing some easy-to-remember actions they can take to lower their risk. This is do-able in principle (recent TRL example for close following intervention) but very little exists in the way of suitable material at present. Choice of CPC module is up to the employer (and none are mandatory) so effectiveness of this countermeasure will be limited by how this is implemented (identification of higher risk drivers, selection of appropriate course, effectiveness of the course at changing future behaviour). There is also some evidence that some employers are putting drivers through the most convenient/cheapest rather than most advantageous Driver CPC training (in fact, the rules have just been changed to prevent over-repetition of modules over the 5-year period).	Low	If a link could be established between police recording/investigation of incidents and Driver CPC training, this could improve the effectiveness of this countermeasure. A similar link exists between speeding offences and training (offered in the form of a speed awareness course by the police). Highways England can't implement directly but could engage with course providers to influence course content, and potentially carry out evaluations of these courses to provide some assurance that the mechanisms for behaviour change are having the desired impact.	No	A driver could miss out on other relevant Driver CPC training. Poor quality training which is not regularly updated will likely not reduce crash risk.	Medium	If training effective changes in driving style may be expected immediately post course but effect could decrease over time. Impact will depend on uptake of appropriate courses.

				Impact may be small if only delivered to drivers who have already been involved in an incident.						
10	Driver – training / education	D4, D6	Hazard perception training for LGV/HGV drivers	Hazard perception training provide increased level of skill in safety-critical driving. There is evidence this countermeasure works well at improving safety in inexperienced drivers. There is no firm evidence of this measure being applied to professional HGV/LGV drivers, but it can be assumed that the mechanism of effect might be the same if suitable content could be delivered. To achieve this would require a library of specific stimuli (scenarios) to provide training on relevant situations and consideration would be needed to consider how this is implemented – as part of the LGV/HGV driver test or periodically throughout driving career (as part of the CPC course on incidents for example).	High	Building valid training materials takes time and would need to be done appropriately and tested. Implementation of the training is not within the direct scope of Highways England, but they could lobby for this to be introduced and provide guidance on possible stimuli.	No	Always a worry that it leads to over-confidence. Needs to be address in the training.	Medium	If it can work, then quick, but depends on roll out.
11	Driver – training / education	E1, E4, E9, ORU1, ORU2, ORU3, ORU4	Media campaigns aimed at other road users understanding limitations of HGVs	Education on the capabilities and limitations of HGV and LGVs for other road users to prevent them from, for example, cutting in front of trucks, and understanding the dangers of frontal shunts and how to drive appropriately around larger vehicles. Research has shown that road safety campaigns can reduce collisions, although this effect is usually small (estimated to be an average of 9% from one meta-analysis) and drink-driving campaigns typically have the biggest effect. Therefore, the effect on accident numbers of this type of campaign might be expected to be small. Campaigns using personal communication, roadside and/or enforcement strategies to deliver their message have been shown to be	Low	Not as easy to implement as some other countermeasures as it needs to reach the entire UK driving population. Could be implemented through educational campaigns, for example, via the TV and radio. Additional training could also potentially be added to the driving test.	Yes	If the educational campaigns do not reach the driving population or if people do not pay attention to them, there will be limited effect on crash risk.	Short	Most probably delayed, as it needs time to reach the entire driving population. Regular campaigns could maintain the effect.

				associated with greater accident reductions.						
12	Infrastructure – Perceptual countermeasures	D1, D6	2 second Chevrons	Should help drivers stay a safer distance apart as they can keep two chevrons between them and car ahead. It relies on vehicle behind to keep 2 chevrons from vehicle in front so should impact risk of shunt collision. Previous research found reductions in collisions (over 40% in one 1995 study, and 16% in a Highways England case study); however, the effect may wear off over time. Re-evaluation may be beneficial and would be possible at current sites where chevrons are still present (e.g. M4 J18-J19).	Medium	Easy to put down as marking – if TM in place for something else or at resurfacing. Costly to close road just to do this though. Might require additional maintenance.	Yes	Fairly benign measure, but only used at lower flow levels and at identified hot spots for close following collisions. Widespread use unlikely to have the effectiveness levels indicated. Analysis STAS19 indicates risk of shunt varies proportionate to flow levels per lane and effectiveness not proven at high flow levels. Motorcyclists dislike road paint in centre of lanes, especially on bends (skid hazard).	Short	Immediate benefit – evidence that effect may reduce with time and wearing of markings.
13	Infrastructure – Speed enforcement	E9, D3, S6	Average speed cameras	Evidence shows that average speed camera installation is costly but has a positive impact on driver behaviour and reducing the number of incidents/KSI. Some evidence would suggest that the money saved on having to deal with incidents which results from the installation of the system essentially "pays for itself". No evidence found for the specific impact of average speed cameras on reducing shunt collisions but the mechanism through which this would occur is clear (reducing speed reduces incidents/the severity of these if they do occur).	High	Existing camera specifications already approved for use on SRN. To implement, Highways England would need to identify areas of the network where average speed cameras would be beneficial.	Yes	Increased speeding on other areas of the network to 'make up time'?	Medium	Likely immediate impact on speed differentials and long lasting if enforcement is perceived.
14	Infrastructure – Variable speed and lane use management	E1, E9, D1, D4	Increased use of MIDAS Queue Protection	MIDAS queue protection is a reactive system using loops in the road detect slow/ stationary traffic. The algorithm automatically turns on mandatory or advisory speed limits upstream to raise awareness of queues up ahead. Safety effect est. c10-15% saving in injury crashes – major savings per KM and increased savings with higher flow levels. No specific evaluation of the effect for shunt collisions.	High	Included in Smart Motorways and on most (if not all) higher flow motorways. Likely to be included in future on Expressways (although might operate using pictograms and/or messages, rather than speed limits which could mean it was less effective).	Yes	Some indication that it is prone to false positives – e.g. sign on but no slow traffic encountered. This decreases confidence and compliance with the signs.	Medium	Immediate once scheme in place and calibrated effectively.
15	Infrastructure – Variable speed and lane use management	E9, D3, ORU1, ORU2, S6	Increased use of Variable Speed Management (VSM)	VSM is a proactive system, setting signals as flows increase (but before flow breakdown occurs). This smooths the traffic and has benefits both in delaying the onset of flow breakdown, and during recovery. The mandatory	Medium	Expensive/ complex – applied as part of Smart Motorways currently Unclear whether VMS will be included in future Expressways?	Yes	Potentially confusing to users – unclear if National Speed Limit enforced or not. False positives/unnecessary speed reductions decrease	Long	Immediate once scheme in place

				speed limits set reduce lane changing and make vehicle speeds less variable. [Note that MIDAS queue protection and VSM can be run independently but currently, VSM only ever operates on motorways equipped with MIDAS queue protection.] No specific evaluations of the impact of VSM on HGV crashes and/or shunts but the mechanism for effect (reductions in speed variability -> reducing collisions/collision severity) are clear.				confidence in the signs and reduce compliance.		
16	Organisational polices and guidance	O2, O3	Increased use of best-practice guidance on health, safety and wellbeing policies for HGV/LGV operators	The aim of this suggestion is to raise the standard of LGV/HGV operators organisational safety culture through an improved approach to Health, Safety and Wellbeing management. Some organisations already do this well, but others may benefit from some promotion of relevant materials or support to make relevant changes. There is existing guidance which covers relevant topics which could be used (e.g. HSE/DfT INDG382 Driving for Work guidance) which could be promoted for this purpose. This guidance chosen should cover mental well-being, as well as physical well-being and H&S laws. Operators need to take a systems approach to this adoption: considering how driver training and these polices/procedures align to ensure the implicit and explicit messages are not contradictory. Following any change in policy, drivers may need education or training to embed these principles.	Medium	Highways England can promote the adoption of existing guidance with operators/FORS or invest in developing specific guidance for operators on the SRN. Adoption of the principles within the guidance will be crucial to ensuring this is successful so it may need to be supported by other actions to ensure it is taken up. Highways England is already championing this general issue through its sponsorship of the Driving for Better Business initiative, but could go further by recommending much more commitment from organisations using the SRN, especially when it comes to having policies which explicitly prioritise safe behaviours over production.	No	Would need to make sure that fleets still pay attention to improvement over time. One issue sometimes seen with ‘champion’ schemes is members assume there is no need to go further.	Medium	Delayed by the time it takes for guidance to be adopted.
17	Organisational polices and guidance	E7, D7, D8, D11, D12, O3, S3	Adoption of a fatigue risk management system (FRMS)	The aim of this countermeasure is to give operators the tools to effectively manage fatigue in their workforce. An FRMS is a scientifically-based, data-driven addition or alternative to prescriptive hours of work limitations which manages employee fatigue in a flexible manner appropriate to the level of risk exposure and the nature of the operation. It may include: a fatigue policy, risk management focused on fatigue (e.g. through measurement of fatigue using bio-mathematical models to estimate fatigue from the work	Medium	Short term, Highways England could consider commissioning further work to develop a FRMS specifically tailored to HGV/LGV operators. Longer term, Highways England cannot implement this directly but could promote the use of these systems through operator engagement.	Yes/No	These systems would need to be designed to minimise any effect on fleet operations.	Medium	Delayed by the time it takes these systems to be adopted and integrated into fleets.

				schedule), fatigue reporting, incident investigation, fatigue awareness and countermeasures training and education and auditing. Bio-mathematical models of fatigue already exist and have been shown to be correlated with factors such as reaction time. However, further work is likely required to refine these and ensure they are appropriately adapted to the HGV driver context.						
18	Policy/ Legislation – Vehicles	V5	Encouraging newer vehicles (with improved safety systems, AEB, lighter, better braking performance etc.) through schemes to encourage newer fleets e.g. scrappage schemes, financial incentives, star ratings, road tax, road charging	Newer vehicles perform better than older ones: they are typically safer because of the improved safety systems. An added bonus is that newer vehicles tend to be greener and quieter and thus have environmental benefits too.	Medium	Highways England can't implement this directly. Would have to lobby for regulation or raise awareness with fleet operators/FORS.	No	Older (less safe) vehicles passed to lower income countries – shifts the problem.	Medium	Delayed by the time needed to penetrate the fleet.
19	Vehicle – V2V Communication	V3, E1	In-vehicle automated queue warning messages via vehicle dashboard or smartphone (V2V communication)	There is work currently underway to develop connected systems that provide warnings to drivers of incidents ahead of them on the road. These systems use data from vehicles stopped on the carriageway (e.g. due to a collision or queue) to provide warnings to following drivers. This service is part of a package of driver assistance services that are already being developed by insurance companies and navigation service providers.	Medium	There are currently some political barriers to accessing the required data in a timely manner and some technical hurdles that need to be overcome to ensure the reliability of the system, but essentially there is nothing insurmountable to prevent this technology from being adopted. To make this effective at reducing shunt collisions, it would need to be adopted by fleet operators. Highways England would need to influence fleet operators to purchase it.	No	False positives could lead to a lack of trust in the system	Requirement to roll out new technology in vehicles or smartphones. Medium - if the system is implemented via smartphone it will have a lower level of resolution and functionality but can be implemented much faster. Long - if it relies on integration into vehicle hardware then it will take longer to introduce.	Likely to take some time to realise full effect as it will take some time to reach a critical level of adoption – likely at least 3-5 years.

20	Vehicles – management	V3	Media campaign to highlight the importance of addressing warning lights on the dashboard by the driver of the other vehicle	People should be better informed about the importance of fixing faults and not driving when the vehicle is unsafe. Warning lights on vehicle are now a potential MOT failure. Media campaigns to increase awareness of this and encourage better vehicle maintenance could help. Research has shown that road safety campaigns can reduce collisions, although this effect is usually small (estimated to be an average of 9% from one meta-analysis) and drink-driving campaigns typically have the biggest effect. Therefore, the effect on accident numbers of this type of campaign might be expected to be small. Campaigns using personal communication, roadside and/or enforcement strategies to deliver their message have been shown to be associated with greater accident reductions.	Low	This could be an extension to the 'vehicle safety checks' campaign.	Yes	None – drivers should be doing this anyway as it's a legal requirement.	Short	Relatively quickly but its already likely low effectiveness will reduce over time unless messaging is kept up.
21	Vehicles – management	V2	Improved adherence to vehicle maintenance requirements and roadworthiness inspection routines for HGVs/LGVs	Goal is to ensure manufacturers' maintenance and inspection routines are followed as a minimum, and that guidance on roadworthiness checks (e.g. from DVSA) is followed.	Low	This may be achieved through increased use of Highways England's vehicle check campaign (although this is targeted at the general driving population so may not be as effective), or a more targeted campaign with HGV/LGV operators.	Yes	None – operators should be doing this anyway.	Short	Delayed by time to implement a campaign. Effect will decrease unless audit/inspection scheme puts pressure on operators to adhere to the guidance to do it.
22	Vehicles – Perceptual countermeasures	D5	Improved maintenance of vehicle lighting on the rear of other road user vehicles to enable drivers to better assess the time to arrival at stopped vehicles ahead	This countermeasure will help following LGV/HGV drivers estimate time to contact through providing better cues (especially with very small vehicles like bikes). The basic principle of conspicuity measures are: - To make the object appear as big and wide as possible, so it (a) can be seen sooner and (b) drivers can determine distance and approach speed sooner (looming cues) - Help the driver understand (a) what they are seeing and (b) where on the road it is.	Low	Highways England can carry out campaigns to achieve improved vehicle lighting – making drivers more aware of the need to maintain rear lights and ensure they are working/clean. Campaigns are more effective if implemented alongside enforcement/targeted advice activities. Longer term Highways England may also wish to invest in research to investigate the size cues from lights (especially for VRUs). There is good evidence that improving light configurations can work in lab-based and road-based research for approaching vehicles, but	Yes	None – driver should be maintaining their vehicles lights anyway.	Short	Relatively quickly but effect may reduce over time unless messaging is kept up.

						none directly for vehicles being approached from the rear (although the underlying science is the same).				
23	Vehicles – safety technology	E10, S1, S2	Develop Truck Mounted Attenuators (TMAs) capable of absorbing impacts by HGVs	TMAs are mobile crash cushions designed to be attached to the back of workzone Impact Protection Vehicles (IPVs). The aim of the TMA is to safely contain an impact by another vehicle to the back of the workzone vehicle. TMAs are an effective way of mitigating injuries caused by rear-end shunts involving workzone vehicles, and in further secondary incidents if these are used to protect other road user vehicles. Unfortunately, in the UK currently TMAs are only designed and crash tested to contain impacts for passenger cars of up to 1,500kg. See DMRB CD378. There currently isn't any TMA test class involving an HGV and therefore these systems are not developed to contain a rear end shunt by an HGV. However, it is known that IPVs often get hit by HGVs and the crash cushions on the IPV aren't designed to contain such energies. Introduction of an HGV impact class to the standard and development of TMAs which are capable of containing HGV impacts could help reduce casualties caused by HGV rear-end shunts around work zones. The literature review has shown that HGVs appear to be over-represented in shunt collisions with roadworks vehicles (IPVs) on motorways;	Medium	Implementation of this countermeasure would require multiple stages: Highways England would first need to engage with TMA manufacturers in the UK to encourage the design of such devices that can contain and HGV impact. Secondly a new HGV impact test class should be introduced into DMRB CD377 so that developed systems can be crash tested and therefore impact performance can be demonstrated in a standardised way.	No	TMAs capable of absorbing an HGV impact would likely to be larger, heavier and more expensive than the existing TMAs on the market. Therefore, such solutions are likely to increase the cost and minimum requirements for the IPVs.	Medium	Effectiveness would be immediate for any vehicle impacting the new type of TMA. However, speed of replacement of the existing TMAs with the new type will determine the timeframe for casualty benefits.

				however, these types of shunt are relatively uncommon compared with shunts with other road user vehicles. Note: TMAs were formerly known as Lorry Mounted Crash Cushions.						
24	Vehicles – safety technology	V4	Better quality voice controls	Research shows that in-vehicle voice control systems reduce driver distraction (reducing eyes off the road time relative to touch screen controls) and subsequent risk of collision. However, more recent research (Ramnath *et al.*, 2020) provides evidence that there is still a level of cognitive workload placed on the driver when engaging in the use of voice controls which presents its own risk.	Medium	Highways England can't implement this directly. Would have to lobby for regulation or raise awareness with fleet operators/FORS.	No	There may be a lack of understanding of the systems; some may improve over time. This needs to be communicated to avoid frustrated drivers turning it off.	Medium	Delayed by the time needed to penetrate the fleet.
25	Vehicles – safety technology	V4	Head up displays	General consensus from research is that these can be effective at maintaining focus on the driving task (reducing eyes off the road time) and less distracting than head-down displays. However, it's important that they are well-designed/implemented so as not to reduce a driver's field of view/visibility.	Medium	Highways England can't implement this directly. Would have to lobby for regulation or raise awareness with fleet operators/FORS.	No	Poorly designed systems could actually increase time spent looking away from the road – further research required to identify best design practice.	Medium	Delayed by the time needed to penetrate the fleet.
26	Vehicles – safety technology	D2	Technology on phones to disable them when driving	Removes the ability to use the device - several commercial products available. These apps may be effective at reducing distraction from mobile phones (although this area would benefit from research to confirm this). However, the app would need to be properly implemented and issues with uptake of these apps (e.g. reliant on individuals opting in to their use, and generally people would rather have their phone available for emergencies/work purposes) would need to be considered for this to be effective.	Low	Requires fleets to equip all their vehicles/drivers if to have any impact. Highways England could raise awareness/promote suitable apps with fleet operators/FORS.	No	System can be worked around by drivers if not mandatory. Might lead to greater risk if drivers then just use their own devices.	Medium	Delayed by the time needed to penetrate the vehicle fleet/for the app to be rolled out.

4 Prioritisation of countermeasures

The countermeasures presented in Section 3.4 were taken forward to a prioritisation workshop with relevant stakeholders to help identify which ones Highways England should pursue further. This is summarised in Section 4.1 and the recommendations following this workshop are included in Section 4.2.

4.1 Stakeholder workshop

The purpose of the workshop was to:

a) Gather insights regarding the practicalities of implementation of the proposed countermeasures to help build a clearer picture of their feasibility.

b) Highlight any feasibility issues with the proposed countermeasures and understand the dependencies[2] and barriers to implementation[3].

4.1.1 Workshop attendees

Workshop participants were identified in collaboration with Highways England and included representatives from:

- Commercial vehicle operators
- Commercial vehicle manufacturers
- Road safety organisations
- Recovery organisations
- HGV-related membership organisations (e.g. FORS, ECO Stars)
- The police
- Highways England

4.1.2 Method

After a short introduction on the project aims, work so far and purpose of the workshop, the majority of the workshop was spent in structured small group discussions with a TRL facilitator to discuss a subset of the proposed countermeasures. Countermeasures were grouped such that similar countermeasures were in the same group to ensure the conversation flowed.

The TRL facilitator presented a summary slide for each countermeasure and then facilitated a discussion to answer the following questions for each one:

[2] Dependencies include things that are required for the intervention to be maximally effective.

[3] Barriers to implementation might indicate things that would prevent the countermeasure being effective at reducing shunt collisions.

1. Require changes to legislation or regulations to be legal and/or effective? **None, Some, A lot**
2. Require other things to be changed or put in place to be effective? (e.g. enforcement, incentives) **None, Some, A lot**
    a. How easy is that to implement? **N/A, easy, difficult**
3. Require changes to business processes? **None, Some, A lot**
4. Rely on other agencies or organisations (outside of Highways England) to implement? **No, Somewhat, A lot/completely reliant**
    a. How much influence and authority does HE have with these other agencies? **N/A, None, Some, A lot**
5. Require maintenance or re-application to remain effective? **None, Some, A lot**
6. Require active management (e.g. by a programme manager, camera operations office)? **None, Some, A lot**
7. Require funding beyond what is normally available? **None, Some, A lot**
    a. Is there a clear funding source? **Yes, No**
8. Require skills or resources that are not readily available? **None, Some, A lot**
9. Align well with existing policies and strategies? **No, Somewhat, Very aligned**

Reponses were recorded in spreadsheet format, with a crude red, amber, green rating for each question to enable an at-a-glance comparison of the countermeasures in terms of ease of implementation and what some of the potential challenges might be (see Table 5-1 in Appendix B). Discussions were recorded to enable further details to be clarified if necessary.

4.1.3 Summary of the key themes from the group discussions

There was considerable value in the group discussions around these countermeasures and the following key themes were identified across the five groups.

Consideration is needed of the applicability/ease of countermeasure implementation for all drivers, in particular how to ensure agency drivers were also included. One group highlighted that whilst training for fleet drivers should be "business as usual" for commercial fleets, this didn't happen universally and there was room for improvement to ensure that this training reached all drivers including agency drivers. Another group also flagged that countermeasures relating to guidance or policies should be developed with sufficient thought given to these drivers. They suggested that historically there have been some challenges with the quality and training of agency drivers and that communications would need to be made explicit for this group.

The acceptance of some countermeasures by the drivers, in particular how to avoid drivers feeling they are being watched by technologies, was a potential barrier to widespread adoption or countermeasure effectiveness. Some of the technology or organisation policy countermeasures (e.g. the adoption of a fatigue risk management systems) were reported to be negatively perceived by drivers who felt that they could be used to "check up on them"

rather than being used as a tool to keep them safe. Many of the countermeasures were flagged as requiring driver buy-in and training to ensure their effective use.

The uptake of countermeasures is likely to be dependent on the costs to operators, the impact on operations and whether it is required by legislation. One group saw great value in technologies that would monitor drivers and thought it would be beneficial to access funding to implement these. It was highlighted that from a cost perspective, bigger operators could see a return on investment of these technologies based on fuel savings; however for smaller operators this may not be the case which could discourage adoption unless funding was available, or it was mandated by legislation.

Driver compliance was identified as being very important, with education campaigns being identified as a good way of underpinning technology and enforcement interventions. The capacity in the 'enforcement agencies' was noted as being problematic for some behaviours where there is high non-compliance. Getting the 'culture' in drivers to be more obviously compliant was flagged as a potential way to improve this.

Another group identified increased use of media campaigns as a substantial opportunity. They considered that to date, campaigns on behaviour around HGVs been mainly aimed at vulnerable road users and that there should be more emphasis towards drivers. For example, campaigns to encourage drivers to be aware of what was behind them when slowing for queuing traffic.

4.1.4 Countermeasures identified as missing from the prioritisation

When asked if there were any countermeasures missing that they expected to see, the workshop attendees brought up perceived issues with the performance of the current AEB equipment on trucks (this was also flagged in the cause analysis in Phase 1). In particular, the need for operators to know if drivers have disabled the technology though telematics data so that this can be monitored: post-crash identification of this fact was flagged as being too late. It was suggested that the technology being turned off due to false alarms may be a mechanism for flagging poor driving and therefore this offered an opportunity for driver training. One vehicle manufacturer flagged that they investigate issues with technologies post-crash, and that there are suppressants in the systems to stop them creating false alarms (e.g. if indicators are on and performing a manoeuvre then the ABS system will not operate); they also flagged that there are situations in which turning the system off is beneficial.

Improvements to the AEBS regulation were considered as a potential countermeasure prior to the workshop (see the detail of this in Appendix A.5). It was concluded that the current work to update the heavy duty vehicle AEBS regulation and the future influence of Euro NCAP performance testing, mean that it would be more beneficial for Highways England to focus their efforts on other countermeasures at this time; **however, they should monitor progress on these aspects to ensure that the technical approach will meet their future needs.**

A second suggestion was made to address the issue of distraction of the driver due to paperwork being competed in the cab or the in-vehicle electronics being used to locate information on their next job. It was suggested that all this information should be recorded electronically and that, similar to the countermeasure suggestion for disabling phones, these systems should also be disabled when the vehicle is in motion to make sure attention is

focused on the road at all times. One concern was raised with this suggestion around the need for some drivers to have access to a phone (or other device) in an emergency for security purposes – for example to combat threats whilst driving. This was widely acknowledged as being a relevant exemption to totally disabling electronic equipment.

4.2 Conclusions and recommendations

This section outlines the findings from the discussions on individual countermeasures and makes recommendations for which ones Highways England should pursue further. To facilitate this, countermeasures have been grouped according to the overall feasibility of implementation (from the workshop) and the strength of evidence for each countermeasure at reducing frontal shunt collisions (from the assessment presented in Table 3-1), and are discussed in the following groups:

- Countermeasures that would be relatively easy to implement (Section 4.2.1)
- Countermeasures which evidence suggests will be highly effective (Section 4.2.2)
- Countermeasures that would be more challenging to implement (Section 4.2.3)
- Countermeasures which should not be pursued further at this time due to issues with feasibility, low levels of effectiveness or the level of funding required (Section 4.2.4)

Recommendations in the following sections are presented in **orange**.

4.2.1 'Easy' countermeasures to implement

Based on an assessment of the responses to the questions in the workshop (see Appendix B), a number of countermeasures look like they would be relatively easy to implement:

1. Media campaigns aimed at other road users understanding limitations of HGVs
2. (Media campaigns to encourage) Improved maintenance of vehicle lighting on the rear of other road user vehicles to enable drivers to better assess the size of vehicles ahead
3. Media campaign to highlight the importance of addressing warning lights on the dashboard by the driver of the other vehicle
4. Training for fleet drivers
5. Two second chevrons
6. Adoption of a fatigue risk management system (FRMS)
7. Better quality voice controls
8. In-vehicle automated queue warning messages via vehicle dashboard or smartphone (V2V communication)
9. Sudden sickness monitoring

The initial steps needed by Highways England to achieve implementation are highlighted as recommendations below.

The first three of these all relate to the use of **media campaigns to change the behaviour of other road users** and reduce the incidence of these frontal shunt collisions. Whilst campaigns

such as this are within Highways England's scope to implement, research has shown that the effect of road safety campaigns on collisions is usually small, in terms of specific accident reductions; therefore, the strength of evidence for these countermeasures was only classified as 'Low' (see Table 3-1). Despite this, such campaigns are useful for ensuring that road users have a good understanding of the road system, so **it is recommended that Highways England pursue these suggestions and review where these messages might fit within their wider portfolio of driver campaigns.** Evidence has shown that using personal communication, roadside and/or enforcement strategies to deliver these messages have been associated with greater accident reductions, so Highways England should also consider these activities alongside any wider media campaigns.

Additional training for fleet drivers was also rated as having 'Low' strength of evidence. The aim of this countermeasure is to train the LGV/HGV drivers better on what to expect from each new vehicle they drive; it could involve additional training sessions on new vehicle types, driving with an instructor, information sheets and/or a knowledgeable contact person for help and questions. As outlined in Section 4.1.3, providing this training to fleet drivers was identified as being the responsibility of the operator, but particular concerns were flagged with providing the same level of training to agency drivers. **To encourage consistency across operators and different driver types, Highways England should develop guidance and/or a checklist on what this training should cover. This could be developed and communicated by Highways England through Driving for Better Business (DfBB) and other communication channels with operators**, perhaps making it a requirement for DfBB Business Champions to demonstrate they have this training in place.

Countermeasures 5 to 9 in the list above were all more promising in terms of effectiveness and were flagged as having a 'Medium' strength of evidence for reducing shunt collisions. **Two second chevrons** could be implemented at shunt collision hotspots fairly easily by Highways England, although would require some funding and on-going maintenance effort. **It is recommended that before an assessment of potential sites is undertaken to assess feasibility of implementation, re-evaluation of sites with this measure currently installed is undertaken to understand the long-term effectiveness of the chevrons at increasing following distances between vehicles, and thus reducing the risk of a shunt collision.**

A **fatigue risk management system (FRMS)** aims to give operators the tools to effectively manage fatigue in their workforce. It may include a number of different elements as outlined in Table 3-1. The discussion around this countermeasure largely focused on the dependencies associated with having a system fitted to the vehicle. The main dependency identified was driver acceptance and this was rated as being "difficult" to overcome. One of the participants in this group referred to a project they had observed in which after-market FRMS had been fitted to vehicles by several volunteer operators. It was reported that despite all relevant assurances being in place to reassure the drivers (i.e. that data captured would be anonymised, and that it was not going to be used for anything negative), almost every camera has been disabled by the drivers – the cameras had been pointed in the other direction or in some instances, damaged. Other members of the group had also experienced this lack of acceptance and suggested that drivers felt like the systems were "a spy in the cab". There was a suggestion that until it becomes standard fitment on every single vehicle, this barrier will exist (comparisons were made to the presence of tachographs). Despite these challenges, the strength of evidence for this countermeasure was assessed as 'Medium' by TRL, reflecting the

fact that these systems can work well when drivers are engaged with the changes; **INDG382 guidance**[4] (HSE, 2014) **provides recommendations on how to achieve this and Highways England should promote this (and its planned web-based replacement which we understand will be available later in 2021) though DfBB and other communication channels with operators.** Campaigns about wellbeing and sleep outside of working hours were also suggested by workshop attendees as mechanisms for normalising the countermeasure.

If **better quality voice controls could be designed and implemented within LGV/HGV cabs**, this could reduce driver distraction incidents. Once implemented in vehicles this was considered to be easy to maintain and manage, with no changes to business processes or legislation required; however, it is acknowledged that to get to this point, it requires research and development by vehicle or system manufacturers whom Highways England do not have direct influence over. To realise the benefits, Highways England would need to lobby for improvements with these manufacturers and raise awareness with fleet operators to encourage adoption of these technologies (or lobby for this through regulation). This may take a substantial period of time and, as outlined in the IAM report (Ramnath *et al.*, 2020), there may still be issues with the level of cognitive workload placed on the driver when engaging in the use of voice controls which presents its own risk. A better suggestion may be to discourage activities whilst driving completely, perhaps by encouraging operators to disable all electronic devices when in motion (except for those required for security), as suggested in Section 4.1.4. **Highways England should engage with Operators to understand current use of these systems, challenges with this, and use the output of this engagement to inform future discussions with vehicle manufacturers about system improvements and fitment.**

In-vehicle automated queue warning messages via vehicle dashboard or smartphone could provide warnings to commercial vehicle drivers of incidents ahead on the road to prevent queue-tail shunt collisions. Some of these services are already being developed by insurance companies and navigation service providers. Workshop attendees discussed that there might need to be some investment from Highways England, agreed through one of the Road Investment Strategy cycles, to ensure technical hurdles (e.g. access to data in a timely manner and roadside infrastructure necessary) could be overcome. Some legislation/regulation changes may be required; there will be ongoing maintenance and management effort once systems are installed and Highways England would need to influence fleet operators to adopt the technology, but this approach is highly aligned with current policy for increased connected services across the SRN. As a result, **the CVIP team at Highways England should engage in discussions about queue warning systems within Highways England and with solutions providers to ensure that the solutions developed are beneficial to LGV and HGV operators, as well as the wider travelling public.**

Sudden sickness monitoring systems will monitor the driver's health state and act if the driver is too unwell to drive safely. This will be a requirement for Level 3 and 4 Automated Vehicles (AVs), and it is envisaged that this system will eventually be implemented in conventional vehicles too. Assuming this technology is developed and adopted within HGVs and LGVs, then there may need to be some changes to business processes or increased

[4] Note that this guidance is due to be updated soon with specific guidance on the use of technology.

management to incorporate the use of these systems into health and safety policies, and ensure that the process after an 'event' flagged by the system is clear. Full development of these systems is not yet complete however, and hence it may be a while before systems are brought to market (especially for non-AVs). Given the potential benefits of the technology, **Highways England should continue to monitor progress with these systems and review whether there is need to intervene to encourage uptake once the systems are developed.**

4.2.2 Highly effective countermeasures

A number of countermeasures were identified as being highly effective ('High' strength of evidence for reducing shunt collisions in Table 3-1) and deemed as potentially feasible to implement from the workshop:

1. Distraction or attention monitoring
2. Fatigue and drowsiness monitoring
3. Hazard perception training for LGV/HGV drivers
4. Average speed cameras
5. Increased use of MIDAS Queue Protection

Both of the first **two monitoring technologies (distraction/attention and fatigue/drowsiness monitoring)** are being implemented as part of the revisions to the General Safety Regulations (GSR) and Pedestrian Safety Regulations (PSR) in the EU (European Commission, 2019). Although the technologies themselves are likely to be effective at reducing frontal shunt collisions (and will be implemented on all new vehicles in the future), it is currently unknown whether the updates to the GSR and PSR will be adopted in GB[5]. **Highways England should ensure that they are engaged in conversations with DfT around the adoption of these regulations**, particularly given that these technologies were flagged as potentially one of the most effective technologies for reducing collision on the SRN in a recent investigation[6] (Wallbank *et al.*, 2020). It should however be noted that these technologies are not a short-term solution: even once regulation is in place, there will be a delayed effect due to time it takes technology to infiltrate the fleet. However, the size of effect will likely increase with advancements in technology capabilities over time.

Within Group 2, **hazard perception training for LGV/HGV drivers** was the countermeasure that was felt to be likely to have the biggest impact on safety. The feeling at the workshop was that no matter how many tools or guidance documents are available, the ultimate responsibility for safety sits with the driver and therefore this training, which aims to provide an increased level of skill in safety-critical driving, could have significant benefits. Implementation of the training is not within the direct scope of Highways England, but they could lobby for this to be introduced and provide guidance on possible stimuli to maximise

[5] The GSR and PSR updates were published in the Official Journal of the European Union and the UK left the European Union. However, the first measures do not 'apply' until 6 July 2022 for new types and 7 July 2024 for all new vehicles, with some measures phased in over a longer timescale.

[6] Note, this considered all KSI collisions, not just frontal shunts involving HGVs/LGVs.

the benefits for the SRN. Note, there is already some evidence this countermeasure works well at improving safety in inexperienced drivers (for example see Thomas, Rilea, Blomberg, Peck & Korbelak, 2016), but **training materials would need to be developed and tested for professional drivers: a funding route for this should be investigated as a next step.**

Average speed cameras at locations where shunt collisions were common was the fourth option which looks promising. Although the rapid evidence review (see Section 3.3) found no evidence for the specific impact of average speed cameras on reducing shunt collisions, the mechanism through which this would occur is clear: reducing speed reduces incidents or the severity of these if they do occur. However, workshop participants flagged concerns that there might be an adverse effect from these cameras in increased tailgating, particularly by HGV drivers. Substantial funding and reliance on others to implement, maintain and manage were potential barriers to this countermeasure; in particular there would be the requirement for an increase in resource for processing of offences (this is a known limitation of the current system where not all offenders are pursued for prosecution due to processing limits). This countermeasure would be most effective if long-lasting enforcement was perceived. Since 2007 there has been no National Speed Camera Programme and instead local and road authorities have the freedom to use cameras as they see fit to reduce casualties in their area (DfT, 2007). As a result, **Highways England first need to identify areas of the network where average speed cameras would be beneficial.** It is understood that there is no existing guidance for this, but in the future, the Speed Management Tool currently being developed by TRL for Highways England could be used to achieve this (Fletcher *et al.*, 2020). Cost-benefit analyses could then be carried out at these sites to inform prioritisation.

MIDAS queue protection is a reactive system using loops in the road detect slow/stationary traffic. The algorithm automatically turns on mandatory or advisory speed limits upstream to raise awareness of queues ahead. The safety benefit is well-established for injury crashes, in particular for sections of road with higher flows. This countermeasure would install the system on more sections of the SRN. Table 4-1 presents an estimate of the current SRN carriageway length covered by MIDAS, and the proportion of traffic travelling on these sections, based on the iRAP data[7].

[7] Sensors were matched to iRAP sections (the average length of an iRAP section is around 6km but range from 0.1 to 37km) and if at least one sensor with Incident Detection and Warning Systems was matched to an iRAP section, the whole section was assumed to have MIDAS present.

Table 4-1: Estimated percentage of carriageway length and traffic with MIDAS present

Road type	Estimated percentage of carriageway length covered by MIDAS	Estimated percentage of traffic[8] covered by MIDAS
Motorway	59%	67%
Dual carriageway A-road	2%	4%
Single carriageway A-road	0%	0%
Total SRN	**28%**	**44%**

This shows that around 59% of the motorway network has MIDAS installed and as expected, this is typically on the more heavily trafficked sections (these sections represent around 67% of traffic). However, far less of the SRN A-road network has any MIDAS installed, suggesting there is considerable scope to improve coverage across the SRN.

Increased use of MIDAS wouldn't require any changes to business processes, or additional legislation, but issues with levels of enforcement and subsequent compliance with the speed limits were identified as potential barriers to increased implementation of the systems. In particular, issues with the number of people offending, capacity within the courts to deal with this and the costs of additional enforcement were flagged. New MIDAS detectors (mostly radar) are being installed on new Smart Motorway sections, but there is no current guidance or impetus to increase coverage on other areas of the SRN. Given the potential for this countermeasure to be effective at reducing collisions (potentially alongside VSM – see Section 4.2.3), **Highways England should review whether other areas of the SRN would benefit from installation of MIDAS and carry out a cost-benefit analyses to inform prioritisation.**

4.2.3 Challenging countermeasures to implement

These countermeasures look like they could be more challenging to implement, but could be beneficial to reduce frontal shunts if feasibility issues can be overcome:

1. Full Road Collision Investigation Bureau (RCIB)
2. Highways England In-depth investigations framework
3. Increased use of Variable Speed Management (VSM)
4. Increased use of best-practice guidance on health, safety and wellbeing policies for HGV/LGV operators

The first two countermeasures are aimed at collecting more information about collisions to provide actionable intelligence; this would have benefits beyond reducing frontal shunt collisions and operators at the workshop were keen to see this implemented. The first, to **create a Road Collision Investigation Branch (RCIB),** proposes using a combination of

[8] The traffic is an estimate for a 2020 'non-covid' scenario based on uplifting 2019 traffic data from NTIS by a factor of 1.02

coordinated investigation techniques to capture evidence, and programmes to convert into the necessary intelligence to inform systematic change and identify suitable interventions. This requires multi-agency coordinated approach, which Highways England would be part of. **Highways England should engage with Department for Transport to advocate for this and gauge its likelihood of adoption**.

The second countermeasure (**Highways England In-depth investigations framework**) involves creating an investigation framework, training and support programme and potentially some equipment (e.g. cameras) for Traffic Officers to use at the scene of incidents to capture in-depth data. TRL supports the HE Fatals database programme which captures in-depth collision data on the events of fatal collisions on the SRN through review of police forensic collision investigation reports and supplementary information where available (e.g. witness statements, toxicology reports and tachograph analysis); this countermeasure would take this a step further to collect data at the roadside to overcome some of the limitations of using data which is collected for a different purpose (i.e. for prosecution purposes, rather than evidence to inform future road safety initiatives). If the RCIB is unlikely to go ahead, **Highways England should conduct a feasibility study to understand the potential costs and benefits of this countermeasure based on experience from the HE Fatals Database and DfT RAIDS programme, and use this information to pursue funding for this countermeasure.** The study should document how the outputs from the framework will be used to improve and inform future countermeasures for all crash types (including frontal shunts) and how this will contribute towards Highways England's Road Investment Strategy KPIs.

Variable Speed Management (VSM) is a proactive system, setting mandatory speed limits as flows increase to smooth traffic; it also has benefits both in delaying the onset of flow breakdown, and during recovery. The arguments for and against its increased use are very similar to those presented for MIDAS queue protection (discussed in Section 4.2.2) but its effectiveness at reducing frontal shunt collisions was assessed to be slightly lower (rated 'Medium'). MIDAS queue protection and VSM can be run independently but currently, VSM only ever operates on motorways equipped with MIDAS queue protection; therefore, **if Highways England pursue increased use of MIDAS, they should also consider implementing VSM alongside.**

As with some of the other countermeasures, the discussion around challenges associated with the **increased use of best-practice guidance on health, safety and wellbeing policies for HGV/LGV operators** tended to focus on transient drivers, such as agency workers. According to participants, the problem with this group of drivers related to the quality of training and the only way noted to mitigate against this would be through legislation. While drivers provided by an agency are subject to licence checks, it was not considered possible by workshop attendees to do a thorough audit of their training history and CPC, and they may not be familiar with the operator's specific health, safety and wellbeing policies. Some participants commented that for agency drivers who do not have English as a first language, the challenge is exacerbated because they do not have the capacity to understand written communication. Mitigations could include translation into appropriate languages, but this would be expensive and time consuming. Despite these challenges, **Highways England should promote the use of relevant guidance (e.g. HSE/DfT INDG382 Driving for Work guidance) through communication channels with operators. This should include examples of how to take a systems approach to adoption of the guidance**: considering how driver training and

these polices/procedures align to ensure the implicit and explicit messages are not contradictory and ensuring that all drivers can benefit, including agency drivers.

4.2.4 Countermeasures which should not be pursued further at present

A number of countermeasures are not recommended for further consideration at present. For example, challenges with feasibility, or particular barriers to implementation were identified with the following countermeasures:

- **Driver behaviour monitoring** was identified as requiring a lot of changes to business processes, management effort and resource/funding to deliver. In particular, issues with enforcement were identified as different operators could choose different feedback mechanisms or tolerances, meaning no consistency in the system performance or effectiveness. Issues with driver consent and feelings of being watched were also flagged – see Section 4.1.3. Even if these concerns could be overcome, it is difficult to see how Highways England could influence this countermeasure, beyond encouraging operators to adopt technologies when appropriate (e.g. through DfBB).
- **Head up displays** (HUD) raised concerns in the group discussions as the devices could be switched off and therefore not provide the benefits of reducing 'eyes of the road time' that they are intended to achieve. If these systems were used more widely, changes to vehicle inspection criteria were considered to be required and operators felt that regulations would be needed for higher uptake; the compliance of HUD devices to safety regulations were deemed to be the concern of the HUD manufacturers and providers, and it was considered that Highways England didn't have a role to play in this.
- **Develop Truck Mounted Attenuators (TMAs) capable of absorbing impacts by HGVs** only target a small number of collisions (i.e. collisions with roadworks vehicles) and multiple issues were identified around feasibility. In particular, it was considered that it would be difficult to engineer a TMA (with the vehicle carrying it) which could absorb the large forces likely from an HGV travelling at top speed. Also, any new systems would require extensive development and testing, potentially requiring development of international standards for crash tests.

The following countermeasures were identified as requiring significant additional funding with no clear funding stream identified:

- Concerns were stated with the countermeasure to **encourage newer vehicles with improved safety systems** because workshop attendees felt that the responsibility for safety shouldn't be removed from drivers by technology; however, an opportunity was seen for fleet operators to monitor activation of systems such as AEB to guide additional driver training – this links to the discussion in Section 4.1.4. This countermeasure was also challenging to implement due to the heavy reliance on others to implement (e.g. including DfT) and significant management effort.
- Collecting data on human factors and behaviours through increased use of **dashcams with proactive monitoring** aims to help build the evidence base with which informed decisions on which countermeasures should be implemented. Workshop attendees

thought that there would need to be an incentive for operators to provide this data, and that it may require some changes to business processes and increased management/maintenance effort to do so. Issues with privacy and driver buy-in would also need to be considered, and funding may need to be provided to equip vehicles. In terms of resource, it would also require a dedicated person to review the footage (or a video processing system to be developed), which could add considerably to the cost. Other countermeasures (e.g. collecting in-depth on-scene data through the RCIB or Highways England In-depth investigations framework – see Section 4.2.3) could have wider reach (due to the fact they would not require individual vehicles to be equipped with technology) and thus wider benefits.

Finally, the following countermeasures were deemed to have 'Low' strength of evidence for reducing shunt collisions (see Table 3-1) and discussions also identified feasibility concerns. Recommendations are presented for these countermeasures however these should be considered lower priority than those presented in earlier sections:

- **Drivers involved in frontal shunt incidents required to undertake relevant CPC training** – whilst it was acknowledged that CPC does potentially have a role to play in educating drivers, workshop attendees flagged that this training shouldn't wait until after a crash occurs. Other training or feedback opportunities from the operators themselves may be a better route to delivering the necessary information. Longer term, **Highways England should consider reviewing what training is provided through CPC and engaging with training providers to ensure this covers topics relevant to driving on the SRN**; this could also link to the hazard perception training (discussed in Section 4.2.2).
- **Improved adherence to vehicle maintenance requirements and roadworthiness inspection routines for HGVs/LGVs** – issues with the maintenance and management effort for this countermeasure were identified at the workshop due to the lack of skilled maintenance technicians in the industry. As a result, operators are reliant on dealerships to maintain vehicles, but dealerships do not share the responsibility for poorly maintained vehicles. Supporting a move towards shared legal responsibility could help ensure dealerships meet the requirements of maintenance schedules. **Highways England could also ensure that relevant guidance (e.g. the 'Guide to maintaining roadworthiness – Commercial goods and public service vehicles'** (DVSA, 2020)**) is promoted in ongoing communications activities with operators.**
- **Technology on phones to disable them when driving**[9] – participants thought this technology was a good idea, provided that it did not prevent using the phone for emergencies (see Section 4.1.4). They felt it would require minimal effort to implement and maintain and aligned well with existing safety policies that discourage mobile phone use while driving. However, they were not aware of it being available

[9] Note that this countermeasure refers specifically to technology installed on phones to disable them when driving and not technology in vehicles that blocks communication between mobile phones and receivers/transmission towers. Such technology cannot discriminate between calls for emergency and other purposes. In the UK, technology that deliberately blocks mobile phone communications is not legal.

to businesses. Some participants also noted that if it functioned through an app on a work phone then personal phone use would potentially still be an issue. **Highways England could review the guidance provided on mobile phone use policies, and any information available related to suitable technology which could be implemented for this purpose, to ensure it remains current and relevant. Highways England should then ensure that this is given adequate exposure as part of their ongoing communications activities with operators.**

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Appendix A Countermeasure suggestions not included in prioritisation

This appendix summarises the countermeasures that were excluded from prioritisation and the reasons for this.

A.1 Out of scope

A number of countermeasures were deemed out of scope of this project as they were not focused on preventing HGV or LGV frontal shunt collisions. However, these could still contribute to Highways England achieving its wider KPI target to reduce KSIs, and so it may still be beneficial to consider whether to take these forward outside of the scope for this project:

- **Traffic Officer rapid scene survey and triage** – this countermeasure would work by improving post-collision response and streaming live drone video of an incident scene to emergency services and/or Highways England control rooms. To achieve this, Traffic Officers would be provided with unmanned aircraft systems (UAS)/drone technology which they could deploy at or near an incident and stream video of the scene back to a central HQ. This would enable an assessment of what actions should be taken and may also provide an opportunity to capture photos and video footage which could be used retrospectively in collision investigation for creating 3D models.
- **GoodSAM app** – this countermeasure would work by improving the post-collision response through the streaming of live video from road user phones. The app would create a video link to regional control or emergency service centres and allow communication to the people with the phone to provide an on-the-ground understanding of the collision to inform post-collision response. The app could also be used to update other road users in the area that a collision has been reported.
- **Introduce the practice of clearing a path for the emergency services by default when the traffic stops behind a collision** – it can be difficult for the emergency services to reach the scene of a collision because the following traffic tends to stop in the carriageway and block live lanes (this is especially true on Smart Motorways with no hard shoulder). This countermeasure would train drivers to leave a path free when an incident occurs, allowing response times to be reduced. This approach is already the default position in some other countries (e.g. Germany).
- **Ensure that heavy recovery assets are available to the fire service when LGV/HGVs are involved in collisions –** it is often necessary to either stabilise or move heavy vehicles at crash sites to permit the extrication of casualties; however, the Fire Service generally does not have the resources available to easily lift or tow heavy vehicles. This countermeasure would either provide the Fire Service with the necessary vehicles and equipment, or provide additional training to recovery contractors (who already have the equipment necessary for these tasks) to work alongside the fire and ambulance services during an extrication (rather than focusing solely on the recovery).

A.2 Not feasible

A further suggestion on the **development of an audio tactile warning system embedded to the road to alert distracted drivers of an incident/congestion up ahead** was deemed not to be feasible at the present time, due to the level of development work that would be needed and the practicalities of implementation. The idea would be to replicate the effect of rumble strips or raised edge markings which have been shown to be effective in reducing run-off-road incidents caused by fatigue, distraction and visibility and to warn drivers about an upcoming junction or decrease in speed limit. Using external audio tactile stimulation, this new system would remotely lay down or raise an audio tactile surface in the lane, once a stationary vehicle is detected. This way, distracted drivers who have not seen any of the messages on the VMSs can be warned through audio tactile input. Some concerns with this idea were raised around motorcyclist stability, particularly if encountering one in the dark and wet, or at the point where riders might be changing lines. It was also considered that the impact of the cue may be greater for small vehicles (cars) than heavy goods vehicles and thus this might not target the collisions of interest for this project.

A.3 Lack of knowledge about effectiveness for reducing shunt collisions

Following a review of the evidence, a number of countermeasures were excluded from further consideration due to the fact there was a lack of evidence that these countermeasures would actually reduce or mitigate shunt collisions:

- **Wider use of Vehicle Arrester Beds** – these provide a runoff area in cases where a driver realises an imminent shunt impact but does not have an alternative physical space to redirect the vehicle to other than the back of another vehicle. These can be highly effective in situations involving runaway vehicles on a downhill gradient. The idea would be to implement these in areas with a high concentration of rear-end shunts, specifically related to steep downhill gradients and problems with brakes. However, the Stats19 analysis in Phase 1 identified very few hot spots for these collisions, and none were on these types of carriageway, so this was considered not to be a cost-beneficial way of mitigating the injuries in a potential shunt collision.
- **Provision of wider hard shoulders at rear-end shunt hot spots** – hard shoulder widening is a proven method for reducing run-off-road incidents and an added benefit is the provision of an alternative empty space for vehicles to be redirected in the event of an imminent shunt collision. On roads with narrow hard shoulders, even evasive action could end up resulting with the rear-end shunt due to the limitation of space and the width of the HGVs so a targeted shoulder widening programme could be considered for locations with high concentrations of these impacts. As above with vehicle arrester beds, due to the limited locations this would be beneficial at, and the high cost, this was not considered a viable option to consider further.
- **Improved standards and training for the securing of loads in commercial vehicles** – anecdotal evidence from TRL experts suggests that there might be an issue associated with loads moving during collisions and causing more severe outcomes. This countermeasure suggestion involved improving equipment and training for drivers on load restraint systems; improving crashworthiness standards for load beds to ensure

that tiedown points, load bars and headboards can deal with the loads seen in a collision and improving compliance with existing regulation. However, there was no evidence from Phase 1 that load security was a particular issue in these crashes, so a decision was made not to pursue this further. Despite this, Highways England should continue to monitor this potential problem as issues with unsecured loads could result as an unintended consequence of other improvements to vehicle design (e.g. improved AEB), or for particular road user groups (e.g. small vans as opposed to HGVs).

- **Promote/enable better access to Event Data Recorders (EDRs)/in-vehicle data** – many vehicles already have EDRs installed, but access to the data is almost impossible to anyone outside of the manufacturer and thus there is little scope to understand technology failures and the impact these have. Adding third party EDRs to a vehicle can help tell us more about the circumstances leading up to a collision (and the data may be more accessible to operators or insurance companies), although the data is not comprehensive. This countermeasure would promote more data and access to this, either through encouraging the installation of EDRs Highways England can then access in the event of a collision or lobbying for better access to manufacturer EDRs. Given the lack of data at present, it is unknown how beneficial this countermeasure would be to understand the true causes of technology failures in shunt collisions and implementation could take a very long time, so this countermeasure was excluded from further consideration as other mechanisms for collecting data were considered to be more robust for these collisions.

A.4 Already being considered by HE

Provision of further Emergency Refuge Areas on Smart Motorways (to increase the chances a broken-down vehicle can make it to one of these areas of relative safety) are already being considered by Highways England.

A.5 AEB regulation improvements

Automated/Advanced Emergency Braking Systems (AEBS) warn drivers of stationary or slow-moving vehicles ahead so the driver has more time to react. These systems can also intervene if the driver is unresponsive to an imminent threat. The intention of the system is to reduce the frequency and mitigate the injuries resulting from this type of collision.

Since 2015 it has been mandatory for all new goods vehicles weighing more than 3.5 tonnes in Europe to be equipped with AEBS (EU Regulation 347/2012); however one countermeasure suggestion explored in this project was changes to this AEB regulation and the performance of these systems to make them more effective at reducing frontal shunt collisions. This section summarises the results of this additional investigation to answer the questions:

Is there more that could be done technically to improve the effectiveness of the heavy duty AEB to reduce frequency of this type of collision?

Is it relevant for Highways England to intervene in AEBS regulation and consumer test requirements to encourage a greater technical performance?

These questions are answered through a review of the current status of the regulations (see Section A.5.1) and a review of the current state of the new car assessment program AEBS test (see Section A.5.2).

A.5.1 Status of the Regulations

A.5.1.1 2009 General Safety Regulation

The General Safety Regulation (GSR) outlined the requirement for all N2, N3 & M2, M3 category vehicles to be fitted with AEBS to reduce the number of rear-end collisions with vehicles of different types. The secondary legislation to achieve this was Regulation (EU) 347/2012 that was implemented in two stages. The first stage came into force from 2015 and the second from 2018, and was effectively based on Regulation (UN) No. 131. The intention of this regulation is to ensure a minimum standard of performance for AEB fitted to all heavy-duty vehicles (HDVs) at collision speeds relevant to highway or intercity roads. In 2016, Knight et al. suggested that it would be possible, in theory, for a truck OEM to develop a system that complied with this regulation if it was only effective in a small speed window (approximately 80 km/h). In reality there is likely to be performance over a wider speed range, however there is no current regulatory driver for performance at lower speeds.

This was the first regulation regarding AEBS, with the passenger car regulation not coming into force until 2022 for new types and 2024 for new registrations. The intention of the passenger car regulation was to reduce the frequency of front-to-rear collisions in urban environments, at lower speeds than the HDV AEB regulation.

The heavy vehicle regulation involves two tests scenarios where the subject vehicle is driven towards a target vehicle, a high-volume series passenger car (M1 AA category vehicle), or soft target with the same dimensions as a car. The stationary test and the moving test are conducted at 80 km/h.

Stationary target test requirements

Subject vehicle travels at 80 km/h towards the stationary target and must reduce speed by a minimum of 10 km/h (from 2015) or 20 km/h (from 2018) before impact.

Moving target test requirements

Subject vehicle travels at 80 km/h towards a target vehicle travelling at 32 km/h (from 2015) or 12 km/h (from 2018) and must avoid the collision.

The heavy vehicle regulation allows for the AEB system to be manually deactivated by the driver because in some instances it may be necessary to deactivate the AEB if the system was faulty or the safety of the system was impaired. However, the AEB will activate with every ignition cycle.

A.5.1.2 UNECE Regulation No. 131 – 02

The first revision of this regulation which came into force in 2014 formed the basis of the EU regulation. Based on the information provided by the relevant UN Informal Working Group (IWG) 'Heavy Duty Vehicle Advanced Emergency Braking Systems Special Interest Group' at their most recent meeting in March 2021 it seems likely that a second series of amendments

will come into force from November 2021 that will align the regulation closer to the passenger car AEB regulation (UN Regulation No. 152). This is likely to ensure that the regulation is more refined and more demanding of the AEB system, including operation at lower speed ranges, and overall providing a higher standard of AEB performance across the heavy-duty fleet.

The IWG have scheduled three meetings in 2021 to discuss the requirements and test procedures for the regulation before the next GRVA meeting in September 2021 so it is too early to deduce exactly what test parameters will be chosen but it is clear that the heavy duty test will consist of a greater number of test scenarios (including pedestrian and cyclist tests), and these tests will be performed over a broader range of test speeds.

Vehicle to Car

The stationary and moving target tests will be conducted over a larger range of speeds:

- 10-90 km/h for N category vehicles
- 10-100 km/h for M category vehicles

The speed of the moving target vehicle has not been decided, but it is likely to be 20 km/h.

Vehicle to Pedestrian and Cyclist tests

These tests were developed in UN Regulation No. 152 where either a pedestrian or cyclist target walks at 5 km/h or cycles at 15 km/h perpendicular across the path of the subject vehicle. These tests replicate a pedestrian or cyclist crossing the road ahead of the subject vehicle. The test speeds for both N and M category vehicles are from 20 to 60 km/h at 5 km/h intervals.

A.5.2 Status of the new car assessment programs

This technology first hit the market at around the same time in both cars and trucks, around 2006-2008. It was made mandatory for HGVs and coaches at the end of 2015. It was introduced in the Euro NCAP rating scheme for passenger cars only one year earlier, in 2014. Although the mandatory fitment resulted in more widespread fitment amongst HGVs and coaches in the short term, the mandatory performance requirements were substantially below what best practice achieved in its first year of introduction. In comparison, fitment to passenger cars was encouraged through the Euro NCAP scheme and the systems that were introduced were generally much closer to best practice, thus offering a greater safety benefit. Furthermore, there has been almost no further technical development of the system on commercial vehicles (with the notable exception of Mercedes offering AEB on buses). By contrast, Euro NCAP has introduced new, more demanding, standards for AEB every two years since 2014. Pedestrian functionality was added in 2016, cyclist and night-time functionality in 2018 and functionality in a turn in 2020. The results show that most vehicles tested in 2019 had the 2018 level technology fitted and for most of those it was fitted as standard. As such, the developments under the voluntary incentive scheme have hugely outpaced regulation. Just five years after the introduction of the HGV regulation, most passenger cars are fitted with far better systems than HGVs.

The car to car test scenarios include the stationary, moving and braking target vehicle at a range of overlaps (-50% to + 50%) and junction turning test where the subject vehicle turns across the path of an oncoming vehicle at a range of speeds. The junction turning test may

not be so relevant for heavy-duty vehicles so the inclusion of this test in the regulation may be unnecessary.

Euro NCAP originally only covered cars, but since December 2020 now includes vans, and there are plans to extend to heavier vehicle categories too. It is recognised that the rating for HGVs will need to be quite different to that for passenger cars, due to the commercial buying processes.

A.5.3 Conclusion

Given the current work of the IWG on heavy duty vehicle AEBS regulation to update it to cover a greater performance level, and to cover lower speeds, there is no longer a need to influence regulation to achieve these steps. Furthermore, the influence of Euro NCAP performance testing is expected to be beneficial in the longer run too, because they have the scope to be more demanding than regulation in terms of both performance and timescales.

It would be worth Highways England monitoring the progress of both the UN working groups on regulation, and the Euro NCAP commercial vehicle group, to assess:

- Whether the test conditions specified align well with the incident data for the network
- Whether there are any gaps, the size of the casualty problem that is being left unaddressed, and the technical approach to try and address those casualties by:
  - Influencing regulation at UN, EC or UK level
  - Influencing Euro NCAP and other consumer ratings standards
  - Implementing other policy options

Appendix B Output from the stakeholder workshop

Table 5-1 summarises the findings from the group discussions on each countermeasure. Red, Amber, Green (RAG) ratings have been used to give an overview of the findings for each countermeasure. A small number of countermeasures were not covered in the workshop due to timings, these have been completed by TRL (informed by the discussions which did take place) to enable comparisons to be drawn across the whole list.

Table 5-1: High-level responses for the questions posed at the prioritisation workshop

No.	Countermeasure	Q1 - Legislation	Q2 - Dependencies	Q2a - Ease of dependencies	Q3 - Business processes	Q4 - Reliant on others	Q4a - influence over others	Q5 - Maintenance effort	Q6 - Management effort	Q7 - More funding	Q7a - Funding source	Q8 - Skills & resource availability	Q9 - Policy alignment
1	Full Road Collision Investigation Bureau (RCIB)	None	None	N/A	A lot	A lot/completely reliant	Some	Some	Some	A lot	No	Some	Very aligned
2	Highways England In-depth investigations framework	None	None	N/A	A lot	Somewhat	A lot	Some	Some	Some	No	Some	Very aligned
3	Promote uptake of dashcams with proactive monitoring to identify appropriate interventions for the behaviours observed	None	Some	Difficult	Some	A lot/completely reliant	Some	Some	Some	A lot	No	A lot	Very aligned
4	Distraction or attention monitoring	None	Some	Easy	None	Somewhat	Some	Some	Some	Some	No	None	Very aligned
5	Fatigue and drowsiness monitoring	None	Some	Easy	None	Somewhat	Some	Some	Some	Some	No	None	Very aligned
6	Sudden sickness monitoring	None	None	N/A	Some	A lot/completely reliant	Some	None	Some	Some	No	None	Very aligned
7	Driver behaviour monitoring	Some	Some	Easy	A lot	A lot/completely reliant	Some	None	A lot	A lot	No	A lot	Somewhat
8	Training for fleet drivers	None	None	N/A	None	Somewhat	Some	A lot	Some	None	N/A	None	Very aligned
9	Drivers involved in frontal shunt incidents required to undertake relevant CPC training (using behavioural change techniques)	Some	Some	Easy	Some	A lot/completely reliant	A lot	Some	A lot	None	N/A	Some	Somewhat
10	Hazard perception training for LGV/HGV drivers	None	Some	Easy	Some	Somewhat	Some	Some	Some	Some	No	Some	Very aligned
11	Media campaigns aimed at other road users understanding limitations of HGVs	None	None	Difficult	None	Somewhat	Some	Some	Some	Some	Yes	None	Very aligned
12	2 second Chevrons	None	None	Easy	None	No	N/A	Some	None	Some	Yes	None	Very aligned
13	Average speed cameras	None	Some	Difficult	None	A lot/completely reliant	Some	Some	Some	A lot	Yes	None	Very aligned

No.	Countermeasure	Q1 - Legislation	Q2 - Dependencies	Q2a - Ease of dependencies	Q3 - Business processes	Q4 - Reliant on others	Q4a - influence over others	Q5 - Maintenance effort	Q6 - Management effort	Q7 - More funding	Q7a - Funding source	Q8 - Skills & resource availability	Q9 - Policy alignment
14	Increased use of MIDAS Queue Protection	None	Some	Difficult	None	Somewhat	Some	Some	Some	Some	Yes	Some	Very aligned
15	Increased use of Variable Speed Management	None	Some	Difficult	None	Somewhat	Some	Some	Some	Some	Yes	Some	Very aligned
16	Increased use of best-practice guidance on health, safety and wellbeing policies for HGV/LGV operators	None	Some	Difficult	Some	Somewhat	Some	Some	Some	Some	Yes	Some	No
17	Adoption of a fatigue risk management system	None	Some	Difficult	Some	Somewhat	Some	None	None	None	N/A	None	Somewhat
18	Encouraging newer vehicles through schemes to encourage newer fleets e.g. scrappage schemes, financial incentives, star ratings, road tax, road charging.	None	Some	Difficult	None	A lot/completely reliant	A lot	Some	A lot	A lot	No	None	Very aligned
19	In-vehicle automated queue warning messages via vehicle dashboard or smartphone (V2V communication)	Some	None	N/A	None	A lot/completely reliant	Some	Some	Some	Some	Yes	None	Very aligned
20	Media campaign to highlight the importance of addressing warning lights on the dashboard by the driver of the other vehicle	None	Some	Easy	None	Somewhat	Some	None	Some	Some	Yes	None	Very aligned
21	Improved adherence to vehicle maintenance requirements and roadworthiness inspection routines for HGVs/LGVs	None	None	N/A	None	A lot/completely reliant	Some	A lot	A lot	None	N/A	A lot	Very aligned
22	Improved maintenance of vehicle lighting on the rear of other road user vehicles to enable drivers to better assess the 'size' of vehicles ahead.	None	Some	Easy	None	Somewhat	Some	None	Some	Some	Yes	None	Very aligned
23	Develop Truck Mounted Attenuators (TMAs) capable of absorbing impacts by HGVs.	A lot	A lot	Difficult	A lot	A lot/completely reliant	A lot	A lot	A lot	Some	No	A lot	Somewhat
24	Better quality voice controls	None	A lot	Difficult	None	A lot/completely reliant	Some	None	None	None	N/A	None	Somewhat

No.	Countermeasure	Q1 - Legislation	Q2 - Dependencies	Q2a - Ease of dependencies	Q3 - Business processes	Q4 - Reliant on others	Q4a - influence over others	Q5 - Maintenance effort	Q6 - Management effort	Q7 - More funding	Q7a - Funding source	Q8 - Skills & resource availability	Q9 - Policy alignment
25	Head up displays	A lot	A lot	Easy	Some	A lot/completely reliant	Some	Some	None	Some	No	Some	Very aligned
26	Technology on phones to disable them when driving	Some	Some	Easy	Some	Somewhat	Some	None	None	Some	No	Some	Very aligned

HGV and LGV frontal shunts on the Strategic Road Network

One of the most common collision types identified for commercial vehicles on the Strategic Road Network (SRN) is frontal shunt collisions, where the front of the HGV or LGV impacts the rear of another vehicle. This project aims to understand the root causes of these collisions (Phase 1 – Wallbank et. al., 2021) and identify countermeasures or interventions which could help to prevent them in the future (Phase 2 – this report). The report presents a number of potential countermeasures to the causes identified in Phase 1 and makes recommendations for which ones Highways England should pursue further.

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