In depth cost-effectiveness analysis of the identified measures and features regarding the way forward for EU vehicle safety

Final Report

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Table of contents

1 Executive summary

In 2015, the European Commission published the report conducted by TRL: *Benefit and Feasibility of a Range of new Technologies and Unregulated Measures in the Fields of Occupant Safety and Protection of Vulnerable Road Users* (Hynd *et al.*, 2015)[1]. This report provided initial feasibility, cost and benefit information for over fifty candidate safety measures that could be implemented as part of the amendment to the General Safety Regulation (Regulation (EC) No 661/2009) and the Pedestrian Safety Regulation (Regulation (EC) No 78/2009).

The present study reviews in more detail the 24 candidate measures selected by the European Commission for potential inclusion in the regulations. It updates the information presented by Hynd *et al.* (2015) with recent data and examines in greater detail the robustness of the available evidence for inclusion as inputs to further impact assessments or cost-benefit studies. See Table 1 for a list of the candidate measures and the applicable vehicle categories, as well as the short code used in this report to refer to each measure.

Table 1: Overview of the 24 candidate measures reviewed for General Safety 2 and the vehicle categories affected

Code	Description	Applicable vehicle categories							
AEB	Autonomous Emergency Braking	M1			N1				
AEB-PCD	Autonomous Emergency Braking for Pedestrians and Cyclists	M1			N1				
ALC	Alcohol Interlock Installation Document	M1	M2	M3	N1	N2	N3		
BFS-AFE	Bus Fire Safety – Automatic Fire Extinguishers		M2	M3					
BFS-CNG	Bus Fire Safety – CNG pressure relief		M2	M3					
DDR	Drowsiness and Distraction Recognition	M1	M2	M3	N1	N2	N3		
EDR	Event Data Recorder	M1			N1				
ESS	Emergency Stop Signal	M1	M2	M3	N1	N2	N3		
F94	Regulation 94 Frontal Offset Occupant Protection – Removal of Exemptions	M1			N1				
FFW	Full-width Frontal Occupant Protection	M1			N1				
FSO	Small Overlap Frontal Occupant Protection	M1							
HED	Adult Head to Windscreen Area Protection	M1			N1				
ISA	Intelligent Speed Assistance	M1	M2	M3	N1	N2	N3		

[1] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

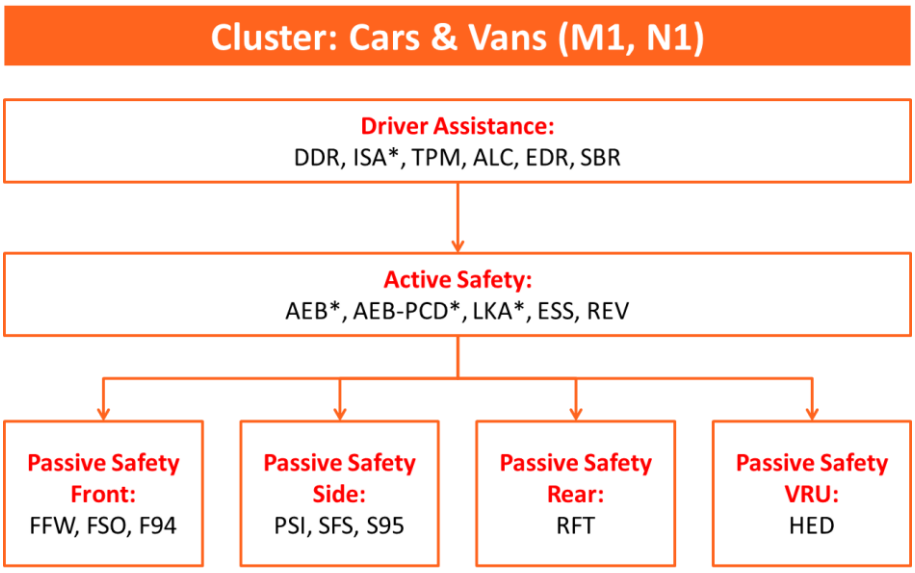
Code	Description	Applicable vehicle categories							
LAT	Lateral Side-Guards					N2	N3	O3	O4
LKA	Lane Keeping Assist	M1			N1				
PSI	Pole Side Impact Occupant Protection	M1			N1				
REV	Reversing Detection or Camera Systems	M1	M2	M3	N1	N2	N3	O3	O4
RFT	Rear Impact Protection of the Fuel Tank	M1			N1				
RUR	Rear Underrun Protection					N2	N3	O3	O4
S95	Regulation 95 Side Impact Occupant Protection – Removal of Exemptions	M1			N1				
SBR	Seat-Belt Reminders	M1	M2	M3	N1	N2	N3		
SFS	Side impact collision protection for Far-Side occupants	M1			N1				
TPM	Tyre Pressure Monitoring System	M1	M2	M3	N1	N2	N3	O3	O4
VIS	Direct Vision and VRU detection		M2	M3		N2	N3		

When considering the implementation of 24 different safety measures it is evident that there will be overlaps in the casualty groups addressed by individual measures and that there will be potential to share components between measures. The former needs to be considered in an impact assessment to avoid overestimating of benefits (each casualty can only be prevented once); the latter to avoid overestimating of costs (if the same hardware fulfils various functions).

TRL developed an approach to organise the measures in groups that allows to take into account their interactions (to the level of detail which can realistically be expected) when all or a subset of measures are implemented. The measures are organised in 'clusters', which are based on the vehicle categories on which the measures are implemented (i.e. where the development effort and costs are accrued; and for most measures also where the benefit arises). Within each cluster, the measures are further organised in three 'layers', based on the phase in which they protect:

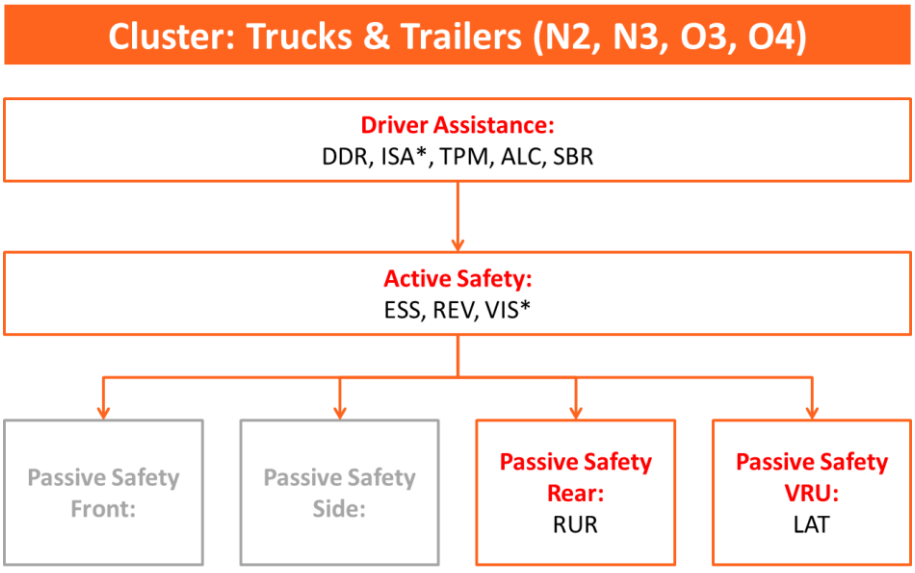
- Driver Assistance (permanent/ongoing collision mitigation)
- Active Safety (mitigation immediately pre-collision)
- Passive Safety (protection during collision)

The proposed organisation of measures in layers for cars & vans, trucks & trailers, and buses & coaches are given in Figure 1, Figure 2 and Figure 3, respectively.



* = potential to share sensor technologies and ECUs (front camera-based)

Figure 1: Technology cluster Cars & Vans



* = potential to share sensor technologies and ECUs (camera-based)

Figure 2: Technology cluster Trucks & Trailers

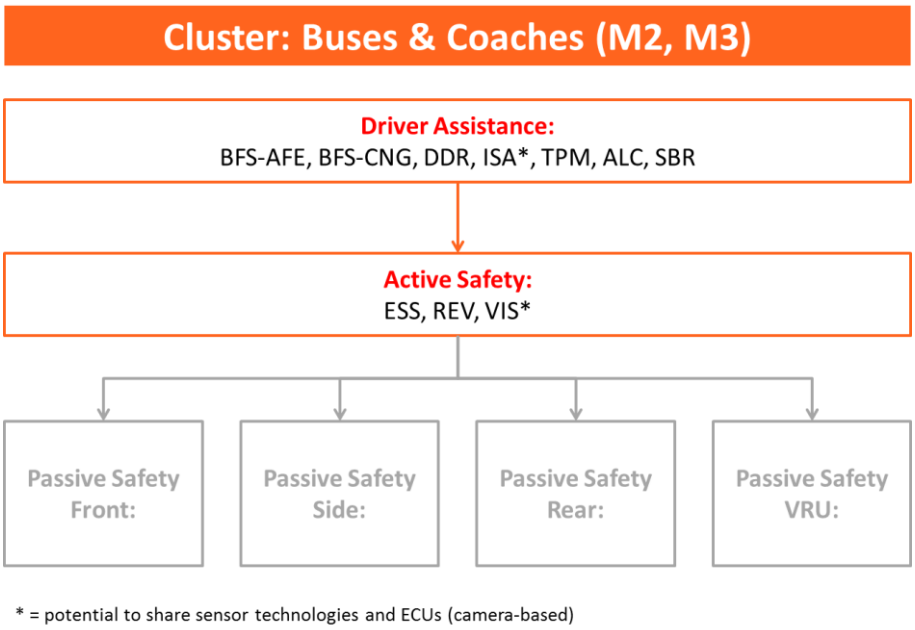


Figure 3: Technology cluster Buses & Coaches

TRL performed a systematic literature search to identify relevant sources for inclusion in this report. In order to review the information in a structured way, we employed a systematic review and assessment process. This provided a standard framework that was used in this case (and which could be used more generally) to identify and assess pertinent information and extract relevant values. For each candidate measure the best sources from the body of suitable evidence were selected based on quality of research, quality of data, timeliness and relevance to populate key input parameters for a cost-benefit assessment with suitable values:

- Relevant casualty target population
- Current and/or predicted penetration of the measure in the vehicle fleet
- Effectiveness of measure in relation to casualty target population
- Implementation cost per vehicle

At the same time as providing more detail on the primary costs and benefits of the candidate measures, this process also employed a 'PESTLE' analysis to identify other political, economic, societal, technical, legal and environmental effects

A wide stakeholder consultation was held to discuss TRL's preliminary findings with representatives from vehicle manufacturers, tier 1 suppliers, government organisations, non-government organisations in the area of road safety and environment, consumer organisations, academic and vehicle safety research and development organisations and consultancies. All inputs, provided in writing or during the two-day face-to-face meeting, were documented and used to update and refine the results of this study where appropriate

The information from all these steps was collated to produce a 'factsheet' for each measure which contains, as the main output of this study, proposed input values for a cost-benefit analysis, covering the target population, fleet penetration, effectiveness and cost of each measure. The factsheets can be found in the main body of this report. The following summary in Table 2 provides an overview of the level of evidence found for each candidate measure (and highlights existing gaps in this context), the main concerns or objections raised by stakeholders, and a short list of considerations and open issues for implementation of technical requirements. Note that this summary table cannot replace the more complex content provided in the main body (it does, for instance, not contain the proposed values but only an assessment of the level of evidence). Note further that the considerations and open issues are a short list of the most relevant items that emerged during the course of this project and stakeholder discussions, but should

not be taken as recommendations by TRL (defining technical requirement was outside the scope of this project).

Table 2: Overview of level of evidence and relevant aspects identified for each candidate measure

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
AEB	- Good level of evidence for M1 target population, fleet penetration and effectiveness - Cost estimate proposed; not contested by stakeholders - No specific evidence for N1; proposed estimates based on M1 data	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests to be defined - Consider common implementation date for moving and stationary obstacles - Consider covering higher speeds than 80 km/h in requirements - Consider requiring detection of small vehicles (e.g. motorcycles) - Consider exemption for ultra-small-volume vehicle manufacturers
AEB-PCD	- Good level of evidence for M1 target population and effectiveness - Future voluntary uptake in the fleet remains unknown; consider purchasing fitment projections - Cost estimate proposed; not contested by stakeholders - No specific evidence for N1; proposed estimates based on M1 data	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests to be defined - Consider including low ambient lighting and high closing speeds in requirements - Consider including avoidance of false positive activation in requirements - Consider exemption for small and ultra-small-volume vehicle manufacturers
ALC	- Good level of evidence for implementation: Existing cost-benefit analysis	- No substantial stakeholder objections regarding implementation if CBA positive	- Technical standard exists (EN 50436-7) - Consider exemption from the 'all new vehicles' date (year 2022) for vehicles "*where OEMs demonstrate that it is not feasible to install an AID without modification of the E/E architecture*"
BFS-AFE	- General paucity of quantitative evidence for this measure, but estimates for target population and benefits proposed - Fleet penetration remains unknown - No cost data available; consider estimating based on aftermarket prices	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level
BFS-CNG	- General paucity of quantitative evidence for this measure, but case reports make clear that relevant incidents do occur - Proposed to assume negligible cost; not contested by stakeholders	- No substantial stakeholder objections regarding implementation	- Type-approval requirements and tests developed at UN level

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
DDR	- Good level of evidence for target population for M1; estimate similar proportions for other categories - Future voluntary uptake in the fleet remains unknown; consider purchasing fitment projections - No high-quality evidence of the effectiveness from retrospective studies; predictive estimates for drowsiness detection available but highly uncertain; distraction detection needs more research - Cost estimates proposed; not contested by stakeholders for M1 and N1; much higher confidential estimates received from OEMs for N2 and N3	- Major objections from some stakeholders regarding implementation on M1, M2, M3, N1, N2 and N3 - Drowsiness recognition: No concerns regarding technical maturity but some concerns regarding real-world effectiveness in preventing collisions - Distraction recognition: Split stakeholder opinions on technical maturity	- Type-approval requirements and tests to be defined - Consider introducing drowsiness detection initially and expanding requirements later to distraction - Consider aligning timelines for distraction recognition with emergence of automated driving functions - Consider exemption for ultra-small-volume vehicle manufacturers
EDR	- Good level of evidence for Part 563-type EDR: Existing benefit study; however, benefits are difficult to monetise - No specific evidence identified for EDRs that also record VRU collisions - Proposed to assume negligible cost for Part 563-type EDR and very low cost for additional VRU collision recording; not contested by stakeholders	- No substantial stakeholder objections regarding implementation of Part 563-type EDR if CBA positive - Stakeholders stressed importance of harmonisation with US CFR 49 Part 563; (this can be interpreted as objection regarding recording of VRU collisions - Stakeholders suggested that privacy concerns around this measure needed to be resolved	- Type-approval requirements and tests to be defined - Consider harmonised requirements with US CFR 49 Part 563 or additional recording of VRU collisions - Consider exemption for small and ultra-small-volume vehicle manufacturers
ESS	- Good level of evidence for effectiveness at reducing brake reaction times, but a model will be required to quantify target population and resulting casualty savings. Suggested a simulation approach. - Proposed to assume negligible fleet penetration and cost; not contested by stakeholders	- No substantial stakeholder objections regarding implementation if CBA positive - Some stakeholders strongly opposed standardising the choice of flashing direction-indicator or stop lamps	- Type-approval requirements and tests developed at UN level - Clarify whether/how trailers (category O) would be affected - Consider standardising activation threshold - Consider standardising the choice of flashing direction-indicator or stop lamps - Consider exemption for ultra-small-volume vehicle manufacturers
F94	- General paucity of quantitative evidence for this measure, but estimates for fleet penetration proposed - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - No cost estimate available; cost remains unknown	- Some stakeholder objections regarding implementation - Concerns that benefits to be expected were very limited (in particular for N1) and that introduction could introduce unwanted negative effects, such as reduced compatibility (higher front-end stiffness) for currently exempt vehicles	- Type-approval requirements and tests developed at UN level (removal of exemptions) - Consider investigating potential unwanted effects further - Consider exemption for ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
FFW	- Good level of evidence for target population in M1 and N1 - Assume that majority of M1 fleet would already meet requirements as they are defined now; fleet penetration for N1 remains unknown - High-quality estimate of effectiveness for M1 from predictive study available; suggested to assume similar effectiveness for N1; no objections from stakeholders - Proposed cost estimate for M1 (not contested by stakeholders); no cost data available for N1 (cost remains unknown)	- No substantial stakeholder objections regarding implementation if CBA positive - Some stakeholders expressed reservations against introduction of the THOR ATD (would require specific analysis at UN GRSP level)	- Type-approval requirements and tests developed at UN level - Consider introduction of the THOR ATD into the test - Consider changes to encourage the introduction of adaptive restraint systems - Consider exemption for ultra-small-volume vehicle manufacturers
FSO	- Good level of evidence for target population - Proposed to assume negligible fleet penetration; not contested by stakeholders; but spillover effects from US possible - No quantitative evidence or estimates regarding effectiveness available; information from a potential second phase of the TRL/CEESAR study might become available in the future - No cost data available; cost remains unknown	- Major objections from some stakeholders regarding implementation - Concerns that active safety measures (in particular ESC, LDW/LKA and evasive steering) would reduce the target population in the future	- Type-approval requirements and tests to be defined (US test protocols exist) - Consider available test configurations to base the test on: IIHS or oblique MDB test - Consider testing both sides of the vehicle - Consider exemption for ultra-small-volume vehicle manufacturers
ISA	- High-quality estimates of casualty savings for M1 and N1 from predictive studies available; single country-based but could be extrapolated to EU - High-quality estimates of casualty savings across EU for M2, M3, N3 and N3 from a predictive study available (study takes into account the effect of maximum speed limiters) - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - Initial cost estimates proposed, but closer definition of system function required for more specific estimate; much higher confidential estimates received from OEMs for N2 and N3	- Split stakeholder opinions on what form of system would be most appropriate (advisory, voluntary or mandatory) - Some stakeholder objections regarding implementation on M1 and N1. Area of concern: Unclear responsibility and costs for keeping map information up-to-date - Major objections from some stakeholders regarding implementation on M2, M3, N3 and N3. Areas of concern: Real-world evidence for HGVs was very limited; existing maximum-speed limiters would reduce the benefits	- Type-approval requirements and tests to be defined (Euro NCAP protocol available and due to be updated) - Consider what form of system should be mandated (advisory, voluntary or mandatory); consider phased introduction - Consider holding consultations with the police about this measure - Consider permitting short-time override and default-on after ignition-on - Consider exemption for ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
HED	- Large body of research available, including predictive EU benefit studies - Range of effectiveness values for M1 and car-derived N1 proposed based on high-quality predictive studies; however, no retrospective evidence of effectiveness available; case number of cyclists in studies are somewhat limited; effectiveness for flat front-end N1 vehicles unknown - Note that additional information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - Proposed to assume negligible fleet penetration for M1 and N1; not contested by stakeholders - Proposed cost estimate; not contested by stakeholders	- Major objections from some stakeholders regarding implementation - Split opinions regarding technical feasibility/maturity of solutions - Some stakeholders raised concerns about potential negative side effects (driver's field of view, packaging issues) - Some stakeholder suggested they expected higher benefits from AEB-PCD, which would reduce the target population for HED more than assumed in studies	- Type-approval requirements and tests to be defined (pertinent proposals from BASt to be available shortly) - Combined positive effects of AEB-PCD and HED were shown to be larger than the effects of the individual measures added up - Consider exemptions for small and ultra-small-volume vehicle manufacturers
LAT	- Good level of evidence for target population and effectiveness (high-quality predictive estimates) - Proposed estimate for fleet penetration; value based on London only, applicability to EU uncertain - Cost estimates proposed and order confirmed by confidential costing information received from OEMs	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider removing any blanket permission for exemptions at the discretion of a type-approval authority to effectively address the existing issue
LKA	- Good level of evidence for target population and fleet penetration - High-quality, retrospective evidence available for effectiveness in M1; suggest to assume similar value for N1 - Cost estimate proposed for sensing technology (not contested by stakeholders); cost for actuation remains unknown and depends on requirements whether or not to upgrade vehicles with hydraulic steering assistance	- Some stakeholder objections regarding implementation - Concerns that the required design changes (and associated cost) for upgrading the steering system of vehicles with hydraulic steering assistance (including N-category vehicles) would be substantial - Suggestion that future emergency lane keeping systems (entering fleet from 2018) could be more appropriate for legislation than current systems	- Type-approval requirements and tests to be defined (pertinent discussions ongoing in IWG ACSF) - Consider what type of system should be mandated (CSF, B1, or emergency lane keeping system) - Consider permission to deactivate system by driver (depending on type of system) - Consider downgrading requirement to a pure warning function (LDW only) for vehicles with hydraulic steering assistance - Consider exemptions for small and ultra-small-volume vehicle manufacturers
PSI	- Good level of evidence with benefit estimates available from different regions; suggest to scale up to EU - Fleet penetration estimates proposed; not contested by stakeholders - Cost estimates proposed; not contested by stakeholders	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider additional requirement for assessment of the window curtain airbag coverage (ejection mitigation) - Consider exemption for ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
REV	- Proposed ways to estimate target population for all vehicle categories - Future voluntary uptake in the M1 and N1 fleet remains unknown (consider purchasing fitment projections); fleet penetration in M2, M3, N2, N3, O3 and O4 fleet assumed negligible - High-quality, retrospective evidence available for effectiveness in M1 and N1 (however, based on data from Australia and New Zealand); no estimates currently possible for effectiveness in M2, M3, N2, N3, O3 and O4 (different accidentology; TRL study on this subject ongoing) - Proposed cost estimates for M1 and N1 (not contested by stakeholders); higher/much higher costs expected for M2, M3, N2, N3, O3 and O4	- No substantial stakeholder objections regarding implementation on M1, M2, M3 and N1 if CBA positive - Some stakeholder objections regarding implementation on N2, N3, O3, O4 - Concerns regarding technical feasibility (non-existent communication protocols for freely combined tractors and trailers) and procedural difficulties with multistage vehicles that are built by different manufacturers	- Type-approval requirements and tests to be defined (Japanese initiative at WP.29; US protocols for camera systems for light vehicles exist) - Consider expanding scope to O2 trailers
RFT	- General paucity of quantitative evidence for this measure, but estimates of target population appear possible - Effectiveness and cost unknown; values from studies on the more severe US tests could give a first indication - Fleet penetration remains entirely unknown	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider adding an assessment of post-crash electrical safety - Consider applying only to new types (not all new vehicles) - Consider exemption for vehicles that do not have fuel storage, fuel supply lines and/or high voltage components located near the rear axle - Consider exemption for ultra-small-volume vehicle manufacturers
RUR	- Good level of evidence for implementation of 03 Series of Amendments to UN Regulation No. 58: Existing cost-benefit analysis	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider introducing introduce an additional load condition (100 kN applied simultaneously to three points) in the future
S95	- General paucity of quantitative evidence for this measure; no specific estimates could be proposed - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - No cost estimate available	- Some stakeholder objections regarding implementation - Concerns that benefits to be expected were very limited considering high seating position of affected vehicles (in particular N1) and the positive effects on structural integrity expected from introduction of pole side impact test	- Type-approval requirements and tests developed at UN level (removal of exemptions) - Consider performing test without ATD for currently exempted vehicles to verify fuel system integrity, protection against electrical shock and door opening - Consider exemption for ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
SBR	- Good level of evidence: Existing benefit study for EU-28 that determined break-even cost values and indicative costs - Stakeholders submitted confidential cost estimates for N2 and N3 passenger seats which were higher than the break-even cost estimates and indicative cost estimates	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level (joint proposal by the EC, Japan and the Republic of Korea) - Consider requiring occupancy detection for rear seats - Consider exemptions for removable seats and seats in a row with suspension seating - Consider provisions for small and ultra-small-volume vehicle manufacturers with regard to 4-point harnesses and two-seater vehicles
SFS	- Good level of evidence for target population - No high-quality retrospective evidence of effectiveness; range of effectiveness values proposed based on good quality predictive estimates - Proposed to assume negligible fleet penetration; not contested by stakeholders - Proposed cost estimate; not contested by stakeholders	- Major objections from some stakeholders regarding implementation - Concerns that no design solutions were proven to be effective - Concerns that no suitable ATD would exist for far-side impact tests	- Type-approval requirements and tests to be defined - Consider exemptions for small and ultra-small-volume vehicle manufacturers
TPM	- Good level of evidence for implementation for N1: Existing cost-benefit analysis (but validity of safety aspects unclear) - Existing cost-benefit analysis for implementation for M2, M3, N2, N3, O3 and O4, but validity of safety aspects unclear and cost assumptions used were contested by some of the stakeholders (supported by others) - No appropriate studies available regarding amendments to existing requirements for M1 (reduction of detection time); cost-benefit situation remains unknown; appears to be mostly a question of technical feasibility	- No substantial stakeholder objections regarding implementation for N1 if CBA positive - Split stakeholder opinions on implementation for M2, M3, N2, N3, O3 and O4. Areas of concern: Technical maturity of solutions seen differently by different groups; Communication standards for tractors and trailers to be defined; Operational difficulties for manufacturers of multi-stage vehicles - Split stakeholder opinions on amendments to existing requirements for M1	- Type-approval requirements and tests for M1 and N1 developed at UN level - Ongoing technical discussion on the effectiveness of TPMS in real-world scenarios - Ongoing technical discussion on potential reduction of detection time requirements in existing M1 regulation - Type-approval requirements and tests for M2, M3, N2, N3, O3 and O4 to be defined

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
VIS	- Large body of research available, including predictive EU benefit and cost-benefit studies - Target population estimates available - No high-quality retrospective evidence of effectiveness; wide range of effectiveness values proposed based on predictive estimates - Proposed cost estimates for camera and detection systems; much higher confidential estimates received from OEMs - Proposed range of cost estimates for direct vision cab-redesigns; however, the exact implementation of the requirements will have a large influence on cost (complete cab-redesign or more minor alterations for best-in-class) influence are considered uncertain	- Some stakeholder objections regarding implementation of camera and detection systems. Areas of concern: Technical maturity of solutions seen differently by different groups - Major objections from stakeholders regarding implementation of direct vision requirements via an undifferentiated approach (same performance requirement for all vehicle applications). Areas of concern: Major re-design of cabs required which might not be suitable for certain applications - Some stakeholder objections regarding implementation of direct vision via a differentiated approach (performance based on vehicle application). Closer definition required for more detailed discussion.	- Type-approval requirements and tests to be defined - For detection systems, consider including avoidance of false positive activation in requirements - For camera and detection systems, consider exemptions for small and ultra-small-volume vehicle manufacturers - For direct vision, consider a differentiated approach based on vehicle application. This could include different performance requirements for urban delivery, large distribution and construction vehicles, respectively. Consider a best-in-class approach for each vehicle category or cab design (instead of a single high-visibility cab approach). - Consider earlier introduction of direct vision requirements for new types if best-in-class approach is used

2 Introduction

2.1 Background

Regulation (EC) 661/2009 of the European Parliament and Council concerning type-approval requirements for the general safety of motor vehicles, their trailers, and systems, components and separate technical units intended therefor[2], was published in the Official Journal in July of 2009. Since 2009, the General Safety Regulation has been amended twice, namely by Commission Regulations (EU) Nos 407/2011[3] and 523/2012[4], both focussing on complementing Annex IV with the list of UN regulations which apply on a compulsory basis. The measures provide for the vehicle type-approval prescriptions for electrical safety, standard fitment of daytime running lamps and electronic stability control systems on cars, vans, trucks, and buses and the fitment of tyre pressure monitoring systems on cars.

In April 2012, the level of mandatory vehicle safety requirements in the General Safety Regulation rose significantly as a result of the finalisation and inclusion of two new EU Implementing Measures featuring new advanced technologies within the General Safety Regulation framework. Specifications were developed for trucks and buses to be fitted with Lane Departure Warning Systems (LDWS)[5] and Advanced Emergency Braking Systems (AEBS)[6] preventing vehicles to drift off the road and enabling them to brake automatically if an obstacle is detected on the road ahead and the driver does not react to this imminent collision risk.

In parallel to the General Safety Regulation, another Regulation of the European Parliament and Council was finalised in 2009, namely Regulation (EC) 78/2009 on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users[7]. This Regulation is a recast of the old Directive 2003/102/EC[8] concerning the same topic, but with modified and more advanced provisions, adapted to the technical progress. The requirements encompassed in the legislation concern passive safety requirements which mitigate the critical injury levels in case of a collision of a vehicle with persons.

Both the General Safety and Pedestrian Safety Regulations acknowledge that the Commission is to provide reporting to the European Parliament and Council in relation to the monitoring of technical developments in the field of enhanced passive safety requirements, the consideration and possible inclusion of new and enhanced safety features as well as enhanced active safety technologies. The commitments are laid down in Article 17 of the General Safety Regulation and Article 12 of the Pedestrian Protection Regulation. As noted in Article 12 of the Pedestrian Protection Regulation, the Commission may, on the basis of the results of the monitoring completed under points 2.2, 2.4 and 3.2 of Annex I, adopt implementing measures as appropriate with regard to the protection assessed by an upper legform to bonnet leading edge test and an adult headform to windscreen test.

On the 30th March 2015, the European Commission published the report conducted by TRL: 'Benefit and Feasibility of a Range of new Technologies and Unregulated Measures in the Fields of Occupant Safety and Protection of Vulnerable Road Users' (Hynd *et al.*,

[2] OJ L 200, 31.07.2009, page 1

[3] OJ L 108, 28.4.2011, page 13

[4] OJ L 160, 21.6.2012, page 8

[5] Regulation (EU)No 351/2012 (OJL 110, 24.4.2012,p.18)

[6] Regulation (EU) No 347/2012 (OJ L 109, 21.4.2012, p.1)

[7] OJ L 35, 4.2.2009, page 1

[8] OJ L 321, 6.12.2003, page 15

2015)[9]. This report provided initial feasibility, cost and benefit information for over fifty candidate safety measures that could be implemented as part of the amendment to the General Safety Regulation and the Pedestrian Protection Regulation. These were rated 'green' 'amber' or 'red', depending on the strength of the candidate measure for regulation.

2.2 Aims and objectives

This project updates the information presented by Hynd *et al.* (2015) with recent data and examines in greater detail the robustness of the available evidence for inclusion as inputs to further impact or cost-benefit studies for the following measures proposed for consideration (see Section 2.3). Any new or proposed changes to legislation must be supported by an impact assessment that quantifies the proposed action in terms of the costs, benefits, and impacts on society, environment, and the economy. The type and quality of cost-benefit assessment that can be made is determined by the type and quality of the information available for the key aspects of the assessment.

In order to review the information in a structured way, we employed a systematic review and assessment process. This provided a standard framework that was used in this case (and which could be used more generally) to identify and assess pertinent information and extract relevant values. These values could be used as inputs in specific studies to evaluate possible inclusion in the General Safety Regulation or Pedestrian Safety Regulation. At the same time as providing more detail on the primary costs and benefits of the candidate measures, this process also employed a 'PESTLE' analysis to identify other political, economic, societal, technical, legal and environmental effects. A wide stakeholder consultation was held to discuss TRL's preliminary findings with representatives from vehicle manufacturers, tier 1 suppliers, government organisations, non-government organisations in the area of road safety and environment, consumer organisations, academic and vehicle safety research and development organisations and consultancies. All inputs, provided in writing or during the two-day face-to-face meeting, were documented and used to verify, update and refine the results of this study where appropriate.

2.3 Measures considered

The candidate measures to be considered were defined by the European Commission. The following candidate measures (see Table 3) were included in the scope of this project.

[9] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

Table 3: Overview of the 24 candidate measures reviewed for General Safety 2 and the vehicle categories affected

Code	Description	Applicable vehicle categories							
AEB	Autonomous Emergency Braking	M1			N1				
AEB-PCD	Autonomous Emergency Braking for Pedestrians and Cyclists	M1			N1				
ALC	Alcohol Interlock Installation Document	M1	M2	M3	N1	N2	N3		
BFS-AFE	Bus Fire Safety – Automatic Fire Extinguishers		M2	M3					
BFS-CNG	Bus Fire Safety – CNG pressure relief		M2	M3					
DDR	Drowsiness and Distraction Recognition	M1	M2	M3	N1	N2	N3		
EDR	Event Data Recorder	M1			N1				
ESS	Emergency Stop Signal	M1	M2	M3	N1	N2	N3		
F94	Regulation 94 Frontal Offset Occupant Protection – Removal of Exemptions	M1			N1				
FFW	Full-width Frontal Occupant Protection	M1			N1				
FSO	Small Overlap Frontal Occupant Protection	M1							
HED	Adult Head to Windscreen Area Protection	M1			N1				
ISA	Intelligent Speed Assistance	M1	M2	M3	N1	N2	N3		
LAT	Lateral Side-Guards					N2	N3	O3	O4
LKA	Lane Keeping Assist	M1			N1				
PSI	Pole Side Impact Occupant Protection	M1			N1				
REV	Reversing Detection or Camera Systems	M1	M2	M3	N1	N2	N3	O3	O4
RFT	Rear Impact Protection of the Fuel Tank	M1			N1				
RUR	Rear Underrun Protection					N2	N3	O3	O4
S95	Regulation 95 Side Impact Occupant Protection – Removal of Exemptions	M1			N1				
SBR	Seat-Belt Reminders	M1	M2	M3	N1	N2	N3		
SFS	Side impact collision protection for Far-Side occupants	M1			N1				
TPM	Tyre Pressure Monitoring System	M1	M2	M3	N1	N2	N3	O3	O4
VIS	Direct Vision and VRU detection		M2	M3		N2	N3		

3 Methodology

3.1 Overview

The following procedure was developed to identify and review the information considered by this project. The three main steps carried out are outlined below (Figure 4) and described in greater detail in the subsequent sections.

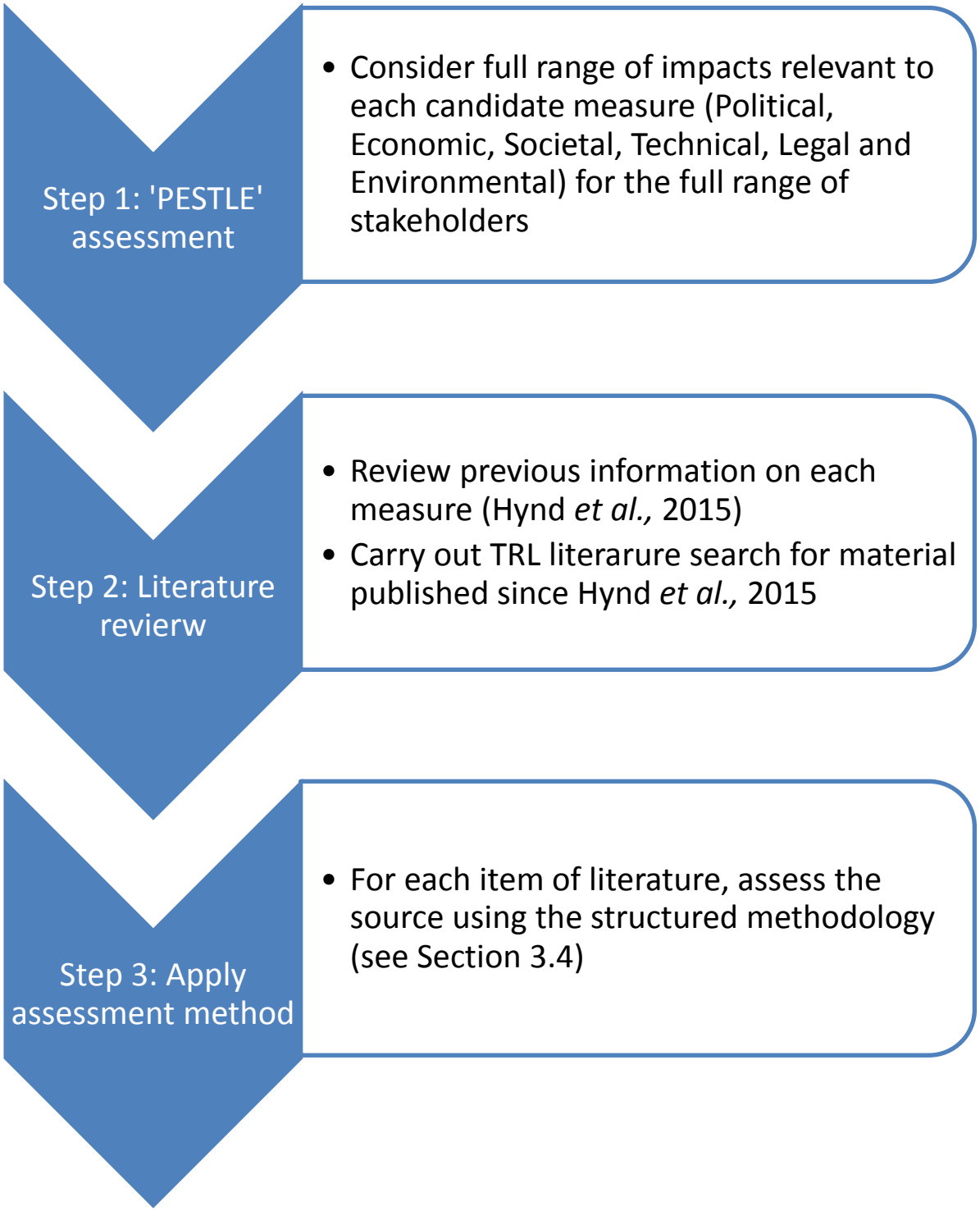


Figure 4: Outline of steps implemented in this project

3.2 PESTLE analysis

This analysis was carried out as the first step in the method and before any literature searches or reviews commenced. The aim of this was to consider the full range of impacts relevant to each candidate measure (Political, Economic, Societal, Technical, Legal and Environmental) for the full range of stakeholders. This approach meant that the areas important for the measure could be captured and considered in the literature searches; these assisted in identifying potential impacts. This is also in line with good practice to consider and identify the likely impacts. Examples of the PESTLE assessment approach can be found in the factsheets for each measure presented in Section 5.

3.3 Literature review

A standard literature search and review process was used to identify relevant sources for inclusion in the review. Firstly, those studies relevant to each of the measures in the scope of this study that were collated as part of TRL's previous work (Hynd *et al.*, 2015) were filtered and included if they met one of the following inclusion criteria:

- Source contains quantitative information on positive impacts (e.g. number of casualties that could be saved by implementation, reduction in fuel consumption)
- Source contains quantitative information on negative impacts (e.g. costs of implementation)
- Source contains pieces of evidence that could be used to indirectly calculate one of the above (e.g. reaction time reduction by flashing brake lights; increase in collision risk due to drunk driving)
- Source contains individual case reports that can provide for meaningful case studies where no other evidence might be available

Studies and reports that did not fit any of the above criteria were also included in the record of literature considered and relevant supporting information was noted; for example, if the source lacked relevant cost or benefit information but included detailed definition of relevant performance criteria and test procedures.

3.4 Assessment methodology

The following methodology was developed to assess the quality of each source and to allow a structured assessment of the primary impacts (these are defined and described in the following section) so that the source could be evaluated and the most robust values selected to be taken forward to subsequent impact assessments.

3.4.1 Primary and secondary impacts

The key impacts for most measures considered in the General and Pedestrian Safety Regulations are casualty reductions (benefit) and costs to implement the candidate measures (cost). The assessment of the quality of evidence therefore focuses on these primary impacts.

Secondary impacts are an important part of an impact assessment, but there is a large variety of secondary impact types (e.g. noise emissions, legislative effort, harmonisation with other regions, encouraging cycling by reducing the perceived risk of cycling on the road etc.). Many of these are 'soft' impacts that are difficult to quantify and/or monetise; therefore, while it is important that they are considered as part of an impact assessment, the method developed herein does not apply the same type of formal review of the quality of evidence to secondary impacts as is used for primary impacts.

Furthermore, some secondary impacts (and in some cases primary impacts) can be addressed using standard data available in the literature. For example, fuel consumption and emission increases per kilogram of vehicle mass are well documented and can be applied during the impact assessment in a standardised way to each measure. Similarly, cost reductions with increasing production volumes are well-documented for several vehicle systems that have been introduced in recent years. These should be used to indicate the likely long-term cost of new systems.

3.4.2 Quality assessment of literature sources

The following structured methodology was developed to allow the objective assessment of research studies and cost-benefit assessments with respect to the impacts identified within the studies. Research or benefit assessments may use different methodologies, use data of differing quality and account for, or make, different assumptions. This can result in values presented that are opaque with respect to these underlying factors, making it difficult to make judgements about the robustness of the findings.

As part of the Commission's efforts to standardise and improve the quality of assessments, the 'Better Regulation' guidance provides details of the method and approach that should be followed in the construction and execution of impact assessments. The methodology developed here uses this guidance to allow the grading of the sources under review so that objective judgements can be made whether the quality of data is sufficient to support the proposed action. Reviewers were trained in applying the methodology and consistency of reviews was maximised via a system of spot checks and individual feedback.

The following aspects of each source were assessed against standardised criteria for the following parameters:

- **Relevance of study:**
  - Study type
  - Relevance of study to measure under assessment
- **Quality of data:**

Benefits	Costs
Timeframe of data sample	Age of data
Geographical scope of data	Origin of estimate
Age of data	
Size of sample	

- **Quality of method:**

Cost-benefit assessment	Research study	Individual case report
Time period	Appropriate analytical design	Incident causation
Discounting and inflation	Assumptions	Mitigation potential
Appropriate assumptions	Peer review	
Peer review		

Each of these parameters was assessed and assigned a standardised score was determined based on the reviewer's assessment of the source against each of these criteria. The range of the score is 0 to 100, with 100 per cent denoting the highest possible quality of a source. A minimum score of 50 per cent for a source was required as necessary criteria to be taken forward into the body of suitable evidence.

The guidance and scoring criteria for each parameter are presented in Annex 1. Overview results of the scoring of the literature sources reviewed are presented in the factsheets for each candidate (Section 5).

3.5 Recommend input values

For each candidate measure the best sources from the body of suitable evidence were selected based on quality of research, quality of data, timeliness and relevance to populate key input parameters for a cost-benefit assessment with suitable values:

- Relevant casualty target population
- Current and/or predicted penetration of the measure in the vehicle fleet
- Effectiveness of measure in relation to casualty target population
- Implementation cost per vehicle

These sources were used to develop the factsheets on each measure, which contain the preliminary recommended input values (Section 5).

3.6 Stakeholder consultation and recommendation of key values

A stakeholder consultation was held to discuss the preliminary findings of the review and the preliminary recommended input values for a cost-benefit assessment. This stakeholder input was used to verify, update and refine the results of this study where appropriate.

Stakeholders had the opportunity to provide written feedback on TRL's preliminary findings and/or participate in a two-day stakeholder consultation meeting in London on 28th and 29th November 2016. The event was kindly hosted by Europe House, providing the venue, sound and visual equipment.

Invitations were sent to the General Safety Stakeholders Contact List:

- 82 people from 61 organisations confirmed initially.
- 72 people from 54 organisations attended the meeting.

The list of attendees can be found in Annex 2.1.

The types of organisation represented included vehicle manufacturers, tier 1 suppliers, government organisations, non-government organisations (NGO) in the area of road safety and environment, consumer organisations, academic and vehicle safety research and development organisations, and consultancies (Figure 5).

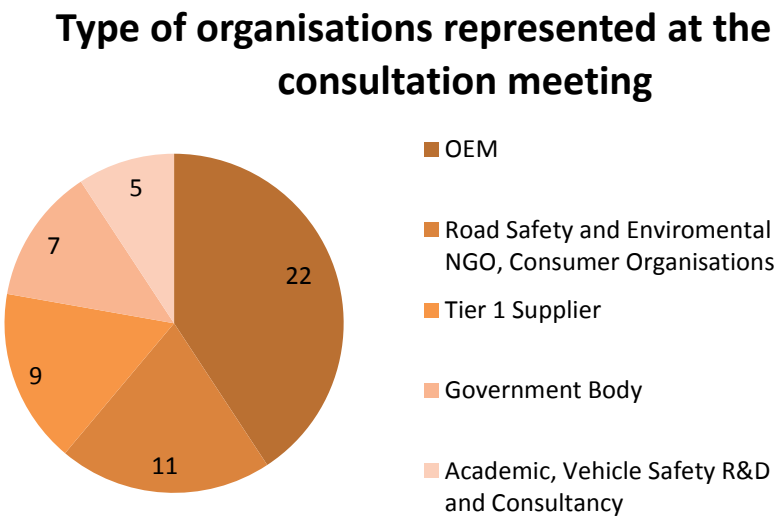


Figure 5: Type of organisations present during the GSR2 stakeholder consultation meeting

The participants were given the opportunity to comment on the safety measures factsheets, which had been uploaded to the project FTP server before the meetings. Several organisations responded with comments which were summarised and incorporated in the information pack for the consultation meetings. This feedback was

presented during the respective safety measures discussions and the stakeholders' comments were captured.

Due to the large number of measures to be discussed, parallel sessions were held on the second day as shown in the table below.

Day	Session 1	Session 2
1 **Monday 28th November 2016** **(10:00 - 16:00)**	Cars and heavy vehicles REV, EDR, ISA, DDR, ALC, SBR and ESS	*N/A*
2 **Tuesday 29th November 2016** **(09:15 – 16:15)**	Room 1 – Cars FFW, FSO, F94, PSI, SFS, S95, RFT, HED, TPM, LKA, AEB and AEB-PCD	Room 2 – Heavy vehicles VIS, TPM, REV, BFS-AFE, BFS CNG, RUR and LAT

For each measure, the TRL topic lead gave a brief presentation to:

- Define the measure
- Indicate the proposed clustering for benefits and technologies
- Summarise the impacts
- Highlight the recommended input values for a cost-benefit study
- Summarise the input received from stakeholders prior to the workshop

The meeting minutes documenting the discussion in the stakeholder meeting for each of the measures can be found in Annex 2.2.

The large number of participants and the active and constructive discussions during the two days led to significant amount of quality written feedback received from 32 organisations (see Table 4; five of the organisations that sent feedback did not attend the consultation meetings, but responded to the original request for comments, distributed in October 2016). The written contributions from stakeholders, as far as not marked confidential by the respondent, are reproduced in full in Annex 3.

Table 4: Organisations that provided input during the GSR2 stakeholder consultation

Organisation name
ACEA
Adam Opel AG
AGU Zürich
AUDI AG
Autoliv
BASt - Federal Highway Research Institute
Bridgestone Europe
CLEPA
DAF Trucks N.V.
DfT
ETRMA
ETSC
European Cyclists Federation
Fédération Inter-Environnement Wallonie
FIA Region I
Fujitsu Ten (Europe) GmbH
German Insurers Accident Research at GDV
JASIC - Japan Automobile Standards Internationalisation Centre
MAN Truck & Bus AG
NIRA Dynamics
PSA Peugeot Citroen
RDW
RoadPeace
SBD Automotive
Schrader / Sensata Technologies
Seeing Machines
Society of Motor Manufacturers and Traders Limited (SMMT)
Toyota Motor Europe NV/SA (as part of ACEA comments)
Transport & Environment (T&E)
Transport for London (TfL)
University of Leeds, Institute for Transport Studies
VTI - Swedish National Road and Transport Research Institute

4 Considerations for impact assessments

4.1 Clustering of measures

When considering the implementation of 24 different safety measures it is evident that there will be overlaps in the casualty groups addressed by individual measures and that there will be potential to share components between measures. The former needs to be considered in an impact assessment to avoid overestimating of benefits (each casualty can only be prevented once); the latter to avoid overestimating of costs (if the same hardware fulfils various functions). Modelling these interactions is complex due to the high number of measures (24 implemented across eight vehicle categories) paired with limitations in the available collision statistics.

TRL developed an approach to organise the measures in groups that allows to take into account their interactions (to the level of detail which can realistically be expected) when all or a subset of measures are implemented. The measures are organised in 'clusters', which are based on the vehicle categories on which the measures are implemented (i.e. where the development effort and costs are accrued; and for most measures also where the benefit arises). Within each cluster, the measures are further organised in three 'layers', based on the phase in which they protect:

- Driver Assistance (permanent/ongoing collision mitigation)
- Active Safety (mitigation immediately pre-collision)
- Passive Safety (protection during collision)

The proposed general structure for modelling the interactions between measures in the future impact assessment is visualised in Figure 6. The initial target population for the calculations should be all EU road casualties. Each 'layer' will prevent some of the casualties and thus reduce the target population for the next layer. The interactions/overlaps within each layer are expected to be limited because the safety systems address distinct collision causes or configurations.

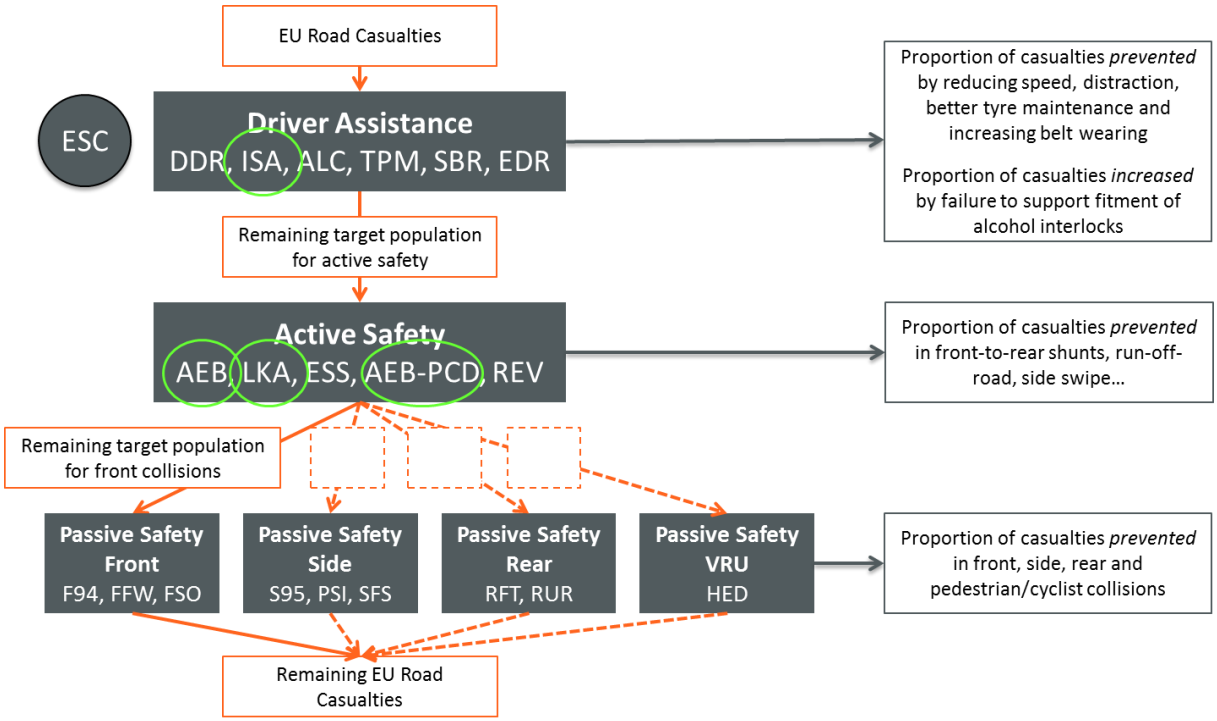


Figure 6: Modelling interactions of safety measures based on layers of protection (driver assistance, active safety, passive safety)

For example, a side impact against a tree, following a lane departure of a tired driver could be prevented by a drowsiness warning (DDR, layer: driver assistance) or by lane keeping support (LKA, layer: active safety), or could be mitigated by improved side impact protection (PSI, layer: passive safety side). In this example, all three layers can contribute protection with a certain probability (effectiveness). In other cases only two, one or none of the layers can have an effect.

Note that the limitations of available collision statistics will not always allow precise mapping of the layers onto each other (what collisions exactly are caused by drowsiness and result in hitting a tree after leaving the lane), but it should be possible to perform overall quantitative estimates that prevent double-counting of avoided casualties.

Potential to share components exists only within the boundaries of each cluster (i.e. within physical vehicle categories) and was identified mainly for camera-based technologies. For these measures, the costs can be apportioned to all measures sharing technology (as proposed in the factsheets for the relevant measures).

The proposed organisation of measures in layers for cars & vans, trucks & trailers, and buses & coaches are given in Figure 7, Figure 8, and Figure 9 respectively.

The selection of sets of measures for potential mandatory implementation, i.e. the definition of different 'policy options' had not been performed at the time of this report. In order to aid the selection of measures for the policy options further, preliminary cost-benefit indicators for individual measures have been calculated and are presented in Annex 4.

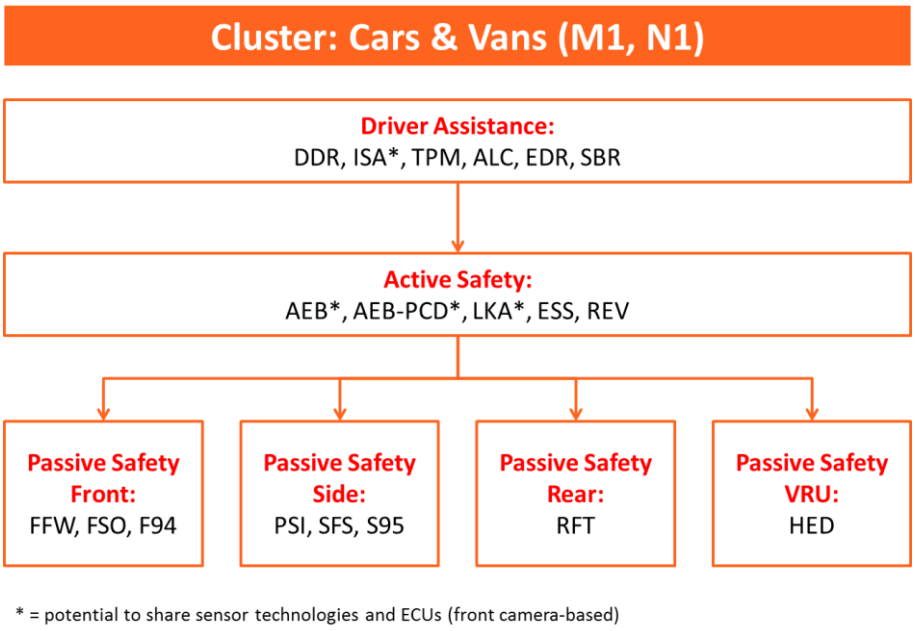


Figure 7: Technology cluster Cars & Vans

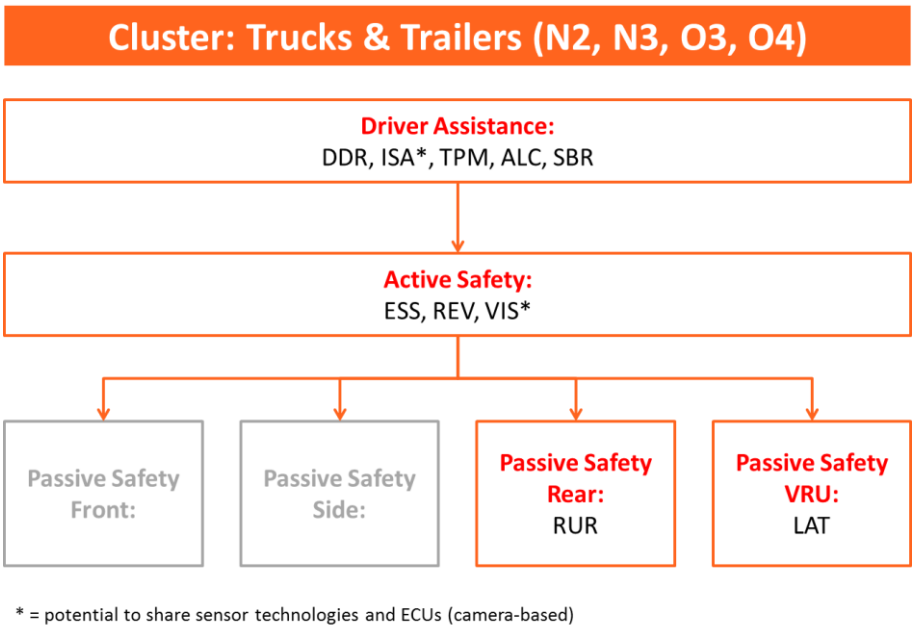


Figure 8: Technology cluster Trucks & Trailers

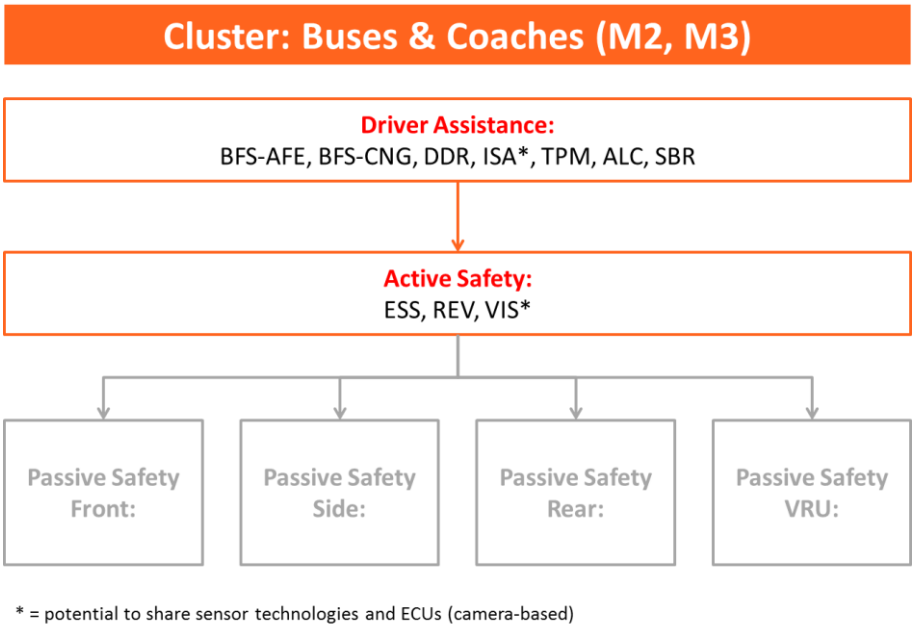


Figure 9: Technology cluster Buses & Coaches

4.2 Stakeholder remarks

During the course of the stakeholder consultation, some general comments were provided to TRL that could be taken into consideration for the impact assessment and updates to the General and Pedestrian Safety Regulations:

- Stakeholders pointed out that there was a considerable amount of under-reporting of collisions to be expected in official statistics, even for serious injury levels. Reports concluded that more than three times as many people are seriously injured in collisions than reported by the police. This should be reflected in cost-

benefit calculations. Pertinent research from the UK Department for Transport (DfT) is available.[10]

- Jeanne Breen Consulting urged to consider other selection criteria than pure cost-effectiveness when considering which safety measures to take forward. High benefit-cost ratios could be found for measures that only protect a small number of casualties simply because the implementation costs are low/negligible. The absolute number of casualties prevented and the equitable treatment of different road user groups (e.g. protecting vulnerable road users) could be additional decision criteria.

[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/568484/rrcgb-2015.pdf

5 Candidate measure factsheets

5.1 Autonomous Emergency Braking (AEB)

Autonomous Emergency Braking (AEB)

Autonomous Emergency Braking (AEB) for vehicle-to-vehicle collisions combines sensing of the environment ahead of the vehicle with the automatic activation of the brakes (without driver input) in order to mitigate or avoid a collision.

From 1st November 2015, the General Safety Regulation has required the fitment of AEB to new vehicles of categories M2, M3, N2 and N3.

Make mandatory for M1 and N1 vehicles (that are derived from M1):

- 01/09/2020 moving obstacle detection for new approved types
- 01/09/2022 moving obstacle detection for new vehicles
- 01/09/2022 stationary obstacle detection for new approved types
- 01/09/2024 stationary obstacle detection for new vehicles

Make mandatory for all N1 vehicles 2-year offset to the above dates.

Notes on measure:

- AEB is increasingly widespread in the vehicle fleet and has proven effective in preventing front-to-rear shunt collision in the field.
- Public acceptance of AEB is very high: Customer surveys show a high awareness of AEB technology (55% of car drivers know the system) and a high demand to have AEB on the next car (51% of car drivers)[11].
- BASt reasoned that there was no technical need for introducing stationary obstacle detection later than moving obstacle detection: This was only relevant in the early days of AEB, when radar sensors were used that could mistake, for example, a road sign for a target. In case of camera systems, there would be target classification algorithms to deal with this problem. UN Regulation No. 131 (for M2, M3, N2 and N3) also implemented tests for moving and stationary obstacles in the same regulation, in the same year.

Considerations regarding potential technical requirements:

- Stakeholders suggested that legislative requirements:
  - Should be discussed at UNECE level and that global harmonisation was desirable.
  - For small-volume vehicle manufacturers should allow ability to switch system off for track use; for ultra-small-volume vehicle manufacturers an exemption should be granted.
  - Should cover the entire range of possible driving speeds, i.e. also higher speeds than currently tested by Euro NCAP (which tests driving speeds of up to 80 km/h).

[11] http://www.imobilitychallenge.eu/files/studies/iMobility_Challenge_D2.3.1__User_Awareness_and_Demand_for_iMobility_systems_version_1.0.pdf

- Should introduce moving and stationary obstacle detection at the same time: BASt reasoned that there was no technical need for introducing stationary obstacle detection later than moving obstacle detection: this was only relevant in the early days of AEB, when radar sensors were used that could mistake, for example, a road sign for a target. In case of camera systems, there would be target classification algorithms to deal with this problem. UN Regulation No. 131 (for M2, M3, N2 and N3) also implemented tests for moving and stationary obstacles in the same regulation, in the same year.
- Could initially apply basic functions and should later extend functions to consider real-world accident typologies.
- Should require AEB to entirely prevent collisions with stationary targets (rather than just reduce impact speed).
- Should require AEB to be permanently active, with only temporary deactivation by the driver allowed in specific situations.
- Should require AEB to also detect smaller vehicles such as motorcycles.
- Collision warnings (before AEB activation) should be complemented by earlier distance information.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: ISA, FFW, RUR, RFT
- Overlaps in technology to consider: LKA, ISA, AEB-PCD (camera-based systems)

Main impacts:

- Positive:
  - Strong evidence of the benefits of AEB suggests potential to reduce fatal, serious and slight casualties and achieve overall reduction in casualties.
  - Potential for reduction in car insurance premiums (fewer front-to-rear collisions).
  - Potential for harmonisation of technical requirements across regions and between OEMs.
- Negative:
  - Increased OEM cost and purchase price of vehicles.

Assessment of available body of evidence:

- There were 12 articles included for a detailed quality assessment, of which 10 were research-related articles and two were cost-benefit studies.

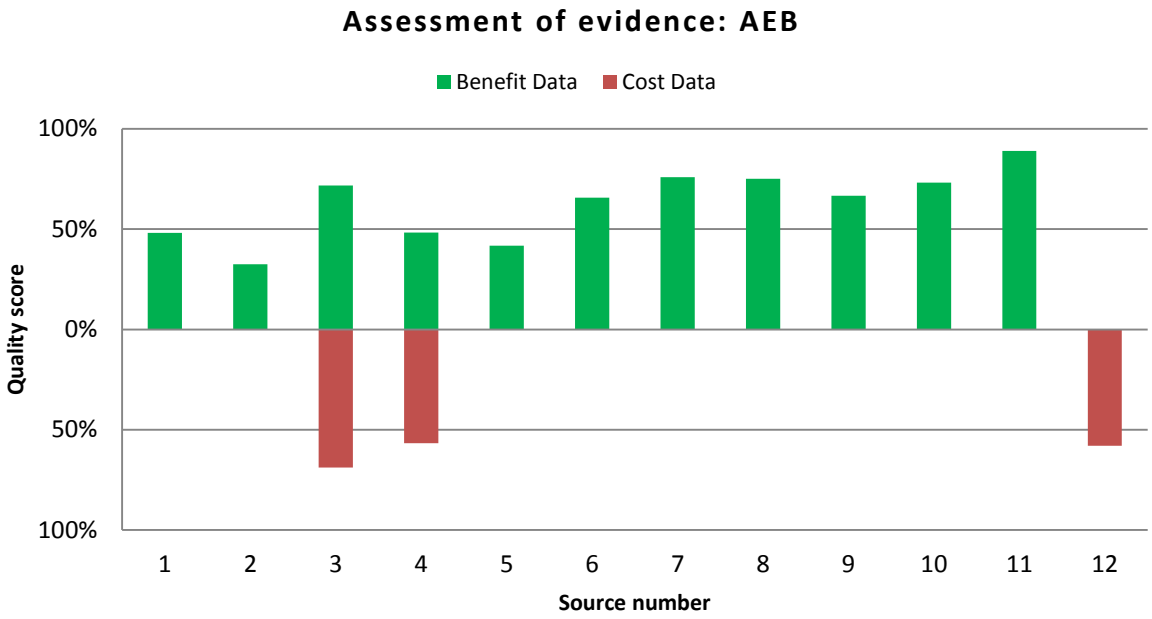


Figure 10: Level of available evidence for AEB

- There is high-quality retrospective evidence available that AEB has a significant role to play in preventing or mitigating rear-end collisions. There may be some benefit in other collision configurations based on predictive studies, and possibly requiring relatively sophisticated AEB systems, but no real-world data on this. Due to the commercially sensitive nature, published cost information was more spare. However, a tear-down cost analysis performed in 2012 for NHTSA provided a basis for an informed system cost estimate.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database and scaled-up national data from member states' police records to extract values based on description of target population.
  - Combined with (for M1 vehicles):
    - Hummel *et al.* (2011) Advanced Driver Assistance Systems - An investigation of their potential safety benefits based on an analysis of insurance claims in Germany[12].
- Fleet penetration:
  - Öörni (2016) iMobility Support – D3.1b Report on the deployment status of iMobility Priority systems and update of iMobility Effects Database[13].

[12] https://udv.de/system/files_force/tx_udvpublications/RR_12__fas.pdf

[13] http://www.imobilitysupport.eu/library/imobility-support-activities/its-deployment-deliverables/monitoring-priority-systems/deliverables-3/2992-d3-1b-and-d3-2b-deployment-status-of-imobility-priority-systems-effects-database-all-appendices/file

- Benefit data:
  - Fildes *et al.* (2015) Effectiveness of low speed autonomous emergency braking in real world rear end crashes[14].
  - Cicchino (2016) Effectiveness of FCW systems with and without AEB in reducing police reported crash rates[15].
- Cost data:
  - NHTSA (2012) Cost & Weight Analysis of Forward Collision Warning System (FCWS) and Related Braking Systems for Light Vehicles[16]

No concerns regarding these sources were raised by stakeholders.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious two-vehicle front-to-rear collisions'
  - Stakeholders reasoned that there was an effect on front-to-side collisions as well. TRL agree that this is the case for real-world implementation, however note that it this is not verified in any of the existing test procedures and the magnitude of the effect has not been quantified in research.
- Fleet penetration:
  - Approximately 1% of M1 fleet was equipped in 2015, with a high new vehicle fitment rate since 2013 (8.9%); based on (Öörni, 2016), see Section 5.4, Tables 120 and 121 for details.
    - Stakeholders have not had a chance to comment on these values because they were identified after the consultation. Note that the previous value based on (Kyriakidis *et al.*, 2015) was wrongly cited as fleet penetration where it was actually new vehicle fitment.
  - Negligible proportion of N1 fleet equipped (assumption).
  - No concerns were raised by stakeholders regarding this assumption.
- Effectiveness (percentage of target population affected, benefit):
  - 38–42% of target population for M1 vehicles (all injury severities; relatively lower effectiveness at higher injury severity levels), based on (Fildes *et al.*, 2015) and (Cicchino, 2016).
  - Similar effectiveness for N1 vehicles (assumption, no detailed studies on N1 identified).
  - No concerns regarding these values were raised by stakeholders.
- Cost per vehicle at time of mandatory implementation:

[14] https://www.ncbi.nlm.nih.gov/pubmed/25935427

[15] http://orfe.princeton.edu/~alaink/SmartDrivingCars/Papers/IIHS-CicchinoEffectivenessOfCWS-Jan2016.pdf

[16] https://www.regulations.gov/document?D=NHTSA-2011-0066-0011

- €47–62 (Camera-based system that shares technology between four systems: AEB, LKA, ISA, AEB-PCD. The total cost for components (camera, ECU, brackets, trim, wiring) and OEM design and development, tooling costs, etc. was estimated at €186–249, based on individual costs extracted from (NHTSA, 2012)).
- No specific concerns regarding these values were raised by stakeholders. However, the general comment was made that AEB and/or AEB-PCD were likely to be implemented in a radar-based version, which would reduce the number of camera-based measures sharing the cost. Nevertheless, camera-based AEB and AEB-PCD systems are available and could be the most cost-efficient implementation.

Table 5: PESTLE analysis for AEB

Autonomous Emergency Braking (AEB)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	EU benefits of saving fatal, serious and slight casualties and overall reduction in casualties	n/a
	Potential for harmonisation of technical requirements across regions and between OEMs	
Economic	AEB helps prevent collisions, thus saving road closures and congestion leading to increase in productivity	Increased vehicle development and OEM compliance cost
	Reduction in emergency service requirements	
	Reduced cost to the economy of fatal, serious and slight casualties	
Societal and Safety	Potential for reduction in car insurance premiums (fewer front-to-rear collision)	Increased purchase price of vehicle
	High customer acceptance of this system expected	
Technological	Established technology with multiple technological options to achieve potential performance requirements	n/a
Legislative	n/a	Cost of defining legislative tests
Environmental	n/a	Slightly increased vehicle mass leading potentially to increased fuel consumption and CO_2 emissions

5.2 Autonomous Emergency Braking for Pedestrians and Cyclists (AEB-PCD)

Autonomous Emergency Braking for Pedestrians and Cyclists (AEB-PCD)

Sensing to detect the presence of pedestrians/cyclists in the path or periphery of the vehicle that can be used to provide a warning signal to the driver and/or can be linked to the automatic braking functionality of the vehicle

Make mandatory for M1 and N1 vehicles (that are derived from M1), coupled with Automatic Emergency Braking (AEB) application:

- 01/09/2024 pedestrian detection for new approved types
- 01/09/2026 pedestrian detection for new vehicles
- 01/09/2026 cyclist detection for new approved types
- 01/09/2028 cyclist detection for new vehicles

Make mandatory for all N1 vehicles 2-year off-set to the above dates.

Notes on measure:

- Pedestrian- and cyclist-capable AEB are both currently available on the market. However, cyclist AEB is only available from a limited number of manufacturers, for example Volvo[17].
- Euro NCAP incentivises pedestrian-capable AEB for cars via their assessment protocol since 2016. Euro NCAP further intends to add cyclist-capable AEB by 2018.
- Transport & Environment reasoned that this measure should also be applied to trucks (N2, N3) because the technology was similar to that for cars (similar cost) and there was potential for additional cost-efficiencies (technology overlap) with already mandatory vehicle-to-vehicle AEB and lane departure warning systems. The Euro NCAP test procedures for cars could provide a basis for truck test procedures.
- The combined positive effects of active and passive safety solutions for pedestrians and cyclists (AEB and VRU airbags) were shown to be larger than the effects of the individual measures added up (Fredriksson & Rosen, 2014)[18], (Edwards *et al.*, 2015)[19], (Fredriksson *et al.*, 2015)[20]. This aspect is considered in more detail under the measure 'Adult Head to Windscreen Area Protection (HED)'.
- Research from Sweden indicates that the level of under-reporting is particularly high for pedal cycle collisions, even when excluding single vehicle collisions (Held, 2016)[21].

[17] https://www.media.volvocars.com/global/en-gb/media/pressreleases/167069/volvo-xc90-receives-top-five-star-rating-in-euro-ncap-assessment

[18] https://www.researchgate.net/publication/267256962_Head_Injury_Reduction_Potential_of_Integrated_Pedestrian_Protection_Systems_Based_on_Accident_and_Experimental_Data_-_Benefit_of_Combining_Passive_and_Active_Systems

[19] https://www.ncbi.nlm.nih.gov/pubmed/26027971

[20] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000051.PDF

[21] http://publications.lib.chalmers.se/records/fulltext/239130/239130.pdf

Therefore, the actual target population for cyclists in this measure in particular could be higher than estimated from CARE and police-reported data.

Considerations regarding potential technical requirements:

- In order for pedestrian and cyclist AEB to achieve the expected results, the systems need to work in low ambient lighting and at high closing speeds. These parameters should be taken into account when designing a type-approval test procedure, otherwise the casualty reductions could be considerably lower (up to a factor of 10) than expected (Rosen, 2013)[22].
- An assessment protocol for pedestrian AEB exists in Euro NCAP. Updates to this procedure will be published early 2017 to include night time testing. The AsPeCSS project for the development of assessment methodologies for integrated pedestrian safety systems concluded in 2014 and the project deliverables are publicly available[23,24].
- An assessment protocol for cyclist AEB has been developed: The CATS project for the development of a testing system for cyclist-AEB systems has concluded in 2016 and the project deliverables are publicly available[25]. Euro NCAP will publish a new test and assessment protocol for AEB cyclist testing early 2017.
- BASt affirmed that accident avoidance was possible only up to a specific speed since the pedestrian or cyclist becomes a relevant target so close to the accident that the time which is available for braking is really low. This was the reason why Euro NCAP performed pedestrian AEB tests only up to 60 km/h and did not require full avoidance for full score for speeds above 40 km/h.
- Stakeholders suggested that legislative requirements:
  - Should be discussed at UNECE level and that global harmonisation was desirable.
  - For small-volume vehicle manufacturers an exemption should be granted (because it was costly and complex to introduce; note that other stakeholders contested this view on the basis that there were off-the-shelf solutions available).
  - For ultra-small-volume vehicle manufacturers an exemption should be granted.
  - Should also cover avoidance of false-positive activation. This was particularly relevant for this measure because pedestrian movement was more erratic than vehicle movement, and this would make it easy to design a system that performs well under test but at the cost of many false-positive activations.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: ISA, DDR, HED
- Overlaps in technology to consider: ISA, LKA, AEB (camera-based systems)

[22] http://www.ircobi.org/wordpress/downloads/irc13/pdf_files/71.pdf

[23] http://www.aspecss-project.eu/mainmenu/home.html

[24] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000358.PDF

[25] https://www.tno.nl/en/focus-area/urbanisation/mobility-logistics/safe-mobility/cats-cyclist-aeb-testing-system-development/

Main impacts:

- Positive:
  - Casualty reduction – reduction of pedestrian and cyclist injury frequency and severity due to reduced vehicle impact speeds and avoidance of collision.
  - Competitive edge for EU companies, which have already implemented pedestrian and cyclist detection systems in production vehicles, creating new jobs.
  - Increase the perceived VRU safety of cars, thereby encouraging cycling and walking as an alternative to car use – improving the health of the population and reducing emissions due to reductions in car journeys.
  - Increase equitable treatment of VRUs in vehicle safety legislation.
  - Potential for reduction in car insurance premiums, because of lower payouts to injured parties due to mitigation of head injuries.
- Negative:
  - Increased OEM cost and purchase price of vehicles.
  - Cost of defining legislative tests.

Assessment of available body of evidence:

- There were 22 articles included for a detailed quality assessment, of which all but one were research-related articles. Of these 22 articles, only two had data relating to the costs of the technology, whilst 21 articles had data related to the benefits. There were also a large number of articles, not included in this analysis, which presented accident data for a particular region. No longitudinal cost-benefit analyses were found, although a number of articles used benefit data to evaluate the break-even costs for the technology, such as Edwards *et al.*, 2014[26].

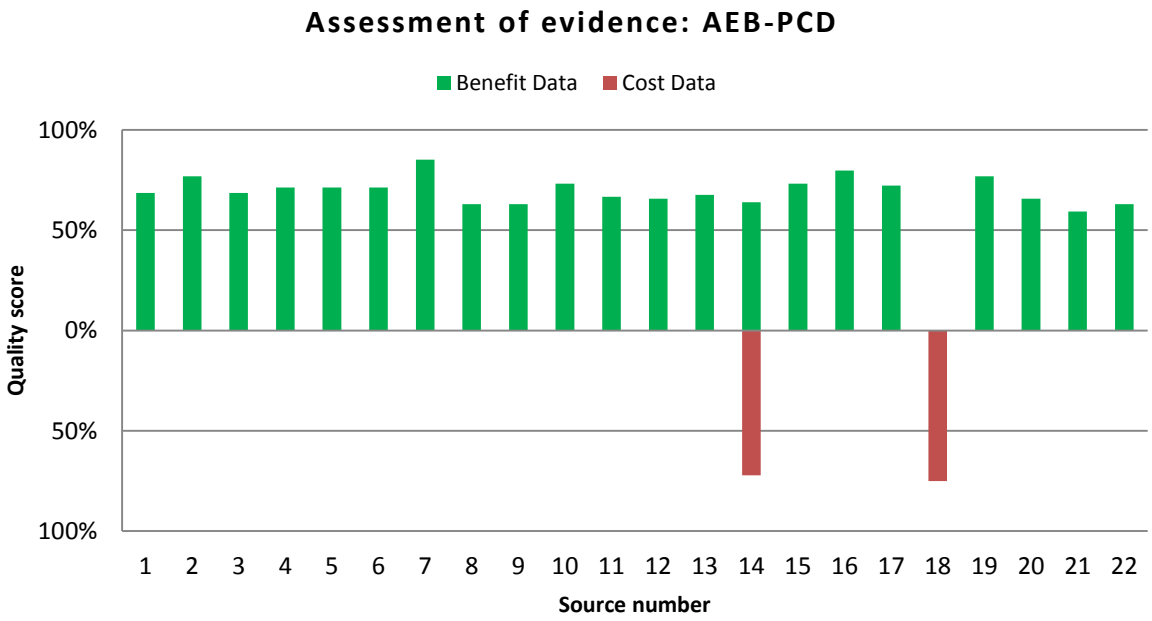


Figure 11: Level of available evidence for AEB-PCD

[26] https://www.ncbi.nlm.nih.gov/pubmed/25307384

- The key conclusions of this research are that there is very little information relating to the costs of this technology and, when this information is presented, this data is often out-of-date. Due to the paucity of information on costs, no longitudinal cost-benefit analyses have been performed and the current state-of-the-art in research provides analyses of the break-even costs for this technology to provide a net benefit to society. It is also important to note that all research had at least one limitation that affected the quality of the approach.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database, scaled-up national data from member states' police records and in-depth data to extract values based on description of target population.
  - Combined with:
    - Rosen (2013) Autonomous Emergency Braking for Vulnerable Road Users[27]
    - Edwards *et al.* (2014) Estimate of potential benefit for Europe of fitting Autonomous Emergency Braking (AEB) systems for pedestrian protection to passenger cars[28]
    - Uittenbogaard *et al.* (2016) CATS Deliverable 1.2: CATS car-to-cyclist accident scenarios[29]
- Fleet penetration:
  - No sources identified; suggest to purchase fitment data from a specialised market analysis provider.
- Benefit data:
  - Rosen (2013) Autonomous Emergency Braking for Vulnerable Road Users
- Cost data:
  - NHTSA (2012) Cost & Weight Analysis of Forward Collision Warning System (FCWS) and Related Braking Systems for Light Vehicles[30]

No concerns regarding these sources were raised by stakeholders.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Pedestrian and cyclist casualties in impacts with car/van front'

[27] http://www.ircobi.org/wordpress/downloads/irc13/pdf_files/71.pdf

[28] https://www.ncbi.nlm.nih.gov/pubmed/25307384

[29] http://publications.tno.nl/publication/34622250/cNYv1h/TNO-2014-R11594.pdf

[30] https://www.regulations.gov/document?D=NHTSA-2011-0066-0011

- Fleet penetration:
  - Negligible proportion of M1 and N1 fleet currently equipped (assumption). Euro NCAP will incentivise uptake for M1, which could lead to accelerated increase in fleet penetration.
  - Given the high momentum in fitting AEB to new vehicles it should be considered to purchase accurate fleet fitment data and projections from a specialised market analysis provider for M1 and N1.
- Effectiveness (percentage of target population affected, benefit):
  - M1 Pedestrian detection: 47.8–49.8% (fatal), 41.7–42.4% (serious), based on (Rosen, 2013).
  - M1 Cyclist detection: 52–58% (fatal), 32.2–33.4% (serious), based on (Rosen, 2013).
  - Similar effectiveness for N1 vehicles (assumption, no detailed studies on N1 identified).
  - No concerns regarding these values were raised by stakeholders.
- Cost per vehicle at time of mandatory implementation:
  - €47–62 (Camera-based system that shares technology between four systems: AEB, LKA, ISA, AEB-PCD. The total cost for components (camera, ECU, brackets, trim, wiring) and OEM design and development, tooling costs, etc. was estimated at €186–249, based on individual costs extracted from (NHTSA, 2012)).
  - Stakeholders reasoned that the cost for cyclist AEB was higher than for pedestrian AEB because sensors with wider view angles would be needed. Nevertheless, no specific concerns regarding the range of suggested cost values were raised by stakeholders. However, the general comment was made that AEB and/or AEB-PCD were likely to be implemented in a radar-based version, which would reduce the number of camera-based measures sharing the cost. Nevertheless, camera-based AEB and AEB-PCD systems are available and could be the most cost-efficient implementation.

Table 6: PESTLE analysis for AEB-PCD

Autonomous Emergency Braking for Pedestrians and Cyclists (AEB-PCD)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	VRU casualties not currently reducing as fast as car occupant casualties - increases equitable treatment of VRUs in vehicle safety legislation	n/a
	Encourages the EU to lead developments in this area, with the eventual aim of harmonisation across regions and between OEMs	
Economic	Increases European industry competitiveness as EU companies have demonstrated that production of systems is possible	Increased vehicle development and OEM compliance cost
	Reduction in road closures/congestion leading to increase in productivity	
	Reduced cost to the economy of VRU fatalities and casualties	
	Reduction in emergency service requirements	
Societal and Safety	Reduction in fatalities and serious casualties	Increased purchase price of vehicles
	Potential for reduction in car insurance premiums through reduced collision rates and casualty costs	
	Encourages modal shift to cycling/walking by reducing the perceived risk of cycling/walking	
Technological	Encouraging innovative technologies/R&D	n/a
Legislative	Early legislative stage of technology, so efforts could be made to harmonise with other regions	Cost of defining legislative tests
Environmental	n/a	Slightly increased vehicle mass leading potentially to increased fuel consumption and CO_2 emissions

5.3 Alcohol Interlock Installation Document (ALC)

Alcohol Interlock Installation Document (ALC)

Alcohol interlock devices (AIDs) require a vehicle operator to provide a breath sample or use a touch sensor and prevent the vehicle ignition from operating if alcohol above a pre-defined threshold is detected. It is proposed to take steps to facilitate easier fitment of aftermarket alcohol interlocks to individual future vehicles (e.g. those of previous offenders). Note: It is *not* proposed to make fitment of AIDs mandatory for certain vehicle types.

To comply with CENELEC standard EN 50436, Part 7, OEMs would have to provide an installation document of a defined content and layout that provides the necessary information about the aftermarket installation of an AID into a vehicle (connection schematics, accessibility instructions and recommendations to avoid safety risks).

Make provisions of EN 50436-7 (Alcohol interlocks – Test methods and performance requirements – Part 7: Installation document) mandatory for all M and N vehicles:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- The target group for fitment of AIDs are private vehicles (commonly those of previous offenders who pay for the installation of the device themselves as part of a rehabilitation or driver improvement course in order to retain the right to drive their vehicle) or fleet vehicles (as part of a fleet policy for example for buses, taxis or commercial vehicle fleets).
- Martino *et al.* (2014)[31] report on the EU-wide implementation status of AID fitment schemes: "*Sweden was the first EU country to launch a pilot trial in 1999 which subsequently evolved into a permanent alcohol interlock rehabilitation programme. Regulatory frameworks in this field of application have also been adopted in Belgium, Finland, the Netherlands, Denmark and the United Kingdom, although practical implementation has yet to happen in the last two Member States. Austria, Germany and Slovenia have carried out, or are currently enacting, pilot projects to assess the feasibility of introducing alcohol interlock programmes. France and Finland provide two relevant examples where alcohol interlocks are fitted following legislative mandatory preventive use whereby alcohol interlocks must be installed in all commercial vehicles performing school and day-care transport. Finally, in Sweden, Finland and Germany, alcohol interlocks are also in use on a voluntary basis as a preventive mechanism in commercial vehicles as they are primarily considered to be tools of quality assurance and corporate social responsibility*".
- The UK Department for Transport (DfT) clarified that in the UK there was legislation in the 2006 Road Safety Act allowing AIDs to be deployed, but it had not been brought into force. A pilot of the scheme was run but it did not indicate evidence of

[31] http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/513993/IPOL-TRAN_ET(2014)513993_EN.pdf

behavioural change and there were concerns about the possibility of devices being tampered with.

- RDW clarified that the alcohol interlock programme in the Netherlands had been stopped due to a lack of participants; however, ETSC commented that there were Parliamentary hearings and support for reinstating the programme.
- The increasing complexity of modern vehicles' electronic architecture makes fitment of AIDs increasingly difficult to new vehicles. Implementing the proposed measure would be a step towards maintaining the ability of AID providers to retrofit each vehicle model (maintain the status quo) and to facilitate easier fitment in the future.
- In a scenario where modern vehicles cannot be fitted with AIDs anymore, the positive contributions of current AID fitment schemes would disappear (this means a potential *increase* in alcohol-related collisions if the measure is not implemented).

Considerations regarding potential technical requirements:

- Requirements are defined in EN 50436-7.
- These requirements are supported by ACEA and FIA. ETSC provided their opinion that in addition also the other parts of EN 50436 should be mandated (including Part 4 on a standardised interface). ACEA reasoned that the proposed measure, i.e. an installation document, had the advantage (compared to standardised interface) that it would not allow development of a "standard countermeasure" to skip an alcohol interlock.
- ACEA further suggested including an exemption from the 'all new vehicles' date (year 2022) for vehicles "*where OEMs demonstrate that it is not feasible to install an AID without modification of the E/E architecture*". This could be critical for vehicles with a complex Electrical/Electronic (E/E) architecture, like electric vehicles and plug-in hybrids. ACEA reasoned that the number of vehicles concerned was small, but the cost to adapt the architecture of these models was very high (in the order of hundreds of thousands of Euros or more). See ACEA input in Annex for details.
- SMMT suggested that small and ultra-small-volume vehicle manufacturers could fulfil this requirement (but questioned necessity).

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: AEB, AEB-PCD, FSO, FFW, F94, PSI, SFS, S95, RFT, HED, RUR. Note that the target population for other measures might increase if ALC is not implemented (potential increase in alcohol-related collisions).
- Overlaps in technology to consider: None

Main Impacts:

- Positive:
  - Maintain the possibility to fit AIDs to modern vehicles with complex E/E architecture: Avoid a possible increase in alcohol-related road collisions (casualties, road closures and emergency service requirements) in a scenario where this would not be possible anymore.
  - Enable countries to implement AID programmes that maintain the mobility and participation in the economy and society of rehabilitating drink-driving offenders, while minimising recidivism rates.

- Allow fleet managers to implement fleet fitment policies with a potential to reduce collision rates and insurance costs.

- Negative:
  - Cost to OEM for making the information document available in the required format and proving compliance.
  - Potential of additional cost to OEM, in some cases, to adapt the E/E architecture of the vehicle to enable the possibility to interface an AID.

Assessment of available body of evidence:

- There were eight articles included for a detailed quality assessment. Five of these were research-related articles all of which contained information on the benefits of fitting AIDs, and three of which contained additional cost estimates for AIDs. The remaining three articles were longitudinal cost-benefit analyses for fitting AIDs (in various forms of policy implementation), two of which were applicable to the EU and sufficiently recent to be relevant:
  - ECORYS (2014) Study on the prevention of drink-driving by the use of alcohol interlock devices.
  - Martino *et al.* (2014) Technical development and deployment of alcohol interlocks in road safety policy.

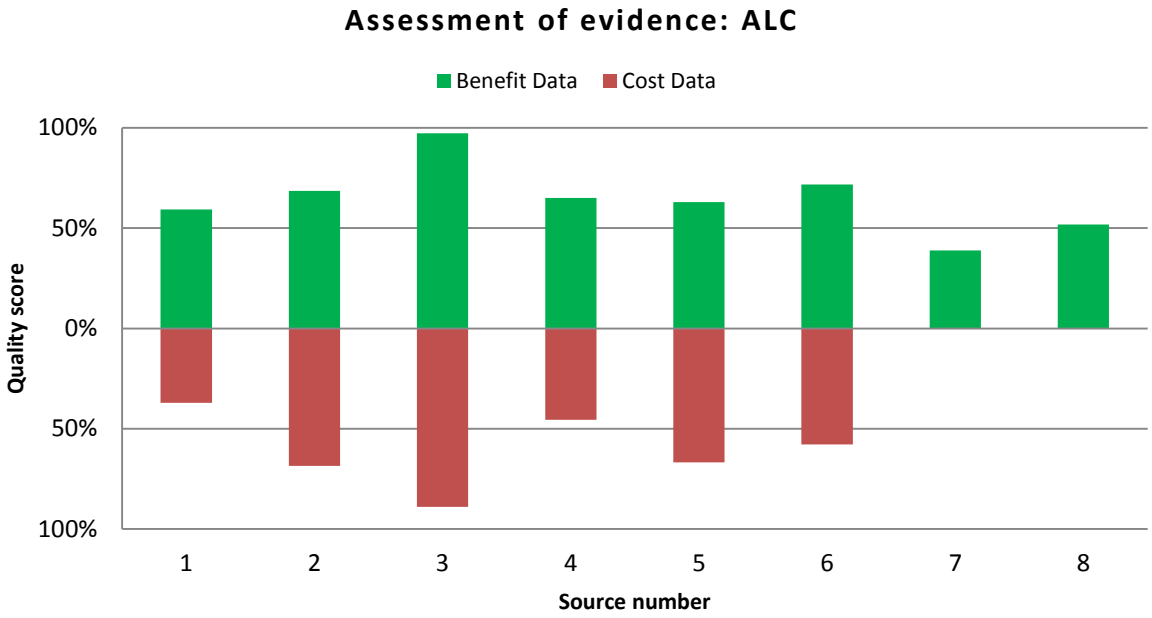


Figure 12: Level of available evidence for ALC

- The key findings were:
  - Installation of AIDs as part of rehabilitation programmes for previous offenders can reduce recidivism rates considerably (Martino *et al.* (2014) estimate a 64–70% reduction), for at least as long as they are installed in the vehicle.
  - ECORYS (2014) and Martino *et al.* (2014) found benefit-to-cost ratios larger than one for implementing various AID fitment programmes across the EU (e.g. in the guise of rehabilitation programmes for previous offenders). The proposed measure is a step to ensuring that such an implementation would still be feasible.
  - ECORYS (2014) also analysed a policy scenario ('Addressing the common technical and operational barriers / Harmonisation of technical aspects'), which is very

closely related to the proposed measure and found a benefit-to-cost ratio favourable of implementation.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Martino *et al.* (2014) Technical development and deployment of alcohol interlocks in road safety policy[32]
  - ECORYS (2014) Study on the prevention of drink-driving by the use of alcohol interlock devices
- Fleet penetration:
  - Martino *et al.* (2014) Technical development and deployment of alcohol interlocks in road safety policy
- Benefit data:
  - Martino *et al.* (2014) Technical development and deployment of alcohol interlocks in road safety policy
- Cost data:
  - No appropriate sources identified for cost of making the information document available in the required format and for adapting the E/E architecture of a vehicle to enable the possibility to interface an AID (where necessary in some cases). Note that (ECORYS, 2014) considered costs for EU harmonisation and exchange of information between member states, but did not include a separate figure for the cost to OEMs of providing the information.

No concerns regarding these sources were raised by stakeholders.

Input values for cost-benefit model:

It is suggested to consider implementing the provisions of EN 50436-7 based on positive cost-benefit results from:

- ECORYS (2014) Study on the prevention of drink-driving by the use of alcohol interlock devices[33]

One of the policy options analysed by ECORYS is closely related to the proposed measure (albeit, EN 50436-7 was not finalised at the time of publication and was therefore not specifically analysed): Policy Option 2 – Addressing the common technical and operational barriers / Harmonisation of technical aspects. This option is described as:

> *"[…] the EU would take an active attitude in overcoming common technical and operational barriers to effective and widespread implementation of alcohol interlock programmes. This could for instance involve taking action for ensuring that retrofitting of vehicles with alcohol interlocks will continue to be possible in the future, also in new car models, and speeding up measures to ensure mutual recognition of driving licence codes."*

[32] www.europarl.europa.eu/RegData/etudes/etudes/join/2014/513993/IPOL-TRAN_ET(2014)513993_EN.pdf

[33] ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/behavior/study_alcohol_interlock.pdf

The benefit-to-cost ratio for Policy Option 2 was found to be 1.8–3.3, and was considered by the authors to be a robust positive result after a sensitivity analysis.

No concerns against this study were raised by stakeholders.

Alternatively, if the implementation of EN 50436-7 shall be analysed in detail, it is suggested to use the following preliminary input values for a cost-benefit model based on the studies referenced above.

- Target population (description):
  - 'Alcohol-related road casualties caused by previously identified drink-drivers or by drivers of commercial vehicles'.
  - Approximately 20–28% of all road fatalities across the EU can be attributed to drink-driving (as of 2012); based on ECORYS (2014).
  - About 1% of the EU-28 driving population are so called "hard-core drink drivers" (based on Martino *et al.*, 2014); term includes repeat offenders and high-blood-alcohol-content offenders. Those identified by the police as such are considered responsible for approximately 75% of alcohol-related road fatalities. Based on Martino *et al.* (2014).
  - It needs to be taken into account that a proportion of "hard-core drink-drivers" is currently already covered by AIDs, which would reduce if the measure is *not* implemented (see Fleet Penetration).
  - No concerns regarding these values were raised by stakeholders.
- Fleet penetration:
  - Approximately 110,000 vehicles across the EU are fitted with AIDs (as of 2014); based on Martino *et al.*, 2014, see Table 3 of source for breakdown by country.
  - Without having access to specific installation information, the development and fitment of AIDs could be impossible for vehicles with a complex E/E architecture in the future. At the proposed time of implementation virtually all new vehicles would feature such complex architecture (assumption).
  - Based on these considerations it could be estimated that the number of vehicles fitted with AIDs would decline in-line with fleet turnover if the proposed measure is not implemented (baseline scenario; assumption). For the action scenario it could be assumed that the fitment rate of AIDs would increase due to increasing implementation of rehabilitation programmes across Europe (assumption).
  - No concerns regarding these values were raised by stakeholders.
- Effectiveness:
  - This measure allows to maintain and/or expand existing programmes (for previous offenders or vehicle fleets) with new vehicles in the future. By *not* implementing the measure the number of alcohol-related casualties might therefore rise; by implementing the measure the current number could be maintained or reduced.
  - The casualty reduction potential for expanding AID installation programmes is estimated to be:
    - Application of EU-wide AID programmes targeting hard-core drink-drivers could reduce annual road fatalities by approximately 7.3% by 2020; based on Martino *et al*. (2014).

    - EU-wide compulsory fitment of AIDs to all commercial vehicles (including passenger transport) could reduce annual road fatalities by 1.3% by 2020; based on Martino *et al.* (2014).
  - No concerns against these values were raised by stakeholders.
- Cost per vehicle at time of mandatory implementation:
  - Negligible cost to OEM for making the information document available in the required format (assumption)
  - No concerns against the assumption of a negligible cost were raised by stakeholders.
  - However, stakeholders reasoned that it would be necessary in some cases to adapt the E/E architecture of a vehicle to enable the possibility to interface an AID. ACEA reasoned that the number of vehicles concerned was small, but the cost to adapt the architecture of these models was very high (in the order of hundreds of thousands of Euros or more). See ACEA input in Annex for details.

The above data indicate that some benefits will be accrued (even though they are difficult to quantify) while implementation costs are assumed to be negligible. On this basis, we recommend that the benefit-to-cost ratio for the ALC measure be considered to be greater than one even though this cannot be quantified precisely at this time.

Table 7: PESTLE analysis for ALC

GENERAL SAFETY REVIEW 2: Alcohol Interlock Installation Document (ALC)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	EU enables countries to implement AID programmes that maintain the mobility of rehabilitating drink-driving offenders, while minimising recidivism rates	n/a
	Fleet operators can be encouraged to fit interlocks if appropriate	
Economic	Allow previous offenders to maintain participation in the economy	Additional cost to OEM for making the information document available in the required format
	Avoid a possible increase in alcohol-related road collisions in a scenario where modern vehicles cannot be fitted with AIDs anymore, thereby avoiding increased congestion and emergency service requirements	Potential of additional cost to OEM, in some cases, to adapt the E/E architecture of the vehicle to enable the possibility to interface an AID
	Potential for reduced insurance cost for fleets equipped with AIDs	
Societal and Safety	Avoid increase in alcohol-related road casualties in a scenario where modern vehicles cannot be fitted with AIDs anymore	n/a
	Allow previous offenders to maintain mobility and thereby participation in society	
Technological	Maintain the possibility to fit AIDs to modern vehicles with complex E/E architecture	n/a
Legislative	n/a	Compliance costs
Environmental	n/a	n/a

5.4 Bus Fire Safety – Automatic Fire Extinguishers (BFS-AFE)

Bus Fire Safety – Automatic Fire Extinguishers (BFS-AFE)

Automatic fire extinguishers (automatic fire suppression systems) for the engine compartment of buses and coaches.

The fitment of automatic fire suppression systems in the engine compartments of M2 and M3 vehicles was included in UN Regulation No. 107:

- For Class III: in Supplement 4 to the 06 series of amendments (not yet applied in the EU)
- For Class I and II: in the 07 series of amendments (not yet applied in the EU)

Make 07 Series of Amendments to R107 mandatory for M2 and M3 vehicles (require automatic fire suppression systems in engine compartment):

- 01/09/2020 new approved types
- 01/09/2022 new vehicles

Notes on measure:

- Automatic fire extinguishers (AFEs) for the engine compartment of buses and coaches are commercially available as off-the-shelf items and are therefore technically feasible. The systems are available with several extinguishing agents which no longer damage the ozone layer.
- Bus fires are reported to be a common issue: In Sweden about 1% of buses burn annually, in Germany about 0.5–1%, according to Försth (2014)[34]. In Finland, there are approximately 5 bus fires per 1,000 registered buses per year (i.e. 0.5%), according to Kokki (2012)[35]. About six bus or school bus fires are reported every day in the USA, according to Rosen (2016)[36].
- Note that bus fires, even those involving casualties and fatalities, are not recorded in road safety statistics unless they were caused by a road traffic collision. This is true for the UK and Germany (DeStatis, 2014)[37] and, to our best understanding, also for other EU member states.
- Försth (2014) reports that losses of lives in bus fires are relatively uncommon (considering their high frequency). Nevertheless, the publication contains a list of 13 examples of bus fires from the past decade with between six and 63 fatalities per case.
- In 2004, Swedish insurers made AFE a prerequisite to cover buses in Sweden. After this introduction there have been no complete vehicle burn-outs due to engine

[34] http://www.sp.se/EN/publications/Sidor/Publikationer.aspx?PublId=32195

[35] http://www.firesinvehicles.com/en/Documents/FIVE%202012/Table%20of%20contents%20FIVE%202012.pdf

[36] https://www.iru.org/sites/default/files/2016-06/rosen-frederik-ros%C3%A9n-expert-bus-safety-sweden.pdf

[37] https://www.destatis.de/DE/Publikationen/Thematisch/TransportVerkehr/Verkehrsunfaelle/VerkehrsunfaelleMonat/VerkehrsunfaelleM2080700161084.pdf?__blob=publicationFile

compartment originating fires (as of 2012). The average cost to insurance companies per fire and the number of high-cost bus fires have reduced considerably since then, as reported by Rosen (2012)[38].

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in 07 Series of Amendments to UN Regulation No. 107.

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: BFS-CNG
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Reduction in fatalities and serious casualties caused by bus fires
  - Increases the safety of bus and coach users and might therefore encourage use of these modes of transport
  - With the addition of fire suppression systems the severity of a potential bus fire should be reduced or mitigated so there is a potential for decreased emergency services costs, road repair costs, and vehicle repair costs
  - Potential for decreased insurance costs
- Negative:
  - Increased cost/price of vehicle
  - Potential for increased service costs
  - Increased development and compliance costs
  - Increased vehicle mass, so potential for increased fuel use and emissions

Assessment of available body of evidence:

- There is a general paucity of research studies in the area of bus safety (compared to areas such as passenger cars). Nevertheless, statistics are available that allow estimating the prevalence of bus fires and particularly of those originating from the engine compartment (target population). Experience from Sweden, cited above, shows a high effect of introduction of AFEs in the fleet.
- No reliable cost information for AFEs could be identified for this review.

[38] https://www.scribd.com/document/323696103/Improving-Fire-Safety-of-Buses-and-Coaches

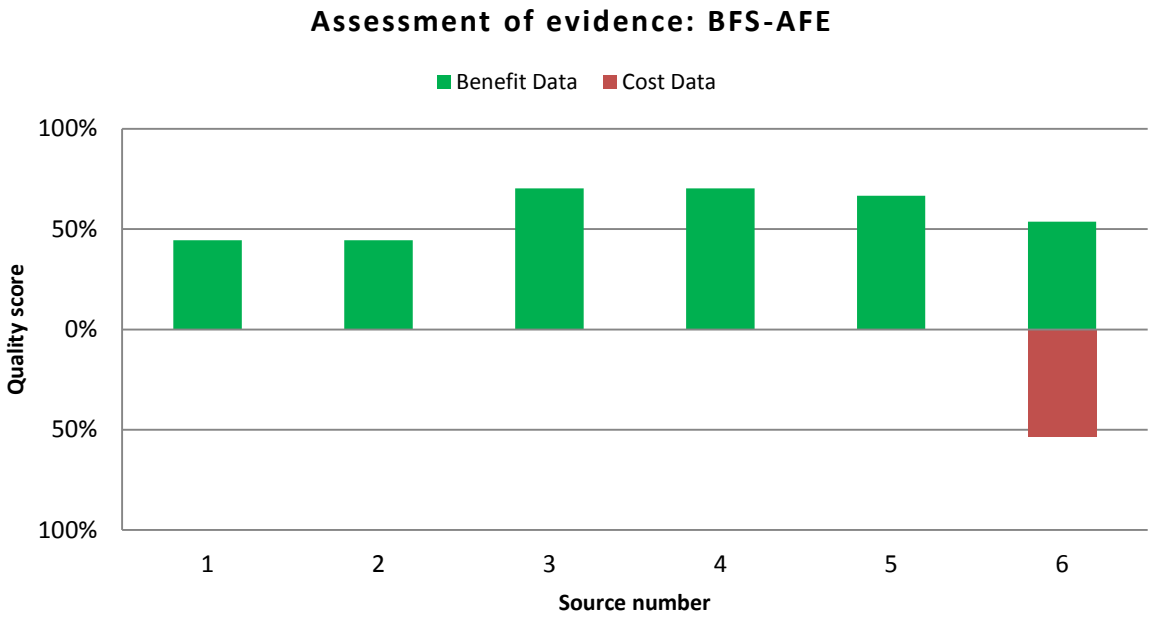


Figure 13: Level of available evidence for BFS-AFE

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use number of registered buses and coaches per country and estimate frequency of bus fires originating in the engine compartment based on the following sources:
    - Försth (2014) Bus fire safety – state of the art and new challenges[39].
    - Kokki (2012) Bus fires in 2010–2011 in Finland[40].
- Fleet penetration:
  - Sweden: Rosen (2012) Improving fire safety of buses and coaches[41].
  - Other EU countries: No sources identified.
- Benefit data:
  - Estimates of the savings to society could be based on the experiences of Swedish insurers as cited in Rosen (2012) Improving fire safety of buses and coaches.
  - No sources for EU-wide benefit data identified.
- Cost data:
  - No sources identified.

No concerns against these sources were raised by stakeholders.

[39] http://www.sp.se/EN/publications/Sidor/Publikationer.aspx?PublId=32195

[40] http://www.firesinvehicles.com/en/Documents/FIVE%202012/Table%20of%20contents%20FIVE%202012.pdf

[41] https://www.scribd.com/document/323696103/Improving-Fire-Safety-of-Buses-and-Coaches

Input values for cost-benefit model:

If an impact assessment is required to implement the 07 Series of Amendments to UN Regulation No. 107, the following preliminary input values for a cost-benefit model are recommended based on the above studies.

- Target population (description):
  - 'Bus and coach fires originating from the engine compartment'.
  - Estimate that 0.5–1% of registered buses and coaches burn annually, based on Försth (2014) and Kokki (2012).
  - Estimate that 60% of these fires originate from the engine compartment, based on Försth (2014).
  - Stakeholders commented that these values appeared high, but did not provide alternative estimates or sources and did not explicitly call into question the validity of the proposed sources.
- Fleet penetration:
  - Sweden: 60% of buses and coaches equipped in 2012, based on Rosen (2012).
  - Other EU countries: Unknown.
  - Stakeholders did not provide additional input on this item. Unless more detailed data becomes available suggest to assume negligible current fleet penetration across EU, except Sweden.
- Effectiveness (percentage of target population affected, benefit):
  - Unknown effectiveness in preventing casualties, but assume effectiveness of close to 100% for preventing fatalities and serious casualties in the relevant fires (assumption).
  - Unknown effectiveness in reducing frequency and cost of relevant fires, but Swedish insurance data suggests very high effectiveness (assumption based on Rosen (2012)).
  - No concerns against these values were raised by stakeholders.
- Cost per vehicle at time of mandatory implementation:
  - If no other information available base estimate on retail prices for aftermarket solutions (e.g. Fogmaker[42]) and apply of a fixed factor to estimate OEM costs (recommended factor: one-third).
  - No cost estimates were provided by stakeholders and no concerns were raised regarding the above suggestion.

[42] http://fogmaker.com/

Table 8: PESTLE analysis for BFS-AFE

GENERAL SAFETY REVIEW 2: Bus Fire Safety – Automatic Fire Extinguishers (BFS-AFE)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Increases the safety of bus and coach users and might therefore encourage use of these modes of transport	n/a
Economic	Encourages industry competitiveness in the manufacture of fire suppression systems	Current aftermarket suppliers might need to adapt their business model
	Fewer, less severe bus fires will reduce road closures/congestion	
	Fewer, less severe bus fires will reduce emergency service requirements	
	Insurance costs may decrease with the installation of fire suppression systems	
Societal and Safety	Reduction in fatalities/serious casualties	Increase in vehicle complexity/maintenance costs
	Decreased risk of damage to surrounding infrastructure, including road surface	Increased purchase price of vehicles
Technological	Encouraging innovative technologies/R&D	
		Increased servicing/maintenance requirements
Legislative	n/a	Increased OEM compliance cost
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass

5.5 Bus Fire Safety – CNG Pressure Relief (BFS-CNG)

Bus Fire Safety – CNG pressure relief (BFS-CNG)

An amendment to UN Regulation No. 110 (R110) has been proposed to regulate the direction of discharging from the pressure relief devices of the CNG containers in buses and coaches. This is intended to minimise the hazard of jet flames originating from the valves causing further damage or harm to people in the vicinity.

Make 02 Series of Amendments to R110 mandatory for CNG-powered M2 and M3 vehicles (regulate CNG gas discharge direction):

- 01/09/2020 new approved types
- 01/09/2022 new vehicles

Notes on measure:

- The changes brought into force by an amended version of R110 for CNG vehicles are based on provisions within Regulation (EC) No. 79/2009 on hydrogen vehicles, which use similar technologies to store and vent hydrogen.
- Studies such as Perette & Wiedemann (2007)[43] and Chamberlain & Modarres (2005)[44] provide general information on CNG bus fire safety.
- Case reports make clear that CNG bus fires can lead to intense jet flames when gas is released through the pressure relief device; see for example Ly (2011)[45], SP Technical Research Institute of Sweden (2013)[46], Dutch Safety Board (2013)[47] and Hemming Fire website (2014)[48]. Ly (2011) and the Dutch Safety Board (2013) emphasise in this context that pressure relief devices should be directed so that any jet flames will not hit other vehicles or persons on the street when activated.
- Because of a paucity of reliable statistical data and research on this specific topic it might be difficult to calculate a benefit-to-cost ratio for this measure. Nevertheless, it is clear from the above sources that relevant incidents do occur that have the potential to cause injury or death to people in the vicinity of the CNG bus (including emergency services), which could be mitigated by implementing the proposed measure.

[43] http://papers.sae.org/2007-01-0430/

[44] https://www.researchgate.net/publication/7865115_Compressed_Natural_Gas_Bus_Safety_A_Quantitative_Risk_Assessment

[45] http://www.cfsinternational.com.au/reports/Enhancing_CNG_vehicle_fire_safety-Dec11.pdf

[46] http://www.arena-international.com/Journals/2015/10/09/f/x/h/Day-2---08-Maria-Hjohlman.pdf

[47] https://www.onderzoeksraad.nl/uploads/phase-docs/398/747435f9a3cbrapport-aardgasbus-en-web.pdf

[48] http://www.hemmingfire.com/news/fullstory.php/aid/2035/Gas-powered_buses__96_hazards_and_evacuation.html

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in 02 Series of Amendments to UN Regulation No. 110.

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: BFS-AFE
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - With the introduction of vertically oriented pressure relief discharge valves there is the potential for reduced risk of:
    - Damage to surrounding infrastructure
    - Injury or death of people in the vicinity of the CNG bus, including emergency services
  - Increase the perceived safety and popularity of CNG and alternative fuel transport, thereby lowering CO_2 emissions
  - Potential for decreased insurance costs
- Negative:
  - Potential for increased development and compliance costs

Assessment of available body of evidence:

- There is a paucity of reliable statistical data and systematic research specific to the redesign of pressure relief devices to ensure safe orientation. However, case reports on relevant cases of CNG bus fires were identified (linked above), which make clear that relevant incidents do occur that have the potential to cause injury or death to people in the vicinity of the CNG bus (including emergency services).
- No sources could be identified that quantify the proportion of CNG buses and coaches which have pressure relief devices directed in any of the directions prohibited by the proposed amendment.
- No information on change of design or manufacturing costs could be identified.

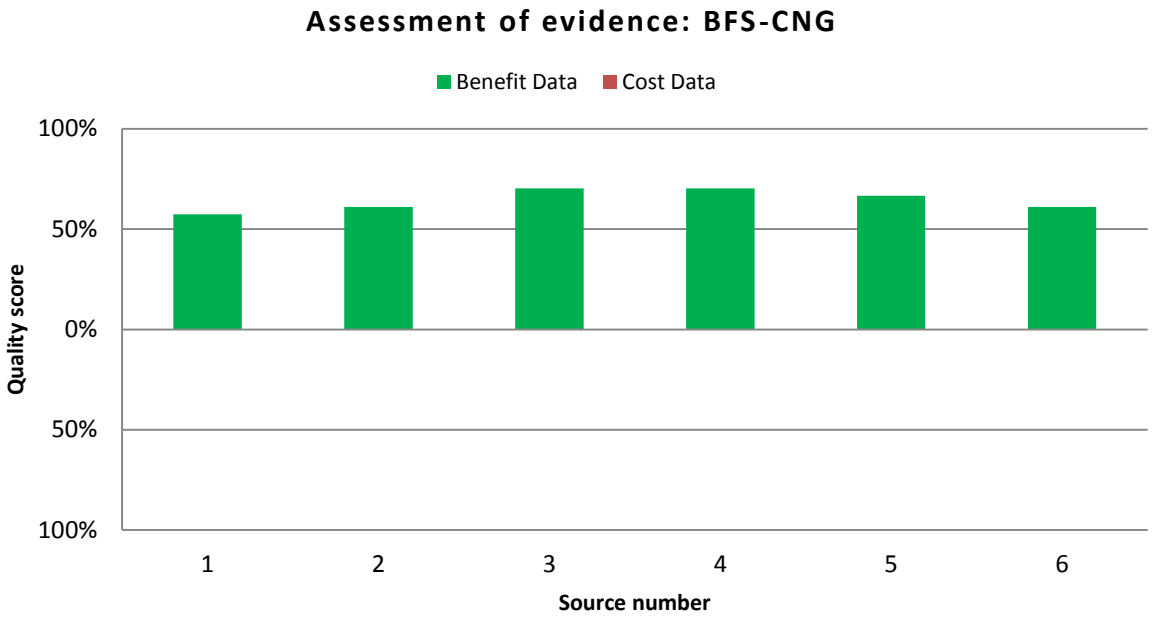


Figure 14: Level of available evidence for BFS-CNG

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Estimate general risk of a vehicle fire for CNG buses from national statistical data about fires and number of registered CNG buses and coaches per country. Take into account the potentially alleviating effect of mandatory installation of automatic fire extinguishers (measure BFS-AFE) in the engine compartment.
- Fleet penetration:
  - No sources identified
- Benefit data:
  - No sources identified
- Cost data:
  - No sources identified

Input values for cost-benefit model:

If an impact assessment is required to implement the 02 Series of Amendments to UN Regulation No. 110, the following preliminary input values are recommended for a cost-benefit model based on the above studies.

- Target population (description):
  - 'CNG-powered buses and coaches that are involved in a vehicle fire and have pressure relief devices directed in any of the directions prohibited by the proposed amendment'.
  - No concerns regarding this description were raised by stakeholders.
- Fleet penetration:
  - Unknown what proportion of CNG buses and coaches has pressure relief devices directed in any of the directions prohibited by the proposed amendment.

- No stakeholder input was received on this parameter.

- Effectiveness (percentage of target population affected, benefit):
  - Assume high effectiveness of the proposed safe design requirements in addressing the specific hazard of jet flames causing injury or death to people in the vicinity of the CNG bus (assumption).
  - No concerns regarding this assumption were raised by stakeholders.
- Cost per vehicle at time of mandatory implementation:
  - Negligible cost for adoption of safe design (assumption).
  - No concerns regarding this assumption were raised by stakeholders.

The above data indicate that some benefits will be accrued (even though they are difficult to quantify) while implementation costs are assumed to be negligible. On this basis, we recommend that the benefit-to-cost ratio for the BFS-CNG measure be considered to be greater than one even though this cannot be quantified precisely at this time.

Table 9: PESTLE analysis for BFS-CNG

GENERAL SAFETY REVIEW 2: Bus Fire Safety – CNG pressure relief (BFS-CNG)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Safe design rule that reduces risk to life and health of people in the vicinity of CNG bus	n/a
Economic	n/a	Potential for increased vehicle development costs
Societal and Safety	Reduced risk of injury or death of people in the vicinity of the CNG bus, including emergency services	n/a
	Decreased risk of damage to surrounding infrastructure, including road surface	
Technological	n/a	n/a
Legislative	n/a	Potential for increased OEM compliance costs
Environmental	Increased perceived safety and popularity of CNG vehicles and alternative fuel transport, thereby lowering CO_2 emissions	n/a

5.6 Drowsiness and Distraction Recognition (DDR)

Drowsiness and Distraction Recognition (DDR)

A system that monitors the driver (directly or indirectly) for signs of drowsiness or distraction and provides a warning.

Development of a technology neutral assessment protocol with several phases to improve the capabilities and effectiveness of the detection systems.

Make mandatory for all M and N vehicles. Application dates to be coupled with Automatic Emergency Braking and Lane Keeping Assist:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- NHTSA have performed extensive research into driver inattention, which includes drowsiness and distraction[49]. Research into the effects of drowsiness and distraction using naturalistic driving data found that drivers engaged in secondary tasks (including talking to passengers) about 23.5% of their driving time (Klauer *et al.*, 2010)[50]. With regard to crash risk the study found that drowsiness and tasks involving eye glances away from the road or button presses increased crash/near-crash risk.
- TRL, TNO and Rapp Trans recently performed a joint study into the wider area of good practices for reducing road safety risks caused by road user distractions for DG MOVE (TRL *et al.*, 2015)[51]. With regard to technology-based countermeasures, the study concluded: "*Systems that operate far in advance of collisions (distraction prevention measures such as phone blocking systems and distraction mitigation measures such as distraction warning systems) are preferred to systems that present warnings regarding impending collisions; however the latter technologies are more mature, and have greater supporting evidence for effectiveness (despite not being solely focused on distraction), making them a better short term alternative for policy focus.*"
- The European Commission is considering an assessment protocol for DDR systems introduced in several phases over which the sophistication of the detection system increases. Different sensor technologies might be required to detect drowsiness, long lasting inattention and long lasting distraction (all three conditions summarised under the term 'attention monitoring'), and situations of short-term inattention and short-term distraction ('advanced distraction monitoring'), respectively. This could be a reason to introduce attention monitoring initially at the above dates and expand requirements later to advanced distraction monitoring.
- ACEA urged that a more precise description of "Drowsiness and Distraction Recognition" was required because this phrase covers a wide range of different aspects.

[49] http://www.nhtsa.gov/Research/Crash-Avoidance/Distraction

[50] http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2010/811334.pdf

[51] https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/behavior/distraction_study.pdf

- For the preliminary input values for a cost-benefit analysis it is assumed that attention monitoring requirements can be fulfilled by indirect detection systems as already offered in some production cars (e.g. via steering wheel input and lane keeping performance). Advanced distraction monitoring would likely require additional research and development and different sensor hardware, independent of driver's steering input, to detect distraction (e.g. via driver-facing sensors).
- Drowsiness detection and warning systems are technically mature and are available in production vehicles.
- Stakeholders pointed out that the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) promotes the fitment fatigue/drowsiness detection systems via subsidies or tax incentives[52].
- Regarding the level of technology maturity of *distraction* detection systems, differing assessments were provided by stakeholders: ACEA provided the opinion that systems were not technically mature yet. Suppliers, on the other hand, provided insight into their system in development and also gave specific examples of direct driver-monitoring systems that are offered in production vehicle already (for example, Lexus Driver Attention Monitor[53]) or will be introduced as OEM-fitted technology with a start of production in late 2017.

Considerations regarding potential technical requirements:

- Euro NCAP has granted awards for Attention Assist systems (drowsiness detection and warning) to two OEMs in the past[54].
- Stakeholders suggested that the requirements should ensure that DDR warning thresholds and intrusiveness will not be irritating for drivers. Early seat belt reminder systems were mentioned as a negative example in this context.
- ACEA pointed out that during the workshop direct (e.g. involving camera technology) and indirect measures (e.g. analysing the steering input on the steering control) were discussed, and stressed in this context that any requirements should remain technology neutral.
- ACEA further mentioned that for future Lane Keeping Assistance Systems (LKAS) requirements were defined to issue warnings if the driver is 'hands-off'. Such requirements should not be in contradiction with any potential DDR requirements. ACEA further questioned whether DDR was required once LKAS and therefore the dedicated requirements were implemented and potentially mandated.
- The importance of DDR could increase with partially automated vehicles where the drivers have to be restricted to performing no (SAE Level 2) or only a limited range of secondary tasks (SAE Level 3). Systems capable of detecting driver distraction might be needed for the approval of automated driving systems, such as Automatically Commanded Steering Functions (ACSF) under UN Regulation No. 79. Stakeholders suggested to consider aligning timescales of distraction recognition requirements for conventional cars with the development timescales of Level 3 automation.

[52] http://www.mlit.go.jp/report/press/jidosha02_hh_000205.html

[53] http://www.lexus.com/models/LS/safety

[54] http://www.euroncap.com/en/vehicle-safety/the-rewards-explained/attention-assist/

- ACEA pointed out that 'driver activity recognition' in the context of automated driving is being addressed by dedicated groups under the UNECE framework, handling the issue of vehicle automation.
- SMMT reasoned that small-volume vehicle manufacturers may fulfil this measure (but expected high cost for calibration and testing with limited benefit given the specific types of vehicles); for ultra-small-volume vehicle manufacturers an exemption should be granted.

Overlaps in benefits and technology:

- Technology cluster: Driver Assistance
- Overlaps in benefits to consider: AEB, AEB-PCD, ESS, LKA, FSO, FFW, F94, PSI, HED
- Overlaps in technology to consider: Potential to share technology with LKA (for systems based on lane following performance), but other solutions based on steering input are possible

Main impacts:

- Positive:
  - Casualty/fatality reduction – reduction of injury frequency and severity due to reduced risk of being drowsy or distracted at the wheel
  - Competitive edge for some EU OEMs and Tier One suppliers, which have already implemented DDR systems in production vehicles
  - Potential for decreased insurance costs, because of reduced payouts for collisions caused by driver drowsiness or distraction
- Negative:
  - Increased cost/price of vehicle
  - Potential for increased service costs
  - Increased development and compliance costs
  - Drivers may regard the system as a 'safety net' that enables them to drive for longer when tired

Assessment of available body of evidence:

- There were nine articles included for a detailed quality assessment, of which seven were research-related articles and three were cost-benefit-related studies.
- There are two high-quality cost-benefit studies for drowsiness detection and warning systems: (eIMPACT, 2008)[55], (ECORYS, 2006)[56]. However, the uncertainties in the calculations regarding system effectiveness and cost remain high. There is little to no cost or benefit information regarding driver distraction detection systems.
- Note that there is no high-quality evidence of the effectiveness of driver warning systems from retrospective studies. The cost-benefit studies suggest estimates about effectiveness but it is unclear how big the effect of these systems would be in real-

[55] http://www.transport-research.info/sites/default/files/project/documents/20130401_142048_96275_eIMPACT_D6_V2.0.pdf

[56] http://www.roadsafetyobservatory.com/Evidence/Details/10803

world use. Moreover, there are concerns that drivers may rely on these systems and take more risk/shift responsibility for recognising fatigue (Jackson et al., 2011)[57].

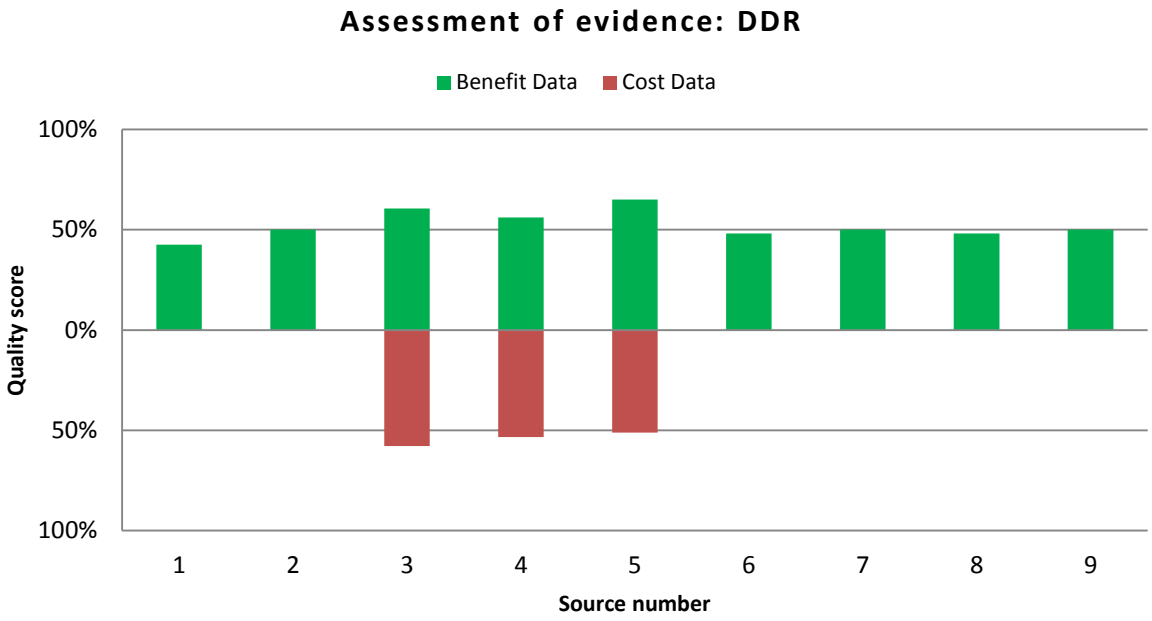


Figure 15: Level of available evidence for DDR

- Information on numbers of collisions involving distraction or drowsiness, types of vehicles involved and resulting fatal and serious injuries can be found and would be useful for cost-benefit analysis.
- There is no information on the cost to develop suitable assessment protocols and testing procedures for the detection systems.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database, scaled-up national data from member states' police records and/or in-depth data to extract values based on description of target population. Combined with:
    - Klauer *et al.* (2006) The 100-Car Naturalistic Driving Study, Phase II - Results of the 100-Car Field Experiment[58].
    - NHTSA (2009) An Examination of Driver Distraction as Recorded in NHTSA Databases[59].
    - Jackson *et al.* (2011) Fatigue and Road Safety: A Critical Analysis of Recent Evidence[60].

[57] http://webarchive.nationalarchives.gov.uk/20121105134522/http://assets.dft.gov.uk/publications/fatigue-and-road-safety-a-critical-analysis-of-recent-evidence/rswp21report.pdf

[58] http://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/Crash%20Avoidance/Driver%20Distraction/100CarMain.pdf

[59] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811216

    - Kühn and Bende (2015) Analysis of car accidents caused by unintentional lane departure[61].

- Fleet penetration:
    - Purchase fitment data from a specialised market analysis provider.
- Benefit data:
    - ECORYS (2006) Cost-benefit assessment and prioritisation of vehicle safety technologies[62].
    - Wilmink *et al.* (2008) eIMPACT Deliverable D4 - Impact assessment of Intelligent Vehicle Safety Systems[63].
    - Euro NCAP (2011) Ford Driver Alert[64].
- Cost data:
    - NHTSA (2012) Cost & Weight Analysis of Forward Collision Warning System (FCWS) and Related Braking Systems for Light Vehicles[65].
    - Baum *et al.* (2008) eIMPACT Deliverable D6 - Cost-Benefit Analyses for standalone and co-operative Intelligent Vehicle Safety Systems[66].

No concerns against these sources were raised by stakeholders. Note that the sources regarding target population were added after the stakeholder consultation based on stakeholder input.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

<u>Attention monitoring (i.e. detection of drowsiness, and long lasting inattention and distraction manifest in steering behaviour patterns):</u>

- Target population (description):
    - 'Injurious collisions, where drowsiness, long lasting inattention or long lasting distraction was a main contributory factor'.
    - The terminology of 'attention monitoring' was introduced after the stakeholder consultation. Previously, the term 'drowsiness detection' was used.
    - Additional sources that can support target population estimations:
        - Jackson *et al.* (2009) quote frequencies of contributory factor 'fatigue', as noted by the police in Great Britain, ranging from 1.8–11.5% for fatal collisions of the

[60] http://webarchive.nationalarchives.gov.uk/20121105134522/http://assets.dft.gov.uk/publications/fatigue-and-road-safety-a-critical-analysis-of-recent-evidence/rswp21report.pdf

[61] https://udv.de/system/files_force/tx_udvpublications/car_51_analysis_of_car_accidents_0.pdf?download=1

[62] http://www.roadsafetyobservatory.com/Evidence/Details/10803

[63] http://s3.amazonaws.com/zanran_storage/www.eimpact.info/ContentPages/2469472028.pdf

[64] http://www.euroncap.com/en/ratings-rewards/euro-ncap-advanced-rewards/2011-ford-driver-alert/

[65] https://www.regulations.gov/document?D=NHTSA-2011-0066-0011

[66] http://www.transport-research.info/sites/default/files/project/documents/20130401_142048_96275_eIMPACT_D6_V2.0.pdf

relevant vehicle categories and severities (see Table 3.1. of the report for different vehicle categories and injury severity levels). This likely represents an underestimate of the actual target populations because fatigue is a contributory factor that is difficult to detect after a collision.

  - Driver drowsiness was a contributory factor in 20% of all crashes in US naturalistic driving experiments in the US, based on Klauer *et al.* (2010).

- Fleet penetration:
  - Unless additional data is provided by stakeholders after publication of this report, it should be considered to purchase fleet fitment data and projections from a specialised market analysis provider.
- Effectiveness (percentage of target population affected, benefit):
  - A European OEM assumed an effectiveness of one third (33.3%) of the relevant target population for drowsiness, based on Euro NCAP (2011).
  - According to estimates by Wilmink *et al.* (2008), drowsiness monitoring and warning systems could reduce *all* road fatalities by 1.5–7.0% and all injured road casualties by 1.0–4.9% (at full fleet fitment in passenger and commercial vehicles; absolute proportion, not related to target population). ECORYS (2006) assumed casualty reductions of 5-15% across all injury severity levels at full fleet fitment.
  - Propose to apply an effectiveness value covering the above range of estimates for drowsiness monitoring to all vehicle categories. Note that these values represent estimates and are not based on retrospective field data (see comments above).
  - Stakeholders did not raise specific concerns regarding these values, but some stakeholders commented that there was no evidence of existing systems' benefits in real-world use.
  - It is reasonable to assume that there will be benefits for situations of long lasting inattention and distraction, but there are no sources available to quantify these effects.
- Cost per vehicle at time of mandatory implementation:
  - €8–10 (assumption that detection is based on existing sensors, such as steering wheel input; cost assigned for a separate display, based on NHTSA (2012)).
  - No concerns regarding these values were raised by stakeholders for passenger cars/vans.
  - Confidential costing information received from OEMs for N2 and N3 vehicles suggests, however, that the costs could be much greater than these estimates. Stakeholders did not have a chance to comment on this information. A smaller effect of economies of scale in these categories (smaller production volume) might be the reason for this.

<u>Added advanced distraction monitoring (i.e. inattention and distraction manifest in short-term driver behaviour such as unsafe gaze direction):</u>

- Target population:
  - 'Injurious collisions, where drowsiness or distraction was a main contributory factor'
  - No concerns against this description were raised by stakeholders.
  - Additional sources that can support target population estimations:

        - NHTSA (2009) quotes estimates that driver distraction might contribute to 16% of fatal collisions, 21% of all injurious collisions or 22% of all collisions in the US.
        - 26% of injurious collisions involving unintentional lane departure in Germany were by distraction or inattentiveness, based on Kühn & Bende (2015).
- Fleet penetration:
    - Currently negligible for all vehicle categories (assumption).
    - No concerns were raised regarding this assumption by stakeholders.
- Effectiveness (percentage of target population affected, benefit):
    - Unknown. TRL and stakeholders could not identify evidence or high-quality estimates of the effectiveness of distraction recognition systems in preventing collisions in the real world.
- Cost per vehicle at time of mandatory implementation:
    - €98–118 (assumption that detection is based on additional driver-facing sensor hardware, based on cost estimates for a drowsiness detection system using a driver monitoring camera in Baum *et al.* (2008)).
    - No concerns against these values were raised by stakeholders for passenger cars/vans.
    - Confidential costing information received from OEMs for N2 and N3 vehicles suggests, however, that the costs could be much greater than these estimates. Stakeholders did not have a chance to comment on this information. A smaller effect of economies of scale in these categories (smaller production volume) might be a reason for this.

Table 10: PESTLE analysis for DDR

GENERAL SAFETY REVIEW 2: Driver Drowsiness and Distraction Detection		
PESTLE	**Positive Impact**	**Negative Impact**
Political	DDR systems have the potential to reduce fatalities	Drivers may rely on these systems and drive for longer than they would without them
	Lead development in this area so more likely to lead any harmonisation initiative	
Economic	Encourages European companies to develop DDR systems	Increased vehicle development costs
	Extra safety features may be appealing to consumers buying new vehicles	
	Fewer, less severe collisions will reduce road closures/congestion	
	Fewer, less severe collisions will reduce emergency service requirements	
Societal and Safety	Reduced risk of injury or fatality	New vehicles may increase in price due to extra technology being added
	Reduction in collisions may reduce damage to road infrastructure (e.g. less HGV collisions into the central reservation due to drivers being alerted to being drowsy)	Detection systems may increase vehicle complexity/maintenance costs
	Drivers will be alerted to their distracted/drowsy state before it become a safety issue	Drivers may rely on the detection systems and drive for longer than they normally would before taking a break.
	Insurance costs may decrease with the installation of the detection systems	
Technological	There are many ways in which detection systems could be implemented and potential for innovative technologies to be developed.	Extra equipment may increase servicing/maintenance requirements
Legislative	n/a	New testing assessments and protocols will lead to legislative/administrative costs.
		Increased OEM compliance and testing cost
Environmental	n/a	Increased vehicle mass leading potentially to increased CO_2 emissions

5.7 Event Data Recorder (EDR)

Event Data Recorder (EDR)

Event data recorders (EDR) record a range of vehicle data over a short timeframe before, during and after a triggering, usually by the deployment of an airbag, caused by a vehicle crash. The EDR stores critical crash-related information such as vehicle speed, state of restraints and braking systems as well as other relevant vehicle data at the time of the collision.

Make EDR mandatory for M1 and N1 vehicles:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- The application of EDR in modern vehicles is not solely about enhancing the data available about collisions – it is also about replacing traditional data sources that new technologies are eliminating (e.g. skid marks are less often apparent due to ABS).
- EDR or EDR-like data is already being recorded in nearly all new EU market M1 and N1 vehicles, which clearly demonstrates technical feasibility. As a result, most of the cost has already been spent; therefore, the benefit-to-cost ratio for the M1/N1 category of vehicles should be greater than one if steps are taken to legislate minimum performance requirements, as well as structure of and access to the data.
- It is possible that information governance issues can be addressed by EU legislation (possibly separate to that to specify EDRs and mandate their fitment). Alternatively, fitment could be mandated at the EU level with requirement for Member States to define the conditions for legal access to the data. This would be analogous to the approach that has been taken in the US, where individual States have allowed access for specific roles (e.g. police) and tasks (e.g. collision investigation research). More recently a Federal-level law has also been enacted. NB: it should be noted that many of the potential benefits of EDR can only be realised if the access to data is appropriately defined.
- Measures to harmonise the specifications in order to realise the potentially substantial benefits from EDR data would have long-term benefits for road safety and access to justice. It is difficult to monetise many of these impacts (e.g. access to justice).
- Furthermore, additional benefits could accrue if the EDR specification was updated to ensure coverage of collisions with VRU and the status of active safety and driver assistance systems. Indeed, there is an argument that continuous recording should be required whenever the driver is out-of-the-loop, i.e. monitoring or relying on an automated driving function. As a minimum, recording in VRU collisions should be triggered if a PCD system is fitted.
- FIA reasoned against a mandatory introduction of EDRs, because the direct road safety benefits were unclear/unproven and the fitment might raise privacy issues. Furthermore, FIA pointed to potential issues regarding the reliability of the recorded data: The reliability and robustness of the in-vehicle sensors might not be sufficient to ensure accurate recording throughout the whole lifetime of a vehicle, and OEMs were in control of designing the EDR, which would allow them to influence the outcome of future litigation/warranty cases based on biased design.

- Note that the EDR specification covered under this measure is intended for conventional vehicles. Additional data recording might be required for automated vehicles, which is outside of the scope of this measure and is being discussed at UN level under the term Data Storage System for Automated Driving (DSSA).

Considerations regarding potential technical requirements:

- Current EDR requirements are based on US regulation CFR 49 Part 563. These are unlikely to record data in collisions with VRUs; if pop-up bonnets, pedestrian head airbags, or AEB with pedestrian and cyclist detection are fitted, this could be used to trigger a recording.
- ACEA suggested that legislative requirements should be harmonised with US CFR 49 Part 563. ETSC suggested that additional data recording in collisions with VRUs should be employed to maximise the safety benefits.
- ETSC supported the introduction of EDR and reasoned that other vehicle categories than M1 and N1 should also be included in this measure. Note that heavy vehicles were indeed in scope of the cost-benefit study (Hynd and McCarthy, 2014) cited below.
- Stakeholders suggested that privacy concerns around this measure needed to be resolved. The use of the EDR data needed to comply with the data protection regulation and clarification was required who has access to the data, how the data can be used and for which purpose. Any set of data required to be collected by EDR should not be in contradiction with national legal requirements.
- SMMT suggested for small and ultra-small-volume vehicle manufacturers an exemption should be granted because it would take time and cost to introduce, as systems were currently not available 'off-the shelf', would require 'restraint control module' to monitor and deploy systems (which are not typically fitted).

Overlaps in benefits and technology:

- Technology Layer: Driver Assistance
- Overlaps in benefits to consider: None
- Overlaps in technology to consider: Technology already fitted for EDR similar to Part 563 minimum requirements; potential to use passive safety triggers or pedestrian/cyclist AEB detection to trigger recording to generate additional benefits; potential to record status of active safety, driver assistance and automated driving features if requirements are enhanced.

Main impacts:

- Positive:
  - Improvement of road safety by improving the data available for research on the performance of current safety systems. This could include VRU protection and active safety / automated driving features if EDR requirements are updated.
  - Access to justice using accurate and verifiable collision and pre-collision data
  - Possible positive effects on driver behaviour
- Negative:
  - The main feasibility concerns for EDR fitment relate to the legal and privacy issues of the data and who has access to the data under which circumstances

Assessment of available body of evidence:

- There were nine articles included for a detailed quality assessment, of which six were research-related articles and three were cost-benefit-related studies. Two cost-benefit studies were specific to the EU:
  - ECORYS (2006) Cost-benefit assessment and prioritisation of vehicle safety technologies[67].
  - Hynd and McCarthy (2014) Study on the benefits resulting from the installation of event data recorders[68].

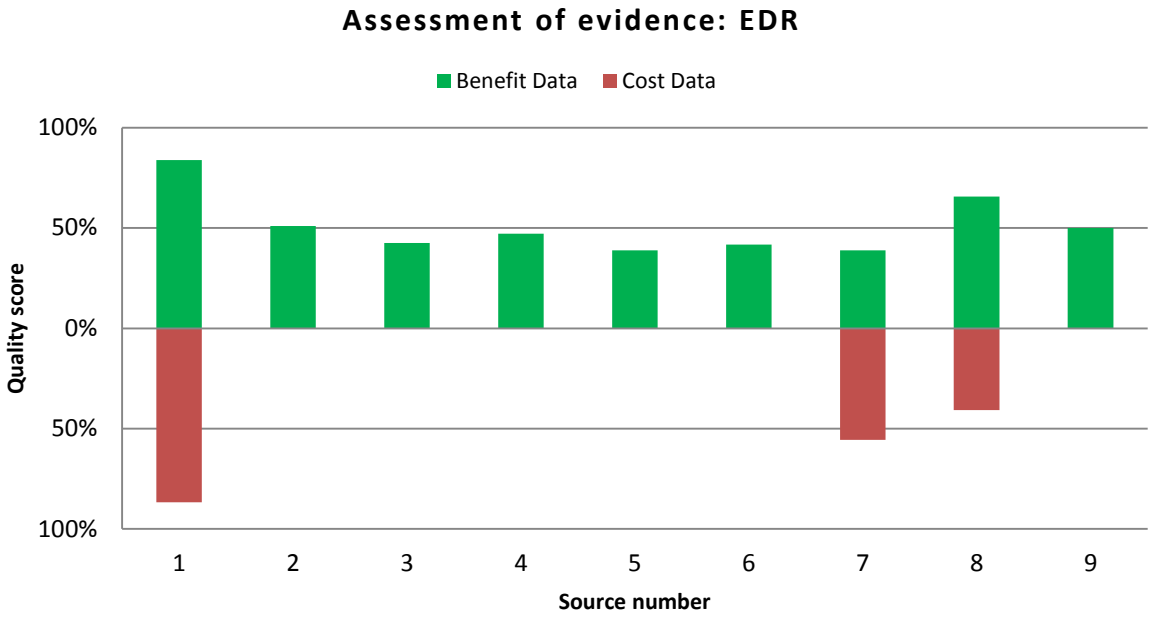


Figure 16: Level of available evidence for EDR

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use EU vehicle fleet records to determine the size of the target population based on the description.
- Fleet penetration:
  - For Part 563-type EDR: Hynd and McCarthy (2014) Study on the benefits resulting from the installation of event data recorders[69].
  - No sources identified for EDR that also trigger from pedestrian protection systems and record status of driver assistance and automated driving functions.

[67] http://www.roadsafetyobservatory.com/Evidence/Details/10803

[68] https://bookshop.europa.eu/en/study-on-the-benefits-resulting-from-the-installation-of-event-data-recorders-pbMI0114866/

[69] https://bookshop.europa.eu/en/study-on-the-benefits-resulting-from-the-installation-of-event-data-recorders-pbMI0114866/

- Effectiveness:
  - Indirect effect on casualties and road safety (ongoing improvements to vehicle design based on real-world data; potential behavioural effects); difficult to quantify.
- Benefit data:
  - Benefits identified, but difficult to quantify and monetise.
- Cost data:
  - For Part 563-type EDR: Hynd and McCarthy (2014) Study on the benefits resulting from the installation of event data recorders.
  - No sources identified for cost to upgrade to EDR that also trigger from pedestrian protection systems and record status of driver assistance and automated driving functions.

No concerns against these sources were raised by stakeholders.

Input values for cost-benefit model:
Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'All M1 and N1 vehicles'
  - No concerns against this description were raised by stakeholders.
- Fleet penetration:
  - 100% of new M1 and N1 (for Part 563-type EDR), based on (Hynd and McCarthy, 2014).
  - Access to data is currently only possible for few vehicle brands in the EU.
  - Unknown fitment rate for EDR that also trigger from pedestrian protection systems and record status of driver assistance and automated driving functions.
  - Stakeholders affirmed that the assumption of full fleet fitment was only valid for Part 563-type EDR.
- Effectiveness:
  - Primary benefits include:
    - Improvement of road safety by improving the data on the performance of current safety systems (which may include occupant restraints, active safety systems, road-side furniture and safety barriers, or road design).
    - Access to justice using accurate and verifiable collision and pre-collision data.
    - Possible positive effects on driver behaviour.
  - Stakeholders commented that there was no evidence of a clear causal relationship between the use of EDRs and an improvement in road safety. TRL acknowledges that the potential effects on driver behaviour have not been examined in detail in research and that the other benefits are difficult to quantify and monetise. Nevertheless, the analytical inference must be accepted that an extended road-safety evidence base created through EDRs has the potential to positively influence vehicle safety design in the future.
- Cost per vehicle at time of mandatory implementation:

- Negligible for Part 563-type EDR; cost already spent (assumption based on Hynd and McCarthy (2014)).
  - Stakeholders affirmed that this assumption was only valid for Part 563-type EDR.
- Unknown for EDR that also trigger from pedestrian protection systems and record status of driver assistance and automated driving functions, but expected to be very low (many current EDR currently do at least some of this voluntarily, but not comprehensively)
  - Stakeholders did not provide more detailed cost data for this item. No concerns were raised regarding the assumption above.

The above data indicate that some benefits will be accrued (even though they are difficult to quantify) while implementation costs are assumed to be negligible for a Part 563-type EDR. On this basis, we recommend that the benefit-to-cost ratio for the EDR measure be considered to be greater than one even though this cannot be quantified precisely at this time.

Table 11: PESTLE analysis for EDR

GENERAL SAFETY REVIEW 2: Event Data Recorders (EDR)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Objective data from EDR can be used in collision research to enhance the performance of vehicles and can provide access to justice for those involved in collisions	Privacy concerns
Economic	Reduced cost of injuries in future vehicle generations	Cost of updating current EDR if current requirements are enhanced for pedestrian/cyclist collisions and automated driving technologies
	More efficient monitoring of the performance of new driver assistance and automated driving technologies	
Societal and Safety	Improvement of road safety by improving the data on the performance of current safety systems (which may include occupant restraints, active safety systems, road-side furniture and safety barriers, or road design)	Safety benefits are at one remove – e.g. EDR data may be used to improve vehicle safety in the next generation of vehicles
	Access to justice using accurate and verifiable collision and pre-collision data	
	Possible beneficial effects on driver behaviour	
Technological	Established technology, available in all new M1 and N1	n/a
	Enhanced EDR may be a suitable mechanism for monitoring the performance of new driver assistance and automated driving technologies	
Legislative	Fitment of and access to EDR will reduce legal costs and bring access to justice	Data privacy requirements and guidance regarding access to data collected from EDR will need to be addressed
	Opportunity to harmonise with or enhance US EDR legislation	
Environmental	n/a	n/a

5.8 Emergency Stop Signal (ESS)

Emergency Stop Signal (ESS)

ESS as permitted in UN Regulation No. 48, Paragraph 6.23:

- Simultaneous operation of all the stop or direction-indicator lamps fitted.
- Lamps flashing in phase at a frequency of 4.0 ± 1.0 Hz (filament light sources: 4.0 +0.0/-1.0 Hz).
- Activated automatically when the vehicle speed is above 50 km/h and the braking system is providing the emergency braking logic signal (at decelerations above 6 m/s^2 for M1 and N1, and 4 m/s^2 for M2, M3, N2 and N3).

Make ESS mandatory (currently optional) for all M and N vehicles:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- This measure was previously referred to as 'emergency braking display (EBD)'. To be consistent with existing terminology in UN Regulation No. 48 (R48) this is now called 'emergency stop signal (ESS)'.
- Stakeholders requested clarification how trailers would be treated, i.e. whether Category O vehicles would be affected by this measure.
- Particularly in peripheral view the attention-getting capabilities of ESS are superior. It could therefore be speculated that ESS might be increasingly beneficial if following drivers direct their gaze away from the road, e.g. towards a mobile phone.
- ESS protects any following vehicle from a frontal impact, i.e. is also beneficial for the legacy fleet. AEB is therefore not a valid replacement for ESS.
- TRL understands that US regulations currently effectively prohibit ESS using stop lamps: It is not allowed to flash stop lamps as part of an ESS signal (noting that US regulations generally allow flashing red stop lamps, but only where the lamps are combined with rear turn signal lamp and limits the use to turn signal indicators).
- Flashing brake lights might have an adverse effect on people suffering from photosensitive epilepsy (PSE), although this has apparently been considered before permitting ESS in UN R48. Consider consultation of experts and/or relevant interest groups before mandating. (GRE, 2003)[70] provides the following information:

  "A study of medical literature on PSE shows the following:

  - The seizure of PSE is closely related with the flashing frequency of the light source. To reduce the risk of the seizure, it is necessary to keep the flashing frequency of the light source to 5 Hz or less, preferably to 3 Hz or less.

  - Red light used in brake lamps is apt to cause PSE seizure.

[70] https://www.unece.org/fileadmin/DAM/trans/doc/2003/wp29gre/TRANS-WP29-GRE-51-09e.pdf

- If the duration of photic stimulation is limited to 2 sec. or less, PSE hardly occurs."

Considerations regarding potential technical requirements:

- Technical requirements for ESS are defined in UN Regulation No. 48, Paragraph 6.23 (currently optional).
- The deceleration thresholds for activation of ESS as defined in the emergency braking logic signal in the braking regulations are 6 m/s^2 for M1 and N1 (UN Regulation No. 13H, Paragraph 5.2.23.) and 4 m/s^2 for M2, M3, N2 and N3 (UN Regulation No. 13, Paragraph 5.2.1.31.). Note that these are minimum thresholds, i.e. activation of ESS only allowed at or above this level. The actual activation threshold is left to the discretion of the manufacturer. It could be considered to standardise an activation threshold for uniform implementation across the field.
- R48 currently allows a choice of using flashing direction-indicator lamps (hazard warning lamps) or flashing stop lamps for ESS. This non-uniformity might become more relevant with rapidly increasing fleet penetration after legislation. The original objective of the informal working group developing these ESS requirements was to define a "single, unique emergency stop signal", but an agreement on this could not be reached. One reviewed study indicated that flashing of direction-indicator lamps could be more effective than flashing of stop lamps (Li *et al.*, 2014)[71]. It could be considered to mandate flashing direction-indicator lamps rather than leaving the choice to manufacturer. ACEA opposed the idea to standardise the signal. Opel reasoned that flashing stop lamps or flashing direction indicator lamps would both convey the necessary information to following drivers because an emergency braking manoeuvre was linked to both, high deceleration (as indicated by stop lamps) and possible danger (as indicated by direction indicators/warning lamps).
- SMMT suggested that small-volume vehicle manufacturers could fulfil this requirement, but ultra-small-volume vehicle manufacturers should be granted an exemption if it requires ABS (but if it used variable brake lights and deceleration sensor it might be possible).
- Stakeholders requested clarification how trailers would be treated, i.e. whether Category O vehicles would be affected by this measure.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: AEB, ISA, DDR, FFW, RUR, RFT
- Overlaps in technology: None (stand-alone, software-based system)

Main impacts:

- Positive:
  - Reduction in rear-end impacts following an emergency braking manoeuvre of leading vehicles
- Negative:
  - Implementation and compliance costs

[71] http://ade.sagepub.com/content/6/792670

Assessment of available body of evidence:

- There were seven articles included for a detailed quality assessment, all of which were research-related articles. No cost-benefit studies were identified.

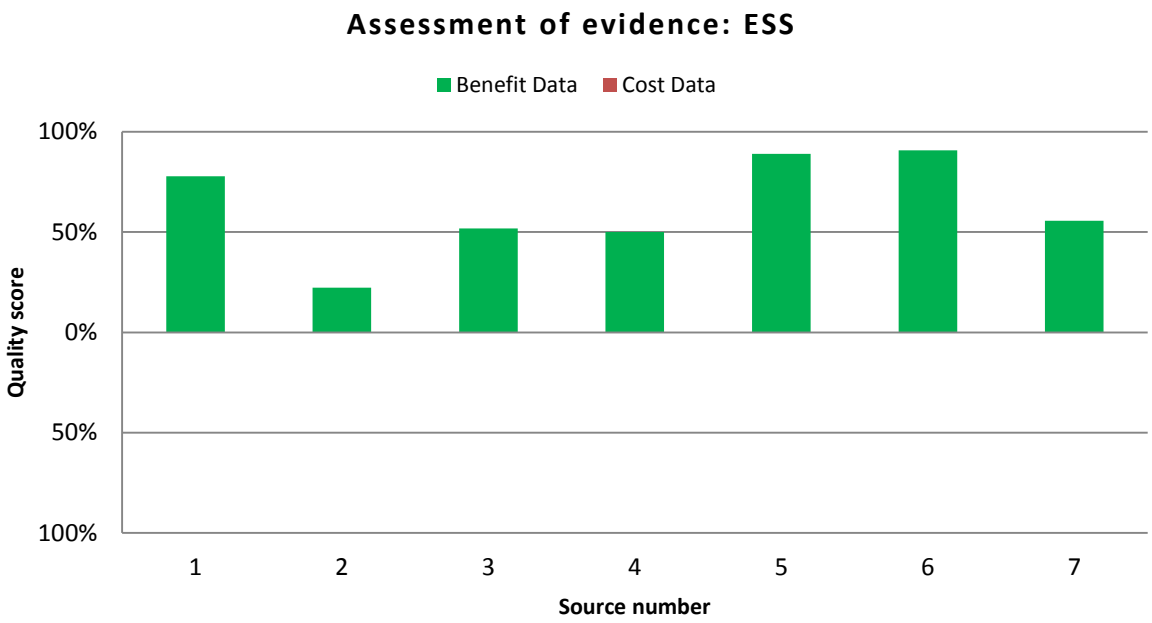


Figure 17: Level of available evidence for ESS

- There is strong evidence from driving simulator studies showing that ESS is effective at reducing brake reaction times of drivers following a vehicle that performs an emergency braking manoeuvre. The studies allow quantification of the magnitude of the reaction time reduction in certain scenarios (e.g. driver is distracted and brake signal is presented in peripheral vision). It can easily be inferred that this will likely translate to reduction or mitigation of collisions arising from this scenario, but a model will be required to transform this into a quantification of casualty savings for Europe.
- There was no data identified related to implementation costs. Costs will arise from implementation on the vehicle CAN bus and validation of the function. No additional sensors required on vehicles.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance:

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to extract values based on description of target population. Use in-depth data to estimate prevalence of crashes after emergency braking manoeuvre.
- Fleet penetration:
  - No sources identified
- Benefit data:
  - Li *et al.* (2014) Effectiveness of Flashing Brake and Hazard Systems in Avoiding Rear-End Crashes[72]

[72] http://ade.sagepub.com/content/6/792670

- Isler & Starkey (2010) Evaluation of a sudden brake warning system: Effect on the response time of the following driver[73]

- Cost data:
  - No sources identified

No concerns against these sources were raised by stakeholders.

Input values for cost-benefit model:
Based on these studies, the following preliminary input values are suggested for a cost-benefit model.

- Target population (description):
  - 'Injurious two-vehicle front-to-rear collisions (that follow an emergency braking manoeuvre of the rear-impacted vehicle with initial speed above 50 km/h)'.
  - No concerns regarding this description were raised by stakeholders.
- Fleet penetration:
  - Negligible proportion of M and N vehicles equipped (assumption).
  - No concerns regarding this assumption were raised by stakeholders.
- Effectiveness (benefit):
  - Brake reaction time reduction of 0.34 seconds (range: 0.03–0.95 seconds) for following vehicle.
  - No concerns regarding this value were raised by stakeholders.
  - Suggest to use a simulation approach to transform this in collisions prevented/ mitigated. This could, for instance, be based on data from the GIDAS pre-crash matrix (PCM) in combination with the PRAEDICO model developed by Autoliv[74].
- Cost per vehicle at time of mandatory implementation:
  - Negligible (assumption, software-based implementation, validation and testing costs, no sensor hardware needed).
  - No concerns regarding this assumption were raised by stakeholders.

The above data indicate that some benefits will be accrued (even though they are difficult to quantify) while implementation costs are assumed to be negligible. On this basis, we recommend that the benefit-to-cost ratio for the ESS measure be considered to be greater than one even though this cannot be quantified precisely at this time.

[73] http://www.sciencedirect.com/science/article/pii/S0003687009001628

[74] https://www.researchgate.net/publication/308937308_Prediction_of_Accident_Evolution_by_Diversification_of_Influence_Factors_in_Computer_Simulation_Opportunities_for_Driver_Warnings_in_Intersection_Accidents

Table 12: PESTLE analysis for ESS

GENERAL SAFETY REVIEW 2: Emergency Stop Signal (ESS)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction in rear-end impacts following an emergency braking manoeuvre of leading vehicles, thereby reducing in-vehicle casualty numbers	n/a
Economic	Reduction in road closures/congestion leading to increase in productivity: The functionality might be particularly effective in preventing crashes on high-speed roads and therefore could reduce congestion (which would result from the collisions prevented) on major carriageways	n/a
	Reduction in emergency service requirements: Reduced casualty numbers	
Societal and Safety	Reduction in fatalities/casualties: Reduction in rear-end impacts following an emergency braking manoeuvre of leading vehicles, thereby reducing in-vehicle casualty numbers	Flashing brake lights may have an effect on people suffering from photosensitive epilepsy (PSE), although this has apparently been considered before permitting ESS in UN R48
	Reduction in property damage: Potential to also reduce these low severity impacts	
Technological	n/a	n/a
Legislative	n/a	Harmonisation of regulation could lead to several variants of the regulation available: TRL understands that ESS are effectively prohibited in US regulations, meaning that this function may need to be deactivated for the US market
Environmental	n/a	n/a

5.9 Regulation 94 Frontal Offset Occupant Protection – Removal of Exemptions (F94)

Regulation 94 Frontal Offset Occupant Protection – Removal of Exemptions (F94)

Currently, off-set impact UN Regulation 94 (R94) is performed only for M1 ≤2,500 kg total permissible mass (i.e. maximum mass), although other vehicles may be approved at the request of the manufacturer.

Expand scope to include all M1 and N1:

- 01/09/2022 new approved types
- 01/09/2024 new vehicles

Notes on measure:

- 'Total permissible mass' is not defined in R94, but is understood to mean the Gross Vehicle Mass, including maximum load due to occupants and luggage.
- Euro NCAP have assessed the frontal crash performance of a selection of M1 passenger- carrying versions of some N1 vehicles, large SUVs and pickups using a 64 km/h ODB test. The good performance in these tests clearly indicates that these N1 vehicles could meet the requirements of R94. (Note that the R94 test has a lower speed of 56 km/h.)
- VTI provided input motivating the development and use of female crash test dummies. The documents included a research review that confirms an elevated injury risk for females compared to males. The specific suggestion made is to use one male and one (average) female dummy on each of the front seats for frontal impact tests. The authors acknowledge that a female average dummy would still need to be developed.

Considerations regarding potential technical requirements:

- Stakeholders raised the concern that UN R94 was specifically limited to 2,500 kg to avoid increasing the front end stiffness of heavy vehicles. Heavy vehicles would bottom out the deformable element and impact the barrier face. Increasing the stiffness of heavy vehicles has been seen as a detriment to compatibility. Note, however, that many of these vehicles will be Euro NCAP tested as well so the actual impact on front-end stiffness in the real-world is unclear.
- Stakeholders commented that all electrically propelled vehicles must already fulfil the impact test requirements of R100 with regard to electrical safety, also those M and N vehicles that are exempted from Regulations R94. Note that R100 does not cover conventional (i.e. petrol- or diesel-powered) vehicles.
- SMMT reasoned that small-volume vehicle manufacturers could fulfil this measure but that ultra-small-volume vehicle manufacturers should be exempt because they are currently using R12.

Overlaps in benefits and technology:

- Technology Layer: Passive Safety Front
- Overlaps in benefits to consider: Target population may be reduced by ISA, DDR, LKA, AEB. SBR might increase the population being potentially protected by this measure.
- No overlaps in technology

Main impacts:

- Positive:
  - Reduction of frontal Impact fatalities and injuries
  - Ensuring minimum protection levels for all M1 and for N1
  - Ensuring that all M1 and N1 meet consumer expectations for frontal crash safety
- Negative:
  - Increased cost/price of vehicle due to the development cost for any vehicles that do not already meet the requirements
  - Compliance costs for vehicles that do meet the requirements despite not being required to
  - Potentially increased vehicle mass, so increased fuel use and emissions, for any vehicles that do not already meet the requirement

Assessment of available body of evidence:

- No specific research- or cost-benefit-related articles could be identified for this measure.
- Euro NCAP results of 17 vehicles whose gross vehicle weight is higher than 2,500 kg were analysed, of which 10 of them were SUV, three were 'Business and Family Vans' and four were 'pick-ups'. These vehicles had adult occupant protection points between 11 and 15.6, indicating that they would very likely meet R94 requirements.

Appropriate sources for input data:

- No specific research- or cost-benefit-related articles could be identified for this measure.
- It should be noted that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly. This study will provide further information on the size of the target population, fleet penetration and potential effectiveness.

Input values for cost-benefit model:

- Target population:
  - Values from TRL/CEESAR study (to be published shortly).
  - Note that a trend over time should be considered accounting for the fact that vehicle mass might increase.
- Fleet penetration:
  - BASt provided data showing that extending the scope to M1 with total permissible mass >2.5 tonnes will affect 6% of the German M1 fleet.
  - Values from TRL/CEESAR study (to be published shortly).
  - Note that a trend over time should be considered accounting for the fact that vehicle mass might increase.
- Benefit data (effectiveness):
  - BASt provided data showing that M1 with total permissible mass >2,500 kg represents 6% of the current M1 fleet, but only 2.4% of M1 occupant fatalities in 2015 in Germany have been occupants of this group (source DESTATIS).

- Values from TRL/CEESAR study (to be published shortly).

- Cost data:
  - No specific values identified.
  - Stakeholders did not provide additional input.

Table 13: PESTLE analysis for F94

GENERAL SAFETY REVIEW 2: Frontal Impact R94 – Removal of Exemptions (F94)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Removal of exemptions for M1 vehicles so that consumers have the minimum level of frontal crash safety that they would expect for a car	n/a
	Expansion of scope to N1 to ensure minimum protection level for van occupants	
Economic	EU Benefits of saving fatal, serious and slight injuries/overall reduction in casualties	Increased cost of vehicles that don't already comply
Societal and Safety	Reduction in the number and cost of fatal and serious injuries	Potentially increased purchase price of vehicles that don't already comply
Technological	The technology required to meet R94 requirements is very well established and understood	n/a
Legislative	n/a	Compliance cost for vehicles that do and don't already meet the requirements
Environmental	n/a	Potential increase of vehicle mass and therefore fuel use and emissions, for vehicles that don't already comply

5.10 Full-width Frontal Occupant Protection (FFW)

Full-width Frontal Occupant Protection (FFW)

Implementation of full-width crash test UN Regulation No. 137 (R137) for M1 and N1:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- R137 test speed is 50 km/h which is lower than the 56 km/h for US FMVSS 208.
- Most current M1 vehicles would meet the R137 requirements without modification.
- Performance of N1 vehicles in this crash test condition is not known; the Euro NCAP heavy vehicles protocol includes M1 variants of vans with 8-9 seats and a gross vehicle mass between 2,500 and 3,500 kg, where the N1 variant as a minimum has optional frontal airbags and seat-belt reminders, but N1 variants are not tested. However, no heavy M1 have been subject to the full-width test to date.
- VTI provided input motivating the development and use of female crash test dummies. The documents included a research review that confirms an elevated injury risk for females compared to males. The specific suggestion made is to use one male and one (average) female dummy on each of the front seats for frontal impact tests (including R137). The authors acknowledge that a female average dummy would still need to be developed. Note that the currently proposed test configuration for R137 includes a small female dummy (5^{th} percentile) on the front passenger seat, which means that the variation in stature between the two dummies is larger than between an average male and the suggested average female dummy.

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in UN Regulation No. 137.
- R137 has a restricted scope of M1 vehicles <3.5 tonnes. Other vehicles (e.g. M1 ≥3.5 tonnes and N1) may be approved according to R137 at the request of the manufacturer.
- Most current M1 vehicles would meet the requirements without modification. To deliver a benefit the following changes are recommended to the test procedure in R137:
  - Introduction of the THOR ATD (which is more biofidelic for thorax injuries, which are the key serious and fatal injury type in full-width collisions) into the test; currently Hybrid III ATDs are specified.
  - Changes to encourage the introduction of adaptive restraint systems, in particular to improve protection of older persons (against thorax injuries) in lower speed impacts.
- ACEA provided the opinion that THOR introduction would require a specific analysis at UN GRSP level to amend R137.
- SMMT suggested that small-volume vehicle manufacturers could fulfil this requirement for vehicles engineered to R94 or US FMVSS208, but ultra-small-volume vehicle

manufacturers should be exempt because it would be expensive to introduce and require destructive testing (currently exempt from under ECSSTA).

Overlaps in benefits and technology:

- Technology layer: Passive Safety Front
- Overlaps in benefits to consider: Target population may be reduced by AEB, ESS, ISA and DDR; increased if ALC not implemented
- Overlaps in technology to consider: No technology clustering with any other measure

Main impacts:

- Positive:
  - Casualty reduction – reduction in frontal impact fatalities and injuries for those vehicles that do not already meet the requirements
  - Casualty reduction – platform for further improvements if the THOR ATD is introduced instead of the Hybrid III ATD
  - Equality of protection – achieve the same standard of protection for all M1 and N1 and guarantee a minimum performance level for consumers
- Negative:
  - Increased cost/price of vehicle due to the development cost for those that do not already meet the requirements
  - Increased vehicle testing costs and compliance costs
  - Increased vehicle mass, so increased fuel use and emissions, for those that do not already meet the requirements

Assessment of available body of evidence:

- Most of the evidence base relates to target population and casualty reduction benefits; two sources had cost and benefit analyses.

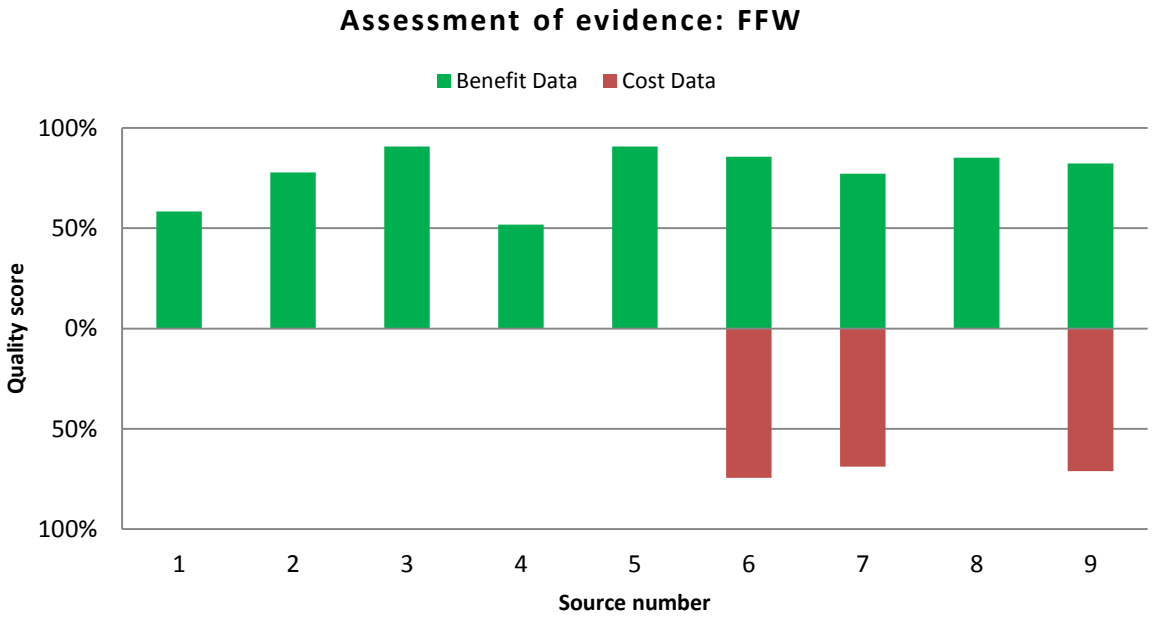


Figure 18: Level of available evidence for FFW

- The key conclusions of a study by Hynd *et al.* (2015)[75] were to include R137, as most of the vehicles already meet the requirements, and include the more biofidelic THOR dummy to make the test more representative.
- The GSR-1 analysis was explicitly limited to M1 vehicles; no new information on N1 vehicles has been identified during this review.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Richards *et al.* (2010) Accident analysis for the development of legislation on frontal impact protection[76].
- Fleet penetration
  - Hynd *et al.* (2015) Assessment of Intended and Unintended Consequences of Vehicle Adaptations to meet Advanced Frontal Crash Test Provisions[77].
- Benefit data:
  - Edwards *et al.* (2013) FIMCAR Deliverable XIII – Cost Benefit Analysis[78].
  - Hynd *et al.* (2015) Assessment of Intended and Unintended Consequences of Vehicle Adaptations to meet Advanced Frontal Crash Test Provisions.
- Cost data:
  - Edwards *et al.* (2008) Cost Benefit Analysis for Introduction of Advanced European Full Width (AE-FW) Test[79].

No concerns regarding these sources were raised by stakeholders.

Stakeholders provided the additional relevant sources demonstrating the usability of THOR and the benefits over the Hybrid III ATD:

- Pipkorn *et al.* (2016) Assessment of an innovative seatbelt with independent control of the shoulder and lap portions using THOR tests, the THUMS model and PMHS tests[80].
- Sunnevång *et al.* (2014) Comparison of the THORAX Demonstrator and HIII sensitivity to crash severity and occupant restraint variation[81].

[75] DOI:10.2769/5101; provided on TRL FTP server

[76] Richards *et al.* (2010) Accident analysis for the development of legislation on frontal impact protection. CPR815. ENTR/05/17.01. Available at: http://www.pedz.uni-mannheim.de/daten/edz-h/gdb/10/report-frontal-impact-protection_en.pdf

[77] DOI:10.2769/5101; provided on TRL FTP server

[78] opus4.kobv.de/opus4-tuberlin/frontdoor/index/index/docId/4547

[79] APROSYS deliverable 123B

[80] http://www.tandfonline.com/doi/full/10.1080/15389588.2016.1201204

[81] http://www.ircobi.org/wordpress/downloads/irc14/pdf_files/42.pdf

- Sunnevång *et al.* (2012) Evaluation of Near-Side Oblique Frontal Impacts Using THOR with SD3 Shoulder[82].
- López-Valdés *et al.* (2014) A Comparison of the Performance of Two Advanced Restraint Systems in Frontal Impacts[83].

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious full-width two-vehicle frontal collisions'.
  - Extract values for different injury severity levels from Richards *et al.* (2010), Tables 5-2 to 5-5, Row '>90% overlap' (unbelted occupants are already excluded from these numbers).
  - Up to 2% of killed road users are N1 occupants (cf. ~50% for M1 occupants).
  - No concerns were raised against this target population definition.
- Fleet penetration:
  - Majority of the M1 fleet already meets the requirement (Euro NCAP and other test results, based on Hynd *et al.* (2015)).
  - Performance of vehicles with 8/9 seats unknown.
  - Implementation would ensure that niche vehicles and those with 8/9 seats are compliant.
  - Performance of the N1 fleet is unknown.
  - No concerns were raised against these values, but stakeholders pointed out that a cost-benefit analysis should consider different vehicles in M1 category (derived from N1).
- Effectiveness (percentage of target population affected, benefit):
  - Vehicle category M1:
    - Proposed R137 test procedure with Hybrid III dummy: Close to zero effect because most new M1 vehicles would already meet the requirements without modification.
    - R137 test procedure with THOR dummy and more stringent injury criteria: Some effect on restraint-related injuries due to higher biofidelity and more stringent criteria. Magnitude unquantified in literature.
    - Test procedure that encourages adaptive restraints: Edwards *et al.* (2013) estimated a 5–11% reduction in restraint-related injuries for M1 occupants.
  - Vehicle category N1:
    - Proposed R137 test procedure with Hybrid III dummy: Unknown.

[82] http://www.tandfonline.com/doi/abs/10.1080/15389588.2014.934367

[83] http://www.tandfonline.com/doi/abs/10.1080/15389588.2014.936410

- R137 test procedure with THOR dummy and more stringent injury criteria: Unknown.
- Test procedure that encourages adaptive restraints: A similar proportion as suggested for M1 may be applicable to N1 (assumption).

- No concerns were raised against the value in relation to adaptive restraints; the other assumptions were taken after the stakeholder consultation phase.
- No additional data for N1 was provided.

- Cost per vehicle at time of mandatory implementation:
  - Edwards *et al.* (2008) estimated €32 (2008 prices) for M1 vehicles that comply with R94 but do not comply with full-width requirements (collapsible steering column, double pretensioner and degressive load limiter). Negligible costs for already compliant M1 vehicles (assumption).
  - Unknown for N1 vehicles.
  - No concerns were raised regarding these values and no additional data for N1 was provided.

Table 14: PESTLE analysis for FFW

GENERAL SAFETY REVIEW 2: Full-width Frontal Occupant Protection (FFW)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Potential reduction of injuries and fatalities	n/a
	Ensuring that N1 performance matches the minimum performance of M1 vehicles	
	Ensuring a minimum performance for vehicles unlikely to be tested by Euro NCAP	
	Some harmonisation with similar requirements in the US, Japan, South Korea, Australia	
Economic	Reduced cost to the economy of full-width frontal collision casualties	Increased cost of vehicle due to additional materials and improved restraint systems
Societal and Safety	Reduction in fatalities/serious casualties	Increased purchase price of vehicles
Technological	Platform for further improvements implementing the THOR ATD	n/a
	Application of existing safety knowledge to N1 vehicles	
Legislative	Platform for harmonisation with other regions if the THOR ATD is introduced	Increased OEM compliance costs
		Increased N1 vehicle development costs
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass (mostly N1)
		Reduced vehicle fuel efficiency due to increased vehicle mass (mostly N1)

5.11 Small Overlap Frontal Occupant Protection (FSO)

Small Overlap Frontal Occupant Protection (FSO)

Test to drive improvements in crashworthiness in small overlap frontal impacts where the major load path is outside the main longitudinal structures. Potential countermeasures such as improved airbag coverage (to mitigate effect of head impact in A-pillar region) and improved passenger compartment integrity could reduce high-cost injuries to head and lower extremities.

Addition of a small-overlap crash test for M1 vehicles:

- 01/09/2022 for new approved types
- 01/09/2024 for new vehicles

Notes on Measure:

- Test to drive improvements in crashworthiness in small overlap frontal impacts where the major load path is outside the main longitudinal structures. This makes it significantly more challenging to design the vehicle to manage the crash energy and maintain occupant compartment integrity. In addition, because the vehicle rotates under offset loading, the occupants move both forward and towards the side of the vehicle during the crash, making it more challenging for the restraint system compared to impacts with higher overlaps in which the occupants move mainly forward only.
- Feasibility for both test and design improvements have been demonstrated by the IIHS small overlap test. This should be the basis of the request for information on this measure.
- ACEA suggest that active safety measures (in particular ESC, LDW/LKA and evasive steering) should reduce and/or mitigate the severity of small overlap impacts. Also in the future, Euro NCAP will introduce assessment of AEB for smaller overlap impacts (50% overlap in addition to current 100% from 2018) and will later include assessment of evasive steering. Both these systems should help further reduce and/or mitigate the severity of small overlap impacts.
- Information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly. This study will provide further and up to date information on the size and nature of the small overlap (~25%) frontal impact problem for cars. Initial conclusions from CEESAR analysis for recent cars in frontal impact against another car are (for more detailed data refer to ACEA input in Annex):
  - Small overlaps represent 14 to 17% of injured belted occupants.
  - Injury severities are slightly lower for small overlaps than for other overlaps.
  - Small overlaps are over-represented in multiple impacts by a factor of two approximately.

Considerations regarding potential technical requirements:

- There are two potential low overlap tests types that could be considered for implementation. These are:
  - The test used by IIHS in their safety rating introduced in 2012.

        - 25% overlap into a rigid barrier at 64 km/h.
    - Tests developed by NHTSA as part of a research programme to develop a test that replicates real-world injury potential in small overlap impacts and oblique offset impacts[84].
        - Mobile Deformable Barrier (MDB) at 56 mph (90 km/h) into stationary vehicle oriented at 7 degrees and with 20% overlap. It should be noted that NHTSA have not reported development work for this test since 2013 and have not made any proposal to introduce it into US NCAP, unlike the oblique test.
        - Note that a similar test with the vehicle orientated at 15 degrees and with 35% overlap was developed for oblique impacts. NHTSA have proposed that this test should be introduced into US NCAP[85].
- There are advantages and disadvantages to each of these types of test. The main advantages of the rigid barrier-type test are that it is simpler and much more experience is available with it. However, it appears that it may encourage designs that glance off the barrier, which may not be desirable. Stakeholders raised the concern that this may increase the incidence of secondary impacts, for example with pedestrians and cyclists on footways and/or with on-coming traffic. In contrast, the MDB test is much more complex, there is little experience with it, although it will probably not encourage designs that glance off due to its small oblique component. Larsson and Bakker (2015)[86] report that the NHTSA MDB low overlap test represents vehicle-to-vehicle low overlaps better than the IIHS rigid barrier test noting that most low overlap impacts (in the US) are vehicle-to-vehicle impacts. They propose that the use of a deformable face for the IIHS test should be considered.
- Testing of both sides of the vehicle may be necessary to assure that countermeasures are fitted to both sides of the vehicle. IIHS recently observed in their tests that the protection in the small overlap test was significantly less on the passenger side of the vehicle compared to the driver side for a substantial proportion of vehicles tested[87].
- The dummy used in chosen test should possess the biofidelity to replicate impact kinematics and be sensitive to the types of injuries seen in small overlap crashes; typically pelvis, hip and femur (Rodney *et al.*, 2011)[88] as well as thorax/head.
- SMMT reasoned for small-volume vehicle manufacturers that this measure would add mass and complexity to the vehicle, making it less attractive to customers and less efficient. Further, that ultra-small-volume vehicle manufacturers should be exempt from this measure because it would be expensive to introduce, and require destructive testing – which they were currently exempt from under ECSSTA.

Overlaps in benefits and technology:

- Technology layer: Passive Safety Front

[84] http://www.nhtsa.gov/Research/Crashworthiness/Small-Overlap-and-Oblique-Testing:-Papers-&-Reports

[85] https://www.regulations.gov/docket?D=NHTSA-2015-0119

[86] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000244.PDF

[87] http://www.iihs.org/iihs/news/desktopnews/vehicles-with-good-driver-side-protection-may-leave-passengers-at-risk

[88] http://www-esv.nhtsa.dot.gov/Proceedings/22/files/22ESV-000384.pdf

- Overlaps in benefits to consider: AEB, LKA, ISA, DDR
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Casualty reduction – Reduction of fatalities and serious casualties in small overlap frontal collisions
  - Some harmonisation with similar requirements in the US (IIHS test/NHTSA test)
- Negative:
  - Increased cost/price of vehicle
  - Increased OEM compliance costs
  - Increased fuel consumption, CO_2 and other emissions due to increased vehicle mass

Assessment of available body of evidence:

- There were eight articles included for a detailed quality assessment, seven of which were research-related articles and one was a cost-benefit study. Note that the cost-benefit study (Edwards *et al.*, 2013)[89] was not focussed on small overlap impacts but contains relevant indications of potential target population.

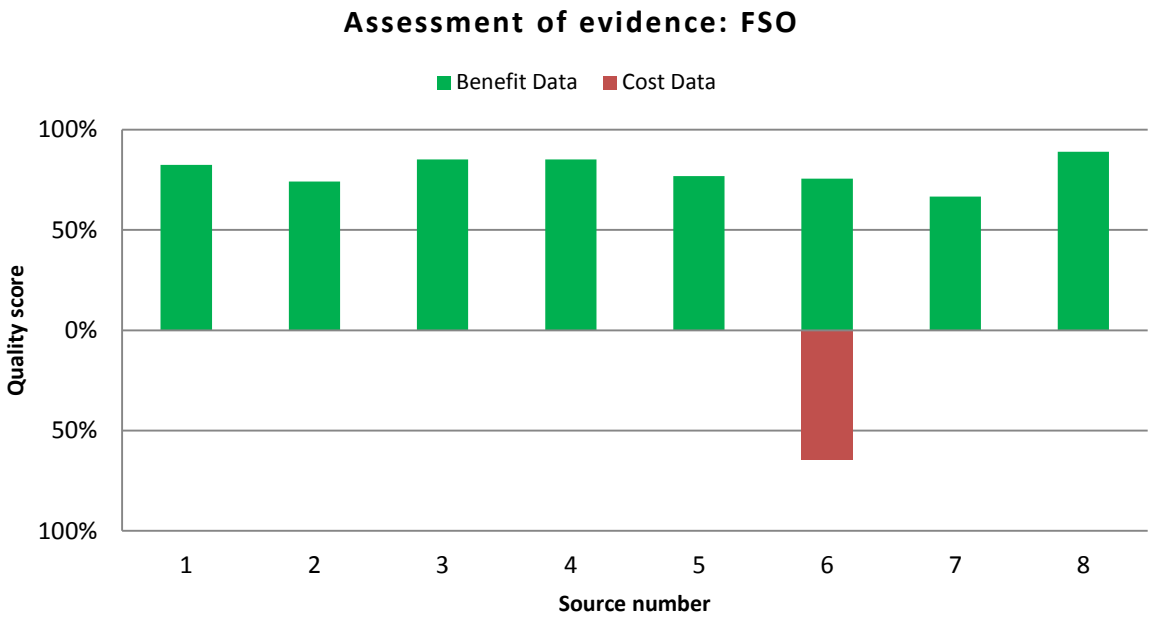


Figure 19: Level of available evidence for FSO

- The information contained within the sources was often not specific to small overlap impacts (with the exception of Richards *et al.* (2010)[90]) and typically identified the target population which was expressed in differing ways and with differing inclusion criteria.
- Further information is required to assess the effectiveness of the measure and the cost impact.

[89] https://depositonce.tu-berlin.de/bitstream/11303/4080/1/FIMCAR_XIII_cost_benefit.pdf

[90] http://www.pedz.uni-mannheim.de/daten/edz-h/gdb/10/report-frontal-impact-protection_en.pdf

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness, and relevance.

- Target population:
  - Use CARE database or scaled-up national data from Member State's police records to extract values based on description of target population. Use in-depth data to estimate the prevalence of small overlap M1 impacts. Combined with:
    - Kühn *et al.* (2013) Small-overlap frontal impacts involving passenger cars in Germany[91].
    - Richards *et al.* (2010) Technical assistance and economic analysis in the field of legislation pertinent to the issue of automotive safety: provision of information and services on the subject of accident analysis for the development of legislation on frontal impact protection[92].
    - Edwards *et al.* (2013) FIMCAR XIII – Cost Benefit Analysis[93].
  - Information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly.
- Fleet penetration:
  - No sources identified
- Benefit data:
  - No sources identified
- Cost data:
  - No sources identified

No concerns were raised by stakeholders against these sources.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious passenger car (M1) frontal impacts in which the main load path is outside the longitudinal vehicle structures'
  - 15% of car accidents based on 3,242 accidents in Germany 2002-2009; 25% of all frontal collisions, based on Kühn *et al.* (2013)
  - ~10% of fatal and MAIS 3+ and MAIS 2+ injured drivers in car-car/LGV frontal impacts (no direct loading of main longitudinal rail), based on Richards *et al.* (2010). In terms of target population Richards estimated that the following for small overlap (no direct engagement of main rail) taking into account that unbelted occupants should not be included in the target population:

[91] https://udv.de/en/publications/compact-accident-research/small-overlap-frontal-impacts-involving-passenger-cars-germany

[92] http://www.pedz.uni-mannheim.de/daten/edz-h/gdb/10/report-frontal-impact-protection_en.pdf

[93] https://depositonce.tu-berlin.de/bitstream/11303/4080/1/FIMCAR_XIII_cost_benefit.pdf

        - Fatalities: 5% of all fatalities in frontal impacts in cars
        - MAIS 3+ surviving: 5% of all MAIS 3+ surviving in frontal impacts in cars.
    - MAIS 2+ surviving: 12% of all MAIS 2+ surviving in frontal impacts in cars, based on Edwards *et al.* (2013). Small overlap target population for cars (M1), selection criteria, belted occupants in front seats, no unbelted occupant behind, no rollover:
        - From CCIS 2000-10; 4% of fatals, 9% of KSI (MAIS 2+).
        - From GIDAS 2000-10; 7% of KSI (MAIS 2+)
    - Small overlaps represent 14 to 17% of all injured belted occupants (based on preliminary CEESAR results; for more detailed data refer to ACEA input in Annex). Further values from TRL/CEESAR study (to be published shortly).
- Fleet penetration:
    - Negligible proportion of European M1 fleet with design that addresses this impact type (assumption; introduction of small-overlap test in US might also improve performance of cars on EU market (spillover effect)
    - No further input was provided by stakeholders and no concerns were raise against these assumptions.
- Effectiveness (percentage of target population affected, benefit):
    - Unknown; potential benefits to head/thorax (improved airbag coverage in A-pillar region) and lower extremities (improved passenger compartment integrity).
    - Consideration should be given to the nature of the injuries in small overlaps compared to other overlaps in terms of their cost.
    - There are currently no quantitative data available for the effectiveness of the measure. Therefore, it could be considered to perform a sensitivity analysis noting the effectiveness of other passive safety measures in the past as a basis.
    - Values from TRL/CEESAR study (potential second phase of the project).
- Cost per vehicle at time of mandatory implementation:
    - Unknown; no further input was provided by stakeholders.
    - It could be considered calculate break-even costs to give an indication of whether or not this measure could be cost-effective.
- Notes:
    - ACEA estimate the mass increase per vehicle to be 20–40 kg in order to achieve compliance.
    - For target population, it is recommended that the values from Richards *et al.* (2010) are used because this work was performed specifically for the purpose of estimating target populations. This should be supplemented with data expected from ACEA.
    - It should be noted that the target populations identified are for small overlaps only, in which the vehicle's main longitudinal rails are not engaged directly (i.e. for IIHS small overlap and NHTSA MDB small overlap type tests). The target population is not appropriate for consideration of the introduction of a test similar to the limited overlap (35%) oblique test proposed by NHTSA for US NCAP, which would likely be quite different.

Table 15: PESTLE analysis for FSO

GENERAL SAFETY REVIEW 2: Small Overlap Frontal Occupant Protection (FSO)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction of fatalities and serious casualties	n/a
	Some harmonisation with similar requirements in the US (IIHS test or NHTSA test)	
Economic	Reduced cost to the economy of small overlap frontal collision casualties	Increased cost of vehicle due to additional materials and improved restraint systems (Coverage of A-pillar with airbags?)
Societal and Safety	Reduction of fatalities and serious casualties	Potential for increased purchase price of vehicles
Technological	n/a	n/a
Legislative	Harmonisation of similar test procedures with US	Cost of defining type-approval requirements
		Increased OEM compliance cost
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass, ACEA estimate in the range of 20 -40 kg per vehicle.

5.12 Adult Head to Windscreen Area Protection (HED)

Adult Head to Windscreen Area Protection (HED)

Considerations for the review of Pedestrian Safety Regulation:

- Extend the adult head impact zone
- Coupled with AEB application; may consider introduction of reduced impact speeds with AEB pedestrian and cyclist detection (for windscreen and A-pillar testing only)

Make mandatory for M1 and N1 vehicles (that are derived from M1); coupled with AEB application:

- 01/09/2024 new approved types
- 01/09/2026 for new vehicles

Make mandatory for all N1 vehicles 2-year off-set to the above dates.

Notes on measure:

- Research by Fredriksson and Rosen (2012)[94], Zander *et al.* (2013)[95] and Otte (2015)[96] shows that, in general, cyclists tend to impact their heads further rearward than pedestrians. Fredriksson and Rosen report an average wrap-around distance (WAD) for pedestrians and cyclists of 193 cm and 226 cm, respectively. Zander *et al.* report that the WAD zone of 2.1 m used in Euro NCAP covers 80% of all pedestrian head impacts but only 65% of cyclist head impacts. An extension of the zone to 2.3 m would cover 80% of cyclist head impacts. It should be noted that WAD in GIDAS, which all these studies used, is measured following the impact points of the VRU from leg impact to bumper to head impact, not in the car's longitudinal direction as in legal and rating test method definitions.
- Fredriksson and Rosen (2014)[97] showed that it is beneficial to combine primary and secondary systems to reduce severe head injury in car to pedestrian crashes. Reasons suggested for this were that an integrated system can combine the advantages of both systems, i.e. a secondary (passive safety) system can provide protection when pedestrian is detected late and it is not possible to brake much. The primary system (active safety) can lower the impact speed to increase the effectiveness of the secondary system, in particular for higher impact speeds (over 40 km/h) which form a high proportion (~70%) of the target population and in which the effectiveness of the passive system becomes limited because the system starts to 'bottom out'.

[94] http://www.ircobi.org/wordpress/downloads/irc12/pdf_files/83.pdf

[95] http://www-esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000180.PDF

[96] http://papers.sae.org/2015-01-1461/

[97] https://www.researchgate.net/publication/267256962_Head_Injury_Reduction_Potential_of_Integrated_Pedestrian_Protection_Systems_Based_on_Accident_and_Experimental_Data_-_Benefit_of_Combining_Passive_and_Active_Systems

- It should be noted that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly. This study will provide further and up to date information on the size and nature of the pedestrian / cyclist to car impact problem.
- ACEA raised concerns regarding technical feasibility/maturity of the technology.
- Stakeholders submitted examples of production vehicles from Volvo[98] and Jaguar Land Rover[99], which are fitted with a windscreen / A-pillar airbag.
- ACEA also identified potential side effects of windscreen / A-pillar airbag. These should be taken into account in the impact analysis and include:
  - Restriction of driver's field of vision.
  - Packaging issues, in particular for smaller vehicles.
- The European Cyclists' Federation (ECF) provided additional evidence in form of a research report[100]. This report highlighted the relevance of windscreen and A-pillar impacts and recommends they should be considered, and concluded that technical solutions were feasible.
- ACEA pointed out other potential counter-measures to mitigate cyclist to car head injury which included:
  - Wearing a helmet.
  - Infrastructure changes to minimise interaction between bicycle and motor-vehicle traffic.

Considerations regarding potential technical requirements:

- Common test conditions for pedestrian and cyclist protection need to be defined, which take into account the issue of the lack of repeatability of head to windscreen impactor tests. A BASt project, due to be published in the near future, has made proposals for modifications to Regulation (EC) 78/2009 to achieve this. These modifications include:
  - An increase in the head test velocity from 35 to 40 km/h.
  - An extension of the test area to include areas such as the windscreen base (maximum of WAD of 2500 mm or upper windscreen frame proposed.)
  - Division of the 'windscreen test area' into a test and monitoring area to avoid the issue of the lack of repeatability for head to windscreen impactor tests. This issue is probably related to the unpredictability of windscreen fracture behaviour.
- SMMT reasoned that small and ultra-small-volume vehicle manufacturers should be exempt from this measure because of the high cost of redesign/implementation.

Overlaps in benefits and technology:

- Technology layer: Passive Safety VRU

[98] http://www-esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000447.PDF

[99] http://www.landrover.co.uk/explore-land-rover/news/euro-ncap.html/295-126962

[100] Schmitt and Muser (2016) Study on Safer Motor Vehicles for Cyclists in the context of the EU Pedestrian Protection Regulations, see Annex of stakeholder contributions

- Overlaps in benefits to consider: AEB-PCD
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Casualty reduction – reduction of pedestrian and cyclist injury frequency and severity, in particular head injury which has high cost.
  - Increase the VRU safety of cars, thereby encouraging cycling and walking as an alternative to car use – improving the health of the population and reducing emissions due to reductions in car journeys.
  - Increase equitable treatment of VRUs in vehicle safety legislation.
- Negative:
  - Increased cost/price of vehicle.
  - Increased development and compliance costs.
  - Increased repair costs in some collisions.
  - Increased vehicle mass, so increased fuel consumption and emissions.

Assessment of available body of evidence:

- There were 10 articles included for a detailed quality analysis, all of which were research-related articles. Three of them contained data relating to costs. Three articles highlighted the benefit of integrated systems, i.e. AEB and passive safety measures. Two of these articles considered the effectiveness of potential AEB, passive and integrated systems.

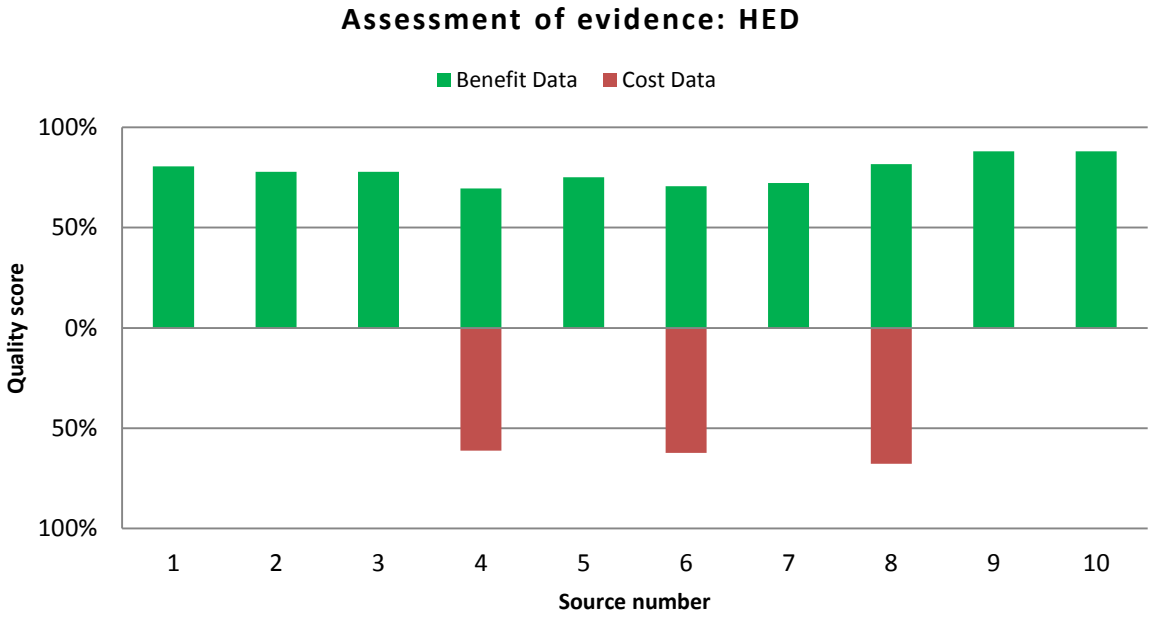


Figure 20: Level of available evidence for HED

- Further research is required to assess the cost impact, although one retail-price figure has been provided by stakeholders for the windscreen airbag fitted to some Volvo cars. Also, further information is required for the real-world benefit for fitment of specific systems, if available, e.g. windscreen airbag fitted to some Volvo cars.

Appropriate sources for input data:
The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled up national data from member states' police records and in-depth data to extract values based on description of target population. Combined with:
    - Rosen (2013) Autonomous Emergency Braking for Vulnerable Road Users[101]
    - Edwards *et al.* (2014) Estimate of potential benefit for Europe of fitting Autonomous Emergency Braking (AEB) systems for pedestrian protection to passenger cars[102]
    - Uittenbogaard *et al.* (2016) CATS Deliverable 1.2: CATS car-to-cyclist accident scenarios[103]
- Fleet penetration:
  - No sources identified.
- Benefit data:
  - Fredriksson and Rosen (2014) Head injury reduction potential of integrated pedestrian protection systems based on accident and experimental data[104]
  - Edwards *et al.* (2015) Assessment of integrated pedestrian protection systems with Autonomous Emergency Braking (AEB) and passive safety components[105]
  - Fredriksson *et al.* (2015) Integrated bicyclist protection systems - Potential of head injury reduction combining passive and active protection systems[106]
- Cost data:
  - Customer retail price of Volvo windscreen / A-pillar airbag and sensing equipment as option to consumer in Japan.

Stakeholders raised certain concerns regarding assumptions taken in the suggested sources (see below).

Input values for cost-benefit model:
Based on these studies, the following preliminary input values for a cost-benefit model are recommended.

- Target population (description):
  - 'Pedestrian and cyclist casualties in impacts with car/van front'.

[101] http://www.ircobi.org/wordpress/downloads/irc13/pdf_files/71.pdf

[102] https://www.ncbi.nlm.nih.gov/pubmed/25307384

[103] http://publications.tno.nl/publication/34622250/cNYv1h/TNO-2014-R11594.pdf

[104] https://www.researchgate.net/publication/267256962_Head_Injury_Reduction_Potential_of_Integrated_Pedestrian_Protection_Systems_Based_on_Accident_and_Experimental_Data_-_Benefit_of_Combining_Passive_and_Active_Systems

[105] https://www.ncbi.nlm.nih.gov/pubmed/26027971

[106] https://www-esv.nhtsa.dot.gov/proceedings/24/files/24ESV-000051.PDF

- No concerns regarding this description were raised by stakeholders.

- Fleet penetration:
  - Negligible proportion of M1 and N1 (derived from M1) fleet currently equipped (assumption). A limited number of Volvo and Jaguar Land Rover M1 vehicles have been equipped with windscreen airbags to date.
  - No concerns regarding this assumption was raised by stakeholders

- Effectiveness (percentage of target population affected, benefit):
  - For Pedestrians hit by M1 vehicles:
    - Based on Fredriksson and Rosen (2014):

      Effectiveness (in relation to severely (AIS 3+) head-injured casualties, i.e. a sub-set of the target population) if introduced without AEB system:

      ~ 30% based on performance of passive system which consisted of a deployable hood and windscreen airbag designed to mitigate head injuries caused by the bonnet area, A-pillars and lower windscreen area where the instrument panel was in close proximity to the windscreen glass.

    - Based on Edwards *et al.* (2015):

      Effectiveness (in terms of reduction of monetary value of injury to target population) if introduced without AEB system:

      ~ 42 to 46 % depending on pedestrian protection level of vehicle system added to. System assumed to cover A-pillars and offer additional protection to these areas at impact velocities between 21 and 51 km/h, reducing HIC at 40 km/h from 6,000 to 400 and proportionally at other speeds according to relationship developed by Searson (2009).

      Effectiveness (in terms of reduction of monetary value of injury to target population) if added to AEB system:

      ~ 34 to 39 % depending on pedestrian protection level of vehicle system added to.

- For cyclists hit by M1 vehicles:
    - Based on Fredriksson *et al.* (2015):

      Effectiveness (in relation to severely (AIS 3+) head-injured casualties, i.e. a sub-set of the target population) if introduced without AEB system:

      ~ 28 to 38% depending on performance of passive system which consisted of a deployable hood and windscreen airbag. The windscreen airbag coverage ranged from hood, lower windscreen and A-pillars (lower end of the effectiveness range quoted) to all of these plus roof front edge (upper end of the effectiveness range quoted).

      Comparison of these effectiveness values from Fredriksson with those for pedestrians indicates that effectiveness of systems for pedestrians and cyclists can be similar. This assumes that the airbag coverage is sufficient for both pedestrian and cyclist head impacts, which in practical terms means that the airbag should protect the hood, windscreen and roof front edge.

- Note that:
  - The above values apply to M1 vehicles. Propose to assume similar effectiveness for N1 vehicles that are derived from M1 vehicles. The effectiveness for other N1 vehicles with a considerably different front-end design (flat front-end) is unknown. Consider, in this context, limiting implementation to car-derived N1 vehicles.
  - Effectiveness in terms of cost will be higher than that in terms of reduction in AIS 3+ injuries because cost model takes into account higher costs of AIS 4 and 5 injuries compared to AIS 3 injury whereas AIS 3+ model does not.
  - ACEA have pointed out that the effectiveness of AEB-PCD has increased compared to the values used in all the studies quoted above.
  - ACEA have pointed out that Edwards *et al*. (2015) is a predictive study and makes a number of assumptions about the performance of the airbag, which by their nature may lead to inaccuracies in the effectiveness estimation. TRL recognise this, but unfortunately no retrospective based studies have been performed, so these are the best data available currently. It should be noted that the airbag performance assumptions were based on information from the Fredriksson papers, which in turn were based on head impactor tests of Autoliv experimental airbags.
  - ACEA have pointed out that the Fredriksson *et al.* (2015) study is based upon a limited number of cases (34).
  - To address the points raised above by ACEA and to help understand and quantify their likely effects on the effectiveness values above, TRL suggests performing a sensitivity analysis on the values used for the effectiveness of the system and the target population (both of which may be reduced by more effective AEB-PCD than assumed in the studies referenced).
- Cost per vehicle at time of mandatory implementation:
  - €170 (windscreen / A-pillar airbag and sensing equipment offered as option to consumer in Japan at a cost of 62,000 yen (approx. €517); OEM cost of €170 estimated assuming approximately one third of consumer cost.)
  - This value was discussed during the stakeholder meeting and no concerns were raised by stakeholders.

Table 16: PESTLE analysis for HED

GENERAL SAFETY REVIEW 2: Adult Head to Windscreen Area Protection (HED)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction in pedestrian and cyclist VRU injuries and fatalities, in particular head injury which has high cost.	n/a
	Increase equitable treatment of VRUs in vehicle safety legislation	
Economic	n/a	System increases cost but penetration in market should lower the cost of the system.
Societal and Safety	EU Benefits of saving serious, fatal and slight injuries/overall reduction in casualties.	Pedestrian / cyclist friendly components may add to the costs
		Additional components could potentially increase the weight of the vehicle
Technological	n/a	n/a
Legislative	n/a	Cost of defining legislative tests
Environmental	Increase the VRU safety of cars, thereby encouraging cycling and walking as an alternative to car use – improving the health of the population and reducing emissions due to reductions in car journeys	Potential increased vehicle mass, so increased fuel consumption and emissions

5.13 Intelligent Speed Assistance (ISA)

Intelligent Speed Assistance (ISA)

ISA describes a range of technologies which are designed to aid drivers in observing the speed limit. The three main forms of ISA are:

- Advisory – alert the driver to when their speed is greater than the speed limit;
- Voluntary – the driver chooses whether the system can restrict their vehicle speed and/or the speed it is restricted to; and
- Mandatory – the driver's speed selection is physically limited by the ISA system.

Make ISA mandatory for all M and N vehicles (to be decided what form of the above):

- 01/09/2020 new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- It needs to be decided what form of system could be mandated: advisory, voluntary or mandatory. Higher intrusiveness may mean higher effectiveness but less public acceptance. For this reason, a pragmatic phased introduction of the measure should be considered.
- ACEA suggested that the intended function should be clarified in more detail before discussing this measure further. PACTS suggested to hold consultations with the police about this measure.
- Systems could be based on maps of speed limits with GPS positioning of the vehicle or traffic sign recognition. The system therefore requires accurate speed information maps and/or adequate road signs. Stakeholders mentioned an 'EU consortium' that dealt with the provision of maps for ITS. Öörni (2016)[107] contains some pertinent information with regard to map coverage.
- Map information would require regular updates and it should be clarified who would be responsible for providing these updates to the vehicles: Would the OEMs or customers bear this cost or would this information be made available, for example from the public agencies? FIA provided the opinion that public authorities and private stakeholders should provide up-to-date maps and speed limit data.
- Euro NCAP incentivises ISA ('Speed Assistance Systems') for cars as part of the safety assist rating.
- TfL will implement mandatory ISA on all London buses (ca. 9,000) within the next years.

[107] http://www.imobilitysupport.eu/library/imobility-support-activities/its-deployment-deliverables/monitoring-priority-systems/deliverables-3/2992-d3-1b-and-d3-2b-deployment-status-of-imobility-priority-systems-effects-database-all-appendices/file

Considerations regarding potential technical requirements:

- The following opinions were submitted by stakeholders with regard to the different forms of ISA, should it be mandated:
  - ACEA argued in favour of advisory-only systems initially.
  - FIA advocates advisory-only systems. Should voluntary systems be legislated, they should be easily switched off by the driver. FIA is not in favour of mandatory (i.e. physically limiting) systems based on the expectation that drivers would not accept those.
  - ETSC favoured: For cars and vans: voluntary systems for that are over-ridable (short-term) but not have an on/off switch. For trucks and buses: Mandatory (i.e. physically limiting) systems.
  - Transport & Environment suggested differentiation between vehicle categories, advocating mandatory, non-over-ridable systems for all trucks buses and vans; and mandatory (i.e. physically limiting), but over-ridable systems for all cars.
  - University of Leeds, Institute for Transport Studies, reasoned that voluntary ISA would provide the best balance between effectiveness (in particular for severe and fatal casualties), technical feasibility and public acceptance, and provided the best benefit-to-cost ratio in the study (Lai *et al.*, 2012) referenced below. Furthermore, customers might prefer voluntary over advisory systems because they provide less annoyance.
- Systems should be required to default to being on, i.e. come on automatically at vehicle ignition on to achieve the effectiveness found in the studies cited below. Effectiveness might be substantially reduced if this is not the case.
- The system should always be easily over-ridden by the driver when necessary, e.g. when overtaking.
- An assessment protocol for ISA exists in Euro NCAP: Speed Assistance Systems as part of the Safety Assist Protocol[108]. Euro NCAP will publish updates to this protocol early 2017, including stronger requirements on quality, robustness, and conditional speed signs.
- SMMT suggested that small-volume vehicle manufacturers should be capable of switching off (for track day use) and that ultra-small-volume vehicle manufacturers should be exempt from this measure because it was more burdensome than for small-volume vehicle manufacturers, given smaller resources and more limited ability to spread costs.

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: AEB, AEB-PCD, ESS, F94, FFW, FSO, S95, PSI, SFS, RFT, RUR, HED
- Overlaps in technology to consider: AEB, LKA, AEB-PCD (camera-based technologies) or existing eCall systems (GPS-based) for M1, N1. VIS (potential to share sensors and/or ECUs with VRU detection cameras) or existing Lane Departure Warning system in N2, N3, M2, M3 (front camera-based system)

[108] http://euroncap.blob.core.windows.net/media/20876/euro-ncap-assessment-protocol-sa-v70.pdf

Main impacts:

- Positive:
  - Casualty reduction – reduction in injury frequency and severity
  - Increase the perceived VRU safety of cars, thereby encouraging cycling and walking as an alternative to car use – improving the health of the population and reducing emissions due to reductions in car journeys
  - Potential traffic calming effect also for non-equipped legacy fleet surrounding an ISA-equipped vehicle
  - Potential for decreased insurance costs, because of lower pay-outs to injured parties due to mitigation of injuries
  - Higher fuel efficiency
  - Reduced CO_2 emissions
- Negative:
  - Increased cost/price of vehicle due to component cost
  - Increased development and compliance costs
  - Increases vehicle testing costs

Assessment of available body of evidence:

- There were 14 articles included for a detailed quality assessment, of which eight were research-related articles and five had cost- and benefit-related information.
- Most of the articles found were single-country-specific, but benefit estimates for the entire EU are missing.

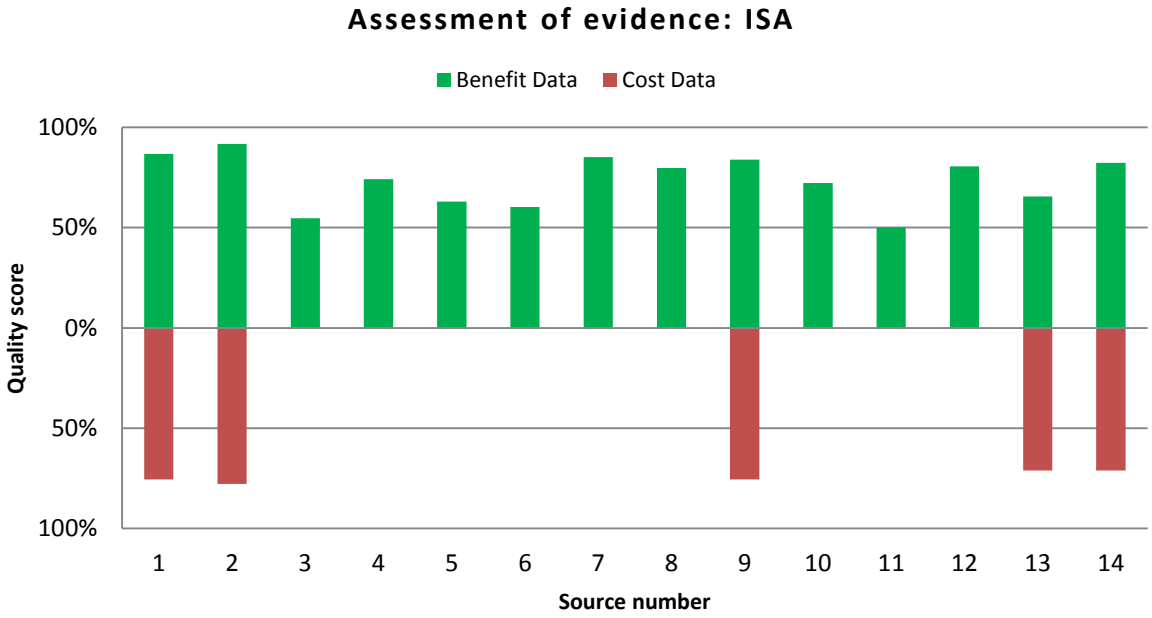


Figure 21: Level of available evidence for ISA

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Either use CARE database and scaled-up national data from member states' police records to extract values based on description of target population or use all road accidents as target populations with effectiveness values applied according to Carsten *et al.* (2008) and Lai *et al.* (2012).
  - It should be noted that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly. This study will provide further information on the size of the target population.
- Fleet penetration:
  - Öörni (2016) iMobility Support – D3.1b Report on the deployment status of iMobility Priority systems and update of iMobility Effects Database[109].
- Benefit data:
  - Carsten *et al.* (2008) Speed Limit Adherence and its effect on road safety and climate change, Final Report[110].
  - Lai *et al.* (2012) How much benefit does Intelligent Speed Adaptation deliver: An analysis of its potential contribution to safety and environment[111].
  - On the interaction with commercial vehicle top-speed limiters: Transport & Mobility Leuven (2013) Ex-post evaluation of Directive 92/6/EEC on the installation and use of speed limitation devices for certain categories of motor vehicles in the Community, as amended by Directive 2002/85/EC[112].
- Cost data:
  - NHTSA (2012) Cost & Weight Analysis of Forward Collision Warning System (FCWS) and Related Braking Systems for Light Vehicles[113].

No concerns regarding these sources were raised by stakeholders.

Input values for cost-benefit model:
Based on these studies, The following preliminary input values for a cost-benefit model are recommended.

- Target population (description):
  - 'Injurious collisions where exceeding the speed limit was a main contributory factor' or use all road accidents as target populations with effectiveness values applied according to Carsten *et al.* (2008) and Lai *et al.* (2012).
  - No concerns regarding these descriptions sources were raised by stakeholders.
  - Consider values from TRL/CEESAR study (to be published shortly).

[109] http://www.imobilitysupport.eu/library/imobility-support-activities/its-deployment-deliverables/monitoring-priority-systems/deliverables-3/2992-d3-1b-and-d3-2b-deployment-status-of-imobility-priority-systems-effects-database-all-appendices/file

[110] http://webarchive.nationalarchives.gov.uk/20110304132839/http:/cfit.independent.gov.uk/pubs/2008/isa/pdf/isa-report.pdf

[111] http://www.sciencedirect.com/science/article/pii/S0001457511000923

[112] http://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=9143677

[113] https://www.regulations.gov/document?D=NHTSA-2011-0066-0011

- Fleet penetration:
  - 1–10% of M1 fleet was equipped in 2015 with some form of built-in speed alert system; based on (Öörni, 2016), see Section 6.6 for details.
  - Stakeholders have not had a chance to comment on these values because they were identified after the consultation.
  - Fitment rates for other categories are unknown. It could be considered to purchase accurate fleet fitment data and projections from a specialised market analysis provider.
- Effectiveness (benefit):
  - Vehicle categories M1 and N1:
    - According to Carsten *et al.* (2008) and Lai *et al.* (2012), advisory, voluntary and mandatory ISA could avoid 2.7%, 12.0% and 28.9%, respectively, of *all* road accidents (not only in relation to the target population) in the UK. Highest effectiveness is in 30 mph (50 km/h) limited areas (pedestrian accidents).
    - For detailed effectiveness estimates (including a breakdown by accident severity) see Lai *et al.* (2012), Table 4 and Carsten et al. (2008), Tables 26 and 27.
    - Scaling of the UK values to EU-28 will be required. Considering that the level of adherence to speed limits in the UK is generally good, this might be a conservative estimate of the EU-wide effectiveness.
    - No concerns against these values were raised by stakeholders.
  - Vehicle categories M2, M3, N3 and N3:
    - According to Transport & Mobility Leuven (2013), introduction of voluntary ISA on M2, M3, N2 and N3 vehicles could reduce *all* road accidents (not only in relation to the target population) in the EU by: 25% (fatal accidents), 18% (serious accidents), or 11% (all injury severities combined).
      - For detailed effectiveness estimates (including a breakdown by road types) see Transport & Mobility Leuven (2013), Table 5-8 (Scenario HCV4).
      - The benefits were calculated using Elvik's Power Model of the relationship between speed and road safety[114]. Note that these figures already take into account that M2, M3, N2 and N3 are maximum-speed limited. The benefit for motorway accidents was consequently regarded as zero.
    - Carsten *et al.* (2008) estimated the following reductions based on very limited data (see Section 4.3.3 of the report):
      - Urban: 1%, 5% and 52% (advisory, voluntary and mandatory, respectively).
      - Rural single carriageway: 2%, 5% and 78% (advisory, voluntary and mandatory, respectively).
      - Motorways, dual carriageways: No effect for speed limited vehicles.
      - Ultimately the researchers considered these values not reliable enough and applied the same estimates as for cars (see values quoted above under M1 and N1).

[114] https://www.toi.no/getfile.php?mmfileid=13206

        - Scaling of the UK values to EU-28 will be required. Considering that the level of adherence to speed limits in the UK is generally good, this might be a conservative estimate of the EU-wide effectiveness.
    - ACEA reasoned that existing evidence for HGVs was very limited because there was only this one trial involving only a single HGV. Volvo trucks questioned the high values for mandatory ISA based on experience from Volvo trucks accident research.
    - ACEA further reasoned that evidence and expected benefit for heavy commercial vehicles was very limited because these were already fitted with maximum-speed limiters. Note that this indeed diminishes the benefit for high-speed roads, but not for lower-speed sections. The figures quoted above already take maximum-speed limiters into account. TfL referred to a recent ISA trial in London buses that revealed the highest effectiveness in low-speed areas.
- Cost per vehicle at time of mandatory implementation:
    - €47–62 (Camera-based system that shares technology between four systems: AEB, LKA, ISA, AEB-PCD. The total cost for components (camera, ECU, brackets, trim, wiring) and OEM design and development, tooling costs, etc. was estimated at €186–249, based on individual costs extracted from NHTSA, 2012).
    - Unknown cost for map-based systems (positioning technology will be available on cars due to mandatory eCall from 2018; other vehicle categories not affected by eCall).
    - ACEA reasoned that the intended function needed to be defined in more detail before it was possible to confirm or provide any cost estimate (too many parameters were still open which might have an influence on the cost).
    - Confidential costing information received from OEMs for N2 and N3 vehicles suggests that the costs could be much greater than the estimates provided above (wide range of estimates was provided with the lower limit in the region of the TRL estimate). Stakeholders did not have a chance to comment on this information. A smaller effect of economies of scale in these categories (smaller production volume) might be a reason for this.

Table 17: PESTLE analysis for ISA

GENERAL SAFETY REVIEW 2: Intelligent Speed Assistance (ISA)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction of speeding and therefore reduction in casualties and fatalities	n/a
	Australia is working on mandating ISA (potential for harmonisation)	
Economic	Saves a number of collisions thereby saving time on road closures.	ISA fitment will increase vehicle cost
	Fewer accidents leading to less emergency service deployment	
Societal and Safety	Reduction of speeding and therefore reduction in casualties and fatalities	n/a
	Increase the perceived VRU safety of cars, thereby encouraging cycling and walking as an alternative to car use – improving the health of the population and reducing emissions due to reductions in car journeys.	
	Potential traffic calming effect also for non-equipped legacy fleet surrounding an ISA-equipped vehicle	
	Insurance cost might reduce with ISA fitment	
	More disciplined driving on the roads	
Technological	n/a	n/a
Legislative	n/a	Cost of drafting type-approval requirements
		Additional testing cost
Environmental	Driving at optimal speeds could increase the fuel efficiency and hence reduce CO_2 emissions	

5.14 Lateral Side-Guards (LAT)

Lateral Side-Guards (LAT)

HGVs and their trailers are presently required to be fitted with lateral side-guards to provide protection to pedestrians and cyclists in collisions with the side of such vehicles, reducing the likelihood of them being run over. However, the current legislative text allows for broad exemptions to fitting these structures; therefore action has now been taken at the UNECE level to improve the relevant legislation (UN Regulation No. 73).

Removal of exemption from fitting side-guards in R73 for certain types of vehicles designed and constructed for special purposes. Make the relevant amendment to R73 mandatory for N2, N3, O3 and O4 vehicles:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- Before removing the exemptions some formal consideration should be given to the feasibility of meeting the functional requirements for vehicles with the addition of side guards. Note that a feasibility study for Transport for London drew a positive conclusion on this question: "*Fitting sideguards to exempt vehicles, even those exempt for reasons of engineering/mechanical obstruction, is possible. Feedback from both operators and bodybuilders demonstrates that there are ways to engineer sideguards around ancillary equipment in order to avoid obstructing controls and mechanisms such as landing legs. Vehicles that travel off-road may be more likely to incur damage to sideguards but it is possible to overcome this with the fitment of detachable or retractable sideguards.*" (AECOM, 2012)[115].
- Note that it could be considered, in addition to the measure discussed (removal of exemptions), to amend the existing side-guard requirements to make existing designs more effective by covering an increased area with reduced ground clearance – see Cookson and Knight (2010)[116] and Thomas *et al.* (2015)[117]. Side guards were introduced to influence collisions where pedal cyclists fell towards the side of a passing lorry. Without side guards, this type of collision can result in the cyclist falling into the gap between the front and rear axles of the vehicle and subsequently be run over by the rear wheels. The most common type of collision where this occurred was when lorries were overtaking cyclists in an approximately straight line. Originally, collisions where a lorry turning left collided with a cyclist or pedestrian were not considered to be in scope of benefits offered by side guards. This is because the vulnerable road user would be knocked to the ground and as the lorry 'cut-in' to the corner, the side guard could pass over the top of the prone person and the rear wheels could still run them over. Side guards with lower ground clearances and smoother surfaces with

[115] http://www.clocs.org.uk/wp-content/uploads/2014/05/encouraging_the_fitment_of_sideguards.pdf

[116] https://trl.co.uk/reports/PPR514

[117] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000169.PDF

fewer gaps may be more effective in this type of situation (Robinson and Cuerden, 2014)[118].

Considerations regarding potential technical requirements:

- ACEA expressed the opinion that some exemptions would still be required due to the intended use of the vehicles. ETSC pointed to available technologies, such as detachable, foldable, or sliding side-guards, that would make it possible to fit lateral side-guards for almost all use cases.
- The relevant amendment, i.e. the removal of exemptions, will be discussed at UNECE GRSG level and could be included in an amendment to UN Regulation No. 73 (supplement or series of amendments). Note that the current draft for Supplement 1 to the 01 Series of Amendments to UN Regulation No. 73[119], put forward for vote at WP.29 at the March 2017 session, still contains an exemption at the discretion of the type-approval authority, so might not address this issue effectively: "*Vehicles where any LPD (e.g. fixed, removable, foldable, adjustable, etc.) is incompatible with their on-road use may be partly or fully exempted from this Regulation, subject to the decision of the Type Approval Authority.*"

Overlaps in benefits and technology:

- Technology layer: Passive Safety VRU
- Overlaps in benefits to consider: DDR, VIS
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - The number of HGVs with no lateral protection will reduce and thereby reduction of pedestrian, cyclist and motorcyclist injury frequency and severity due to deflecting off the guard rather than falling or driving under the HGV.
  - Increased harmonisation between markets.
  - Increase the perceived VRU safety of HGVs, thereby encouraging cycling and walking as an alternative to car use – improving the health of participants and reducing emissions due to reduced car journeys.
  - Increase equitable treatment of VRUs in vehicle safety legislation.
- Negative:
  - Potential increase in purchase price of vehicles fitted with side guards.
  - Adding lateral protection to certain HGV and trailer design without compromising vehicle functionality may prove difficult in some cases. Off-road performance could be compromised.
  - Increased mass which may reduce payload (impact on operator profit if load is mass-limited rather than volume-limited) and will increase fuel consumption and emissions.

[118] http://www.londoncouncils.gov.uk/node/22932

[119] http://www.unece.org/fileadmin/DAM/trans/doc/2016/wp29grsg/ECE-TRANS-WP29-GRSG-2016-18e.pdf

Assessment of available body of evidence:

- There were 12 articles included for a detailed quality assessment, all of which were research-related articles and to a large extent also contained cost information.

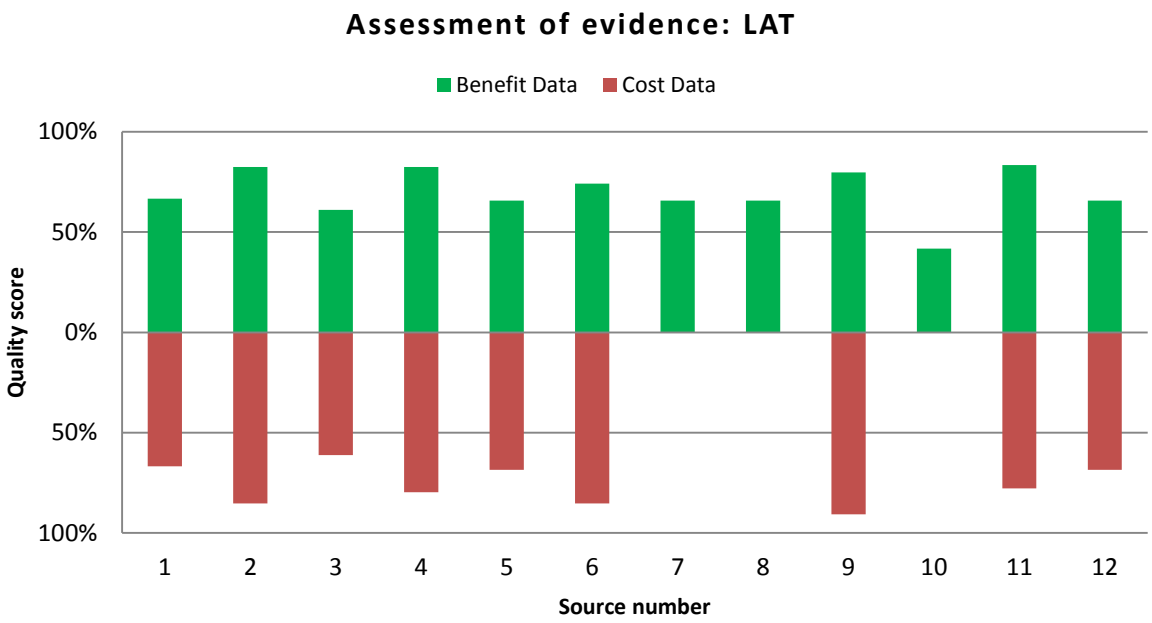


Figure 22: Level of available evidence for LAT

- There is strong evidence that side-guards are highly effective in one collision scenario (passing collisions), but that the effectiveness of current designs in turning scenarios is much lower (high ground clearance of side-guard means it can miss a cyclist lying on the ground). This leads authors to the conclusion that removing fitment exemptions of certain vehicles could address the passing collisions but that adapted design requirements (increased area with reduced ground clearance) would be required to effectively address the turning scenario.
- Although there were no full EU cost-benefit studies for the measure discussed, some articles included estimates of fitment costs for fixed side guards. Cost information for detachable, retractable or extendable side-guards could not be identified.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database, scaled-up national data from member states' police records and/or in-depth data to extract values based on description of target population, in particular those collisions where the HGV was not fitted with sideguards.
- Fleet penetration:
  - Robinson and Cuerden (2014) Safer lorries in London: Identifying the casualties associated with side guard rails and mirror exemptions – PPR683[120]; or
  - Knight *et al.* (2005) Integrated safety guards and spray suppression – Final summary report[121].

[120] http://www.londoncouncils.gov.uk/node/22932

- Cookson and Knight (2010) Sideguards on heavy goods vehicles: assessing the effects on pedal cyclists injured by trucks overtaking or turning left[122].
- Thomas *et al.* (2015) Fatal urban cyclist collisions with lorries: An In-depth study of causation factors and countermeasures using a system-based approach[123].

- Benefit data:
  - Robinson and Cuerden (2014) Safer lorries in London: Identifying the casualties associated with side guard rails and mirror exemptions – PPR683.
- Cost data:
  - AECOM (2012) Encouraging the Fitment of Sideguards to Exempt Commercial Vehicles – A Feasibility Study for Transport for London[124].

Input values for cost-benefit model:

Based on these studies, the following preliminary input values for a cost-benefit model are suggested.

- Target population (description):
  - 'Injurious collisions HGV-to-pedal cycle and HGV-to-pedestrian collisions where the HGV was passing (going in same direction) and was not fitted with sideguards'.
  - Note that this description of the target population does not contain collisions where the HGV was turning because current side-guard designs are not protective in this scenario (Knight *et al.*, 2005; Cookson and Knight, 2010; Thomas *et al.*, 2015). Should it be considered to amend the design requirements (e.g. reduced ground clearance) the target population would increase and also include turning collisions.
- Fleet penetration:
  - 10.5–26.0% of current fleet exempted (assumption, data from London), based on (Robinson and Cuerden, 2014).
  - Note that the situation could vary largely between regions and member states. No other pertinent sources were identified or submitted by stakeholders.
- Effectiveness (percentage of target population affected, benefit):
  - HGV-to-pedal cycle collisions: 50–74% for fatalities; 3–9% for serious casualties, based on (Robinson and Cuerden, 2014).
  - HGV-to-pedestrian collisions: 17–27% for fatalities; no effect for serious casualties, based on (Robinson and Cuerden, 2014).
  - These values were identified after the stakeholder consultation. The previously proposed values based on (Knight *et al.*, 2005) were of a similar order of magnitude but less detailed. Stakeholders did not raise concerns regarding the previous values.
- Cost per vehicle at time of mandatory implementation:

[121] https://trl.co.uk/reports/PPR075

[122] https://trl.co.uk/reports/PPR514

[123] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000169.PDF

[124] http://www.clocs.org.uk/wp-content/uploads/2014/05/encouraging_the_fitment_of_sideguards.pdf

- Fixed side-guards: €115–288 (based on cost estimate of £100–250 in (AECOM, 2012).
- No concerns were raised by stakeholders regarding this value. Confidential costing information received from OEMs confirmed the order of the estimates above.
- Detachable, retractable, extendable side-guards: TRL suggested to use the assumption that the cost for detachable side-guards was only slightly higher than fixed side guards. Stakeholders expressed reservations against this assumption. More detailed cost data was not provided. Suggest to investigate potential cost further, for example with suppliers.

Table 18: PESTLE analysis for LAT

GENERAL SAFETY REVIEW 2: GSR-2: Lateral Side-Guards (LAT)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Making HGV's safer for VRUs	n/a
	VRU casualties not reducing as fast as car occupant casualties - increases equitable treatment of VRUs in vehicle safety legislation	
	Increase harmonisation between markets	
Economic	Reduced cost to the economy of VRU and serious casualties	Potential Increase in purchase price of vehicles fitted with side guards.
	Reduction in emergency service requirements	
	Reduction in road closures/congestion leading to increase in productivity	
Societal and Safety	Reduction in fatalities/serious casualties	Increase in vehicle complexity/maintenance costs.
	If designed to be aerodynamic, money lost through increased weight could be regained through the reduction in fuel consumption.	
	Encourages cycling/walking which in turn improves health of society and reduces congestion	
Technological	n/a	n/a
Legislative	n/a	Increased OEM compliance costs
		Increased vehicle development costs
Environmental	Potentially reduced CO_2 and other emissions due to possible aerodynamic properties.	Potentially increased CO_2 and other emissions due to increased vehicle mass.

5.15 Lane Keeping Assist (LKA)

Lane Keeping Assist (LKA)

Lane Keeping Assist (LKA) monitors the position of the vehicle with respect to the lane boundary and, when a lane departure is about to occur, corrects the course of the vehicle by applying a torque to the steering wheel or braking of individual wheels.

Make mandatory for M1 and N1 vehicles (derived from M1):

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Make mandatory for all N1 vehicles 2-year offset to the above dates.

Notes on measure:

- LKA systems help the driver to stay in their lane and are an advancement of functionality from lane departure warning (LDW) systems. They function at speeds typically from 65 km/h by monitoring the position of the vehicle with respect to the lane boundary (typically via a camera mounted behind the windscreen sited behind the rear view mirror) and applying a torque to the steering wheel or pressure to the brakes when a lane departure is about to occur.
- LKA prevents vehicles drifting out of the lane unintentionally. LKA systems provide an improvement to LDW, which only warns the driver of the lane departure and may not provide any warning until the point of crossing or even just after, at which point it may be impossible to avoid a collision. Therefore, the casualty benefit of LKA is likely to be towards the upper range of the estimate made for LDW.
- There is currently a move towards emergency lane keeping systems that intervene only in case of an imminent threat such as leaving the road rather than leaving the lane, or leaving the lane with oncoming traffic. Stakeholders suggested that these systems will be introduced into the car fleet in 2018 and that Euro NCAP might change their assessment protocol to take these systems into account. BASt provided their opinion that it was too early to perform a benefit assessment of LKA systems and suggested to investigate emergency lane keeping systems in the future.

Considerations regarding potential technical requirements:

- The UN type-approval legislation around LKA systems is currently under discussion in the Informal Working Group Automatically Commanded Steering Functions (ACSF) under GRRF. The current requirements in UN Regulation No. 79 will be amended based on these discussions.
- ACEA commented that the category to be mandated based on R79/ACSF discussions should be confirmed (CSF or B1). Further, they commented that this measure might also be considered an extension of UN Regulation No. 130 (LDW for M2,M3,N2 and N3).
- Stakeholders commented that the required design changes (and associated cost) for upgrading the steering system of vehicles with hydraulic steering assistance (including N-category vehicles) would be substantial. It could be considered to downgrade the requirement to a pure warning function (LDW only) for vehicles with hydraulic steering assistance.

- LKA systems can typically be switched on and off by the driver and the system retains the last status at the start of the subsequent journey. Therefore, if the driver switches it off, then no benefit is realised. For traditional assistance LKA systems, ACEA and DfT raised objections against them being re-activated automatically after ignition-on, because the system might not work perfectly under all conditions and result in potential customer annoyance.
- Stakeholders suggested that it could be considered to mandate future emergency lane keeping systems (see above) rather than the traditional assistance LKA systems. These emergency systems could be permanently on or default to being on after ignition-on.
- SMMT reasoned that small and ultra-small-volume vehicle manufacturers should be exempt from this measure because it required power assisted steering (which was often not fitted) and calibration and safety testing was likely to be expensive. Additionally, ESC/ABS systems may also be needed to redirect the vehicle, which ultra-small-volume vehicle manufacturers were currently exempt from.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: DDR, FSO, F94
- Overlaps in technology to consider: AEB, ISA, AEB-PCD (camera-based systems)

Main impacts:

- Positive:
  - LKA systems act to maintain the vehicle in the lane; they provide a higher level of assistance than LDW.
  - OEMs predict a high number of fatalities and serious casualties saved per annum in EU for M1/N1 vehicle categories.
- Negative:
  - Drivers' acceptance of LKA or an inclination to turn the system off could reduce effectiveness in the field.

Assessment of available body of evidence:

- There were 12 articles included for a detailed quality assessment, of which eight were research-related articles and four were cost-benefit-related studies.
- The available literature suggests high potential benefits of the system and there is a very recent retrospective study available based on real-world data (mainly for LDW systems with a few LKA-equipped vehicles). Due to the commercially sensitive nature, published cost information was spare. However, a tear-down cost analysis of other camera-based systems performed in 2012 for NHTSA provided a basis for an informed cost estimate of the sensing system. No cost information was identified for the necessary actuators.

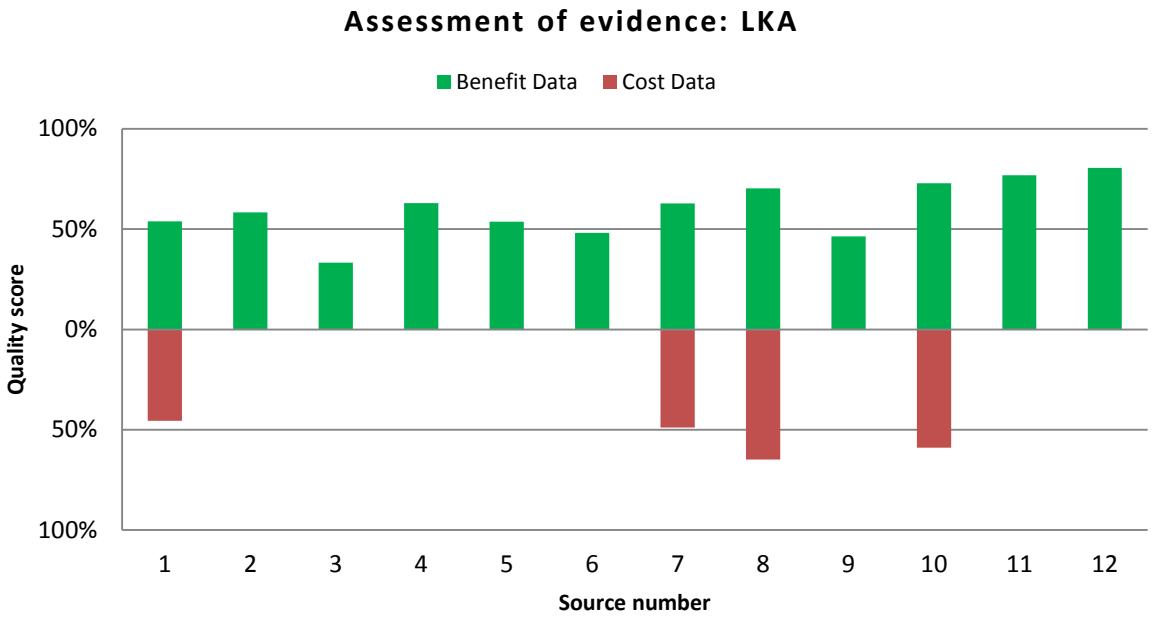


Figure 23: Level of available evidence for LKA

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to estimate values based on description of target population.
- Fleet penetration:
  - Öörni (2016) iMobility Support – D3.1b Report on the deployment status of iMobility Priority systems and update of iMobility Effects Database[125].
- Benefit data:
  - Sternlund *et al.* (2017) The effectiveness of lane departure warning systems – a reduction in real-world passenger car injury crashes[126].
  - TRL previously suggested (Robinson *et al.*, 2011) [127], a prospective study mainly on LDW. This was changed to (Sternlund *et al.*, 2017), which is considered more reliable because it is based on retrospective real-world data. The criticism expressed by stakeholders that also the Sternlund study mainly regards LDW systems is acknowledged; however, TRL considers this the best available evidence and considers it a conservative approach because LKA can be considered an extension of LDW function. No studies were identified on emergency lane keeping systems discussed above.

[125] http://www.imobilitysupport.eu/library/imobility-support-activities/its-deployment-deliverables/monitoring-priority-systems/deliverables-3/2992-d3-1b-and-d3-2b-deployment-status-of-imobility-priority-systems-effects-database-all-appendices/file

[126] http://www.tandfonline.com/doi/full/10.1080/15389588.2016.1230672?src=recsys

[127] https://trl.co.uk/reports/PPR586

- Cost data:
  - NHTSA (2012) Cost & Weight Analysis of Forward Collision Warning System (FCWS) and Related Braking Systems for Light Vehicles[128].

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious head-on and single vehicle collisions on roads with speed limits between 70–120 km/h and with dry or wet road surfaces (i.e. not covered by ice or snow)'.
  - Note that this description was adapted after the stakeholder consultation to align the target population description with Sternlund *et al.* (2017). The previously suggested description was: 'Single-vehicle run-off-road, head-on and sideswipe collisions where the subject vehicle unintentionally left the lane'.
- Fleet penetration:
  - Approximately 1% of M1 fleet was equipped in 2015 with lane keeping support (which includes *both* LDW and LKA), with a high new vehicle fitment rate since 2012/2013 (4.2% and 5.6% respectively); based on (Öörni, 2016), see Section 5.6, Tables 126 and 127 for details.
  - Stakeholders have not had a chance to comment on these values because they were identified after the consultation. Note that the previous value based on (Kyriakidis *et al.*, 2015) was wrongly cited as fleet penetration where it was actually new vehicle fitment.
  - Negligible proportion of N1 fleet equipped (assumption).
  - No concerns were raised by stakeholders regarding these values.
- Effectiveness (percentage of target population affected, benefit):
  - 53% for injurious head-on and single vehicle collisions of M1 vehicles (lower limit of 95% confidence interval: 11%), based on Sternlund *et al.* (2017).
  - Similar effectiveness for N1 (assumption)
- Cost per vehicle at time of mandatory implementation:
  - €47–62 for sensing (Camera-based system that shares technology between four systems: AEB, LKA, ISA, AEB-PCD. The total cost for components (camera, ECU, brackets, trim, wiring) and OEM design and development, tooling costs, etc. was estimated at €186–249, based on individual costs extracted from NHTSA (2012))
  - Unknown whether/what additional cost is accrued for steering actuation.
  - No concerns were raised by stakeholders regarding the cost estimate for sensing technology. However, stakeholders commented that the cost for upgrading the steering system of vehicles with hydraulic steering assistance (including N-category vehicles) would be substantial. Note, in this context, the legislative option discussed above to downgrade requirements to LDW for certain steering systems.

[128] https://www.regulations.gov/document?D=NHTSA-2011-0066-0011

Table 19: PESTLE analysis for LKA

GENERAL SAFETY REVIEW 2: Lane Keeping Assist (LKA)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction in lane departure collisions, leading to reduction in casualty numbers	n/a
Economic	LKA is a comfort function as well as a safety function and might therefore encourage customers to buy new cars	n/a
	Saves a number of collisions thereby saving time on road closures	
	Fewer accidents leading to less emergency service deployment	
Societal and Safety	Reduction in lane departure collisions, leading to reduction in casualty numbers	Misunderstanding of system functionality (overreliance on system) might result in additional collisions, which might partially offset collision reductions
Technological	n/a	Increase in vehicle servicing/maintenance costs
Legislative	n/a	Cost of defining legislative tests
		Vehicle testing cost increases due to the complex system and variants
Environmental	n/a	Increased vehicle mass leading potentially to increased CO_2 emissions

5.16 Pole Side Impact Occupant Protection (PSI)

Pole Side Impact Occupant Protection (PSI)

Addition of pole side impact crash test UN Regulation No. 135 (R135):

- 01/09/2020 new approved M1 types and certain N1
- 01/09/2022 all new M1 vehicles and certain N1

Notes on measure:

- GTR 14 on PSI was established in the Global Registry November 2013. FMVSS 214 in the US has incorporated PSI requirements for nearly 10 years, including requirements for 50th percentile male (ES-2re) and 5th percentile female (SID-IIs) dummies, in driver and FSP seating positions.
- Vehicles perform well in the current Euro NCAP pole test, which is similar to the R135 test, which demonstrates clearly that current vehicles can meet the proposed test requirements. Euro NCAP head and pelvis requirements are stricter than R135.
- 12 out of 12 Euro NCAP models tested to date in 2016 had some form of curtain airbag and performed satisfactorily. Four out of 44 2015 Euro NCAP models did not have the pole test (two 'business and family vans' with 8/9 seats, one supermini, and one two-seat roadster); one other two seat roadster was subject to the PSI test and performed satisfactorily. Most vehicles tested used a curtain airbag, but several used separate front head airbags (and separate rear head airbags if rear seats fitted).
- VTI provided input motivating the development and use of female crash test dummies. The documents included a research review that confirms an elevated injury risk for females compared to males. The specific suggestion made is to use a male in one of the side impact tests (R95 and R135) and an (average) female dummy in the other side impact test. The authors acknowledge that a female average dummy would still need to be developed. Note that the intent of GTR No. 14 was to use a small-female dummy (5th percentile) in order to ensure that curtain airbags come down low enough for smaller occupants (male or female).

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in UN Regulation No. 135.
- GTR 14 on PSI was established in the Global Registry November 2013. Since GSR-1, Australia has mandated the technical requirements of GTR No. 14, as transposed into the 01 Series of Amendments to UN R135, in ADR 85/00. The ADR will apply to different vehicle categories between 1 November 2017 and 1 November 2022. Japan also began applying GTR 14 on 15 June 2015.
- Euro NCAP has included a PSI test for over 10 years and the requirements are now very similar to GTR 14 (WorldSID-50M dummy, oblique 32 km/h impact). US and Korean NCAP use a very similar test condition, the US with the SID-IIs dummy and Korea the ES-2 (WorldSID-50M from 2017). Australian NCAP and Latin NCAP include 90° PSI tests (the latter being an optional test for 5-stars).
- Euro NCAP head and pelvis requirements are stricter than R135. Euro NCAP additionally assesses the inflated airbag position with respect to a zone defined by the

seating and head positions of 5th percentile female and 95th percentile male dummies; this could be considered as an additional requirement to enhance R135.

- In order to provide (partial) ejection mitigation benefits, an additional requirement for assessment of the window curtain airbag coverage could be added to R135 for implementation in the EU. This requirement could be based on FMVSS 226 for harmonisation. Note that an ejection mitigation exemption could be given for vehicles for which fitment of a curtain bag is not practical, e.g. convertibles.
- SMMT reasoned that small-volume vehicle manufacturers could fulfil this measure (as per US FMVSS 216), but that ultra-small-volume vehicle manufacturers should be exempt from this measure because it would be expensive to introduce, and require destructive testing – which they are currently exempt from under ECSSTA.

Overlaps in benefits and technology:

- Technology layer: Passive Safety Side
- Overlaps in benefits to consider: ISA, LKA, DDR, SFS
- Overlaps in technology to consider: SFS (curtain airbag may be protective in both)

Main impacts:

- Positive:
  - Reduction in side impact fatalities and injuries
  - Potential for ejection mitigation, depending on the PSI requirements
  - Potential for benefits if a side curtain airbag is deployed in oblique frontal collisions or side collisions with larger vehicles or objects
- Negative:
  - Potential for increased cost/price of vehicle
  - Potential for increased vehicle mass, so increased fuel use and emissions

Assessment of available body of evidence:

- There were seven articles included for analysis, of which two were research-related articles and five were cost-benefit-related articles. One of them was a regulatory impact analysis of US FMVSS No. 214. There were also a large number of articles that presented accident data for particular regions.
- GTR 14 has considerable information on costs and benefits, but notes that the incremental costs and benefits will have to be assessed in each region depending on the influence of other actors such as local NCAPs.
- Edwards *et al.* (2010)[129] concluded that a PSI test was the most beneficial and most cost-beneficial approach to improving side impact protection in pole and car-to-car collisions. Billot *et al.* (2013)[130] showed a negative benefit-cost result for France.

[129] Edwards M, Cuerden R, Langner T, Pastor C, Sferco R and Binder S (2010). Analysis to estimate likely benefits and costs for the EU of modifying Regulation 95. European Enhanced Vehicle-safety Committee (EEVC) WG13 and WG21 Subgroup

[130] http://www-esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000440.PDF

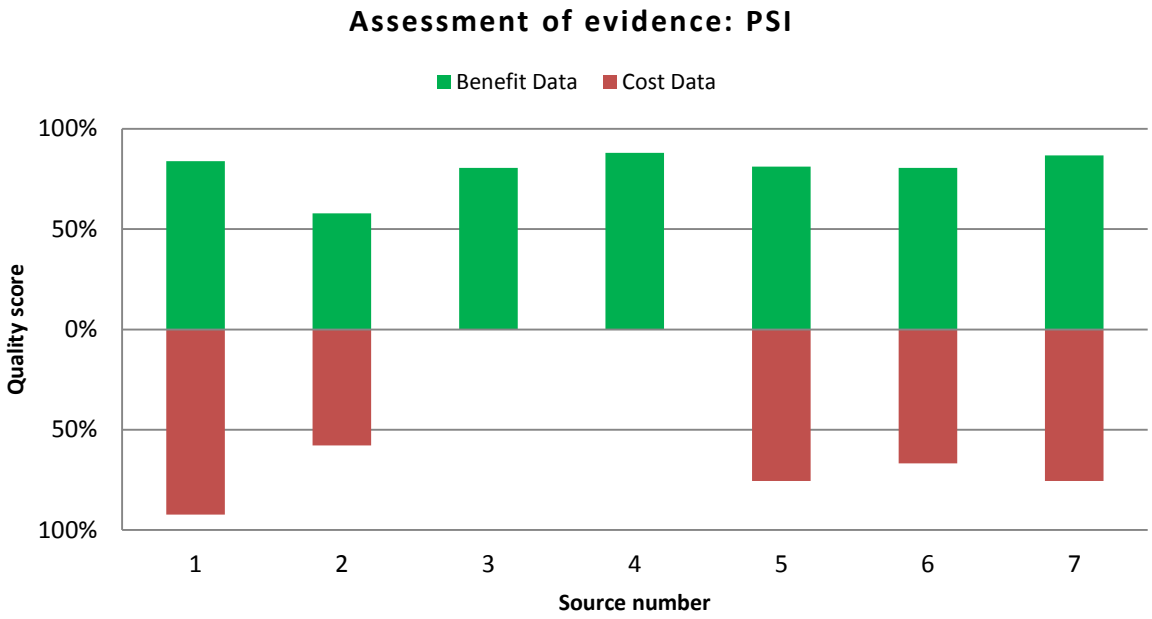


Figure 24: Level of available evidence for PSI

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to extract values based on description of target population. Use in-depth data to estimate prevalence of single-vehicle impacts against narrow objects; or
  - Fitzharris and Stephan (2013) Assessment of the need for, and the likely benefits of, enhanced side impact protection in the form of a Pole Side Impact Global Technical Regulation[131].
- Fleet penetration:
  - No publications identified; assumptions below based on Euro NCAP results.
- Effectiveness:
  - Billot *et al.* (2013) Pole impact test: study of the two current candidates in terms of cost and benefits for France[132].
- Benefit data:
  - Edwards *et al.* (2010) Analysis to estimate likely benefits and costs for the EU of modifying Regulation 95[133]. NB: the potential extra benefits that curtain airbags with adequate coverage could offer in rollover accidents were not included.

[131] Final version (October 2013) available from TRL's FTP server, previous version (November 2012): https://www2.unece.org/wiki/download/attachments/5800432/PSI-08-04e.pdf

[132] http://www-esv.nhtsa.dot.gov/Proceedings/23/files/23ESV-000440.PDF

- Cost data:
  - Edwards *et al.* (2010) Analysis to estimate likely benefits and costs for the EU of modifying Regulation 95. Note that the costs estimated in this study were thought to be too high by some stakeholders.
  - GTR 14 cost data[134] inflated to 2016 prices.
  - Billot *et al.* (2013) Pole impact test: study of the two current candidates in terms of cost and benefits for France.

No concerns were raised by stakeholders regarding these sources, but reference to an additional study by LAB was provided (Chauvel, 2012)[135], which showed a negative benefit-cost result for France. Note that (Chauvel, 2012) is based on the same data as the study suggested by TRL (Billot *et al.*, 2013) and the central conclusions are identical.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious single-vehicle side collisions with poles, trees and other narrow objects'
  - Some benefits may also accrue in other side impact collisions if airbag coverage and ejection mitigation requirements are added to R135.
  - Stakeholders suggested to include car-to-car collisions in the target population (improved head protection).
  - ACEA provided an analysis of French data indicating the proportion of exempt M1 and N1 vehicles based on the scope of R135 (for detailed data refer to ACEA input in Annex 3).
- Fleet penetration:
  - >90% of new M1 would already meet R135 (assumption based on 2015/16 Euro NCAP results). N1 unknown, stakeholders commented that Euro NCAP requirements for N1 are fully aligned with M1, and suggested that it normally took 8–9 years for a new generation of vans to be introduced.
  - >90% of new M1 would already meet additional Euro NCAP coverage requirements (assumption based on 2015/16 Euro NCAP results); N1 unknown, but assumed to be low.
  - <<10% of new M1 would meet FMVSS 226-style ejection mitigation requirements. Euro NCAP commented that a single vehicle brand had airbags that stayed inflated.
  - No concerns were raised by stakeholders regarding these values.

[133] Edwards M, Cuerden R, Langner T, Pastor C, Sferco R and Binder S (2010). Analysis to estimate likely benefits and costs for the EU of modifying Regulation 95. European Enhanced Vehicle-safety Committee (EEVC) WG13 and WG21 Subgroup

[134] http://www.unece.org/fileadmin/DAM/trans/doc/2014/wp29grsp/ECE-TRANS-180a14e.pdf

[135] https://www2.unece.org/wiki/download/attachments/5800432/PSI-08-10e.pdf

- Effectiveness (percentage of target population affected, benefit):
  - 75 fatal (5% of car occupant fatalities) and 230 serious injuries (2% of serious car occupant casualties) would be prevented in M1 vehicles annually in the UK (Edwards *et al.*, 2010); this was based on a fleet that did not meet pole impact requirements yet. Scaling to EU-28 required.
  - Cost-benefit information for N1 given in Billot *et al.* (2013) (just France).
  - Effectiveness for N1 vehicles approximately 20% (fatalities and serious in France) cf. M1 (Billot *et al.* 2013).
  - Effect of ESC: breakeven cost reduced by 5% (M1) and 6% (N1) (Billot *et al.*, 2013) (NB: 41% reduction of target population in US[136]).
  - No concerns were raised by stakeholders regarding these values.
- Cost per vehicle at time of mandatory implementation:
  - Negligible cost to update current state-of-the-art vehicle that already meets the requirements (no changes to design, just compliance cost).
  - $9.5 (currently €8.63) to upgrade from standard side curtain and side thorax airbag to GTR 14 wide airbags.
  - $163 (currently €148.65) to upgrade from narrow head/thorax side airbag to GTR 14 wide airbags.
  - No concerns were raised by stakeholders regarding these values.

[136] https://www.unece.org/fileadmin/DAM/trans/doc/2010/wp29grsp/RD-2e.pdf

Table 20: PESTLE analysis for PSI

GENERAL SAFETY REVIEW 2: Pole Side Impact Occupant Protection (PSI)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Potential reduction of injuries and fatalities	n/a
	Harmonisation with similar test procedures and requirements in other regions	
	Ensuring a minimum performance for vehicles unlikely to be tested by Euro NCAP	
	Some harmonisation with similar requirements in the US, Japan, South Korea, Australia	
Economic	Reduced cost to the economy of narrow object side impact collision casualties	Increased cost of vehicle due to additional materials and improved restraint systems (noting that most M1 tested by Euro NCAP already meet more stringent requirements)
	Potential to reduce cost to the economy of injuries in other side impact collisions and rollover collisions, depending on the option adopted	
Societal and Safety	Reduction in fatalities/serious casualties in narrow object side impact collisions	Potentially increased purchase price of vehicles
	Potential to reduce cost to the economy of injuries in other side impact collisions and rollover collisions, depending on the option adopted	
Technological	Existing safety knowledge / technology for M1	n/a
	Application of existing safety knowledge to N1 vehicles	
Legislative	Potential for harmonisation with other regions via GTR14 (Australia and Japan have adopted GTR14 and the US has very similar requirements for nearly 10 years)	Increased OEM compliance costs
Environmental	n/a	Potentially increased CO_2 and other emissions due to increased vehicle mass (mostly N1 which are not yet compliant)

5.17 Reversing Detection or Camera Systems (REV)

Reversing Detection or Camera Systems (REV)

Sensing systems that increase the view of drivers or otherwise warn them of persons or obstacles behind reversing vehicles. Particularly vulnerable in this context are short, crouching or slow moving people, such as the elderly and children.

Preference between camera and/or detection with visual/acoustic warning to be determined. Possible to consider the new US FMVSS 111 requirements designed to protect small children.

Make mandatory for all M and N vehicles, as well as O3 and O4 trailers:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- Research from Germany, showed that reversing-car-to-pedestrian collisions are a serious issue; based on Kühn (2016) Car to Pedestrian Accidents Caused by Reversing (unpublished, see Annex 3):
  - In 17% of the car-to-pedestrian collisions the pedestrian was hit by the rear of a reversing car (16% when restricting to MAIS 3+ injured pedestrians).
  - The casualties involved were mainly elderly; children accounted for 6% which was less frequent than adults. The accidents mostly occurred in daylight and the reversing speed was low (95% of cases less than 10 km/h).
  - The share of serious injuries was found to be remarkably high considering the low driving speeds (MAIS 2+: 86%; MAIS 3+: 35%)
- Research from the Netherlands showed that reversing-van-to-pedestrian collisions, have the most serious outcome of all crashes involving delivery vehicles in urban areas (Davidse and van Duijvenvoorde, 2012)[137].
- Research by NHTSA suggests that camera-based systems are more effective than detection sensor systems. Thus, NHTSA suggested that the greatest cost-benefit is likely to be realised through the mandating of camera-based systems.
- Research by Kidd *et al.* (2014)[138] found that the blind spot reduction achieved by a camera system is two to eight times larger than that achieved by a parking sensor system alone.
- Research by Hurwitz *et al.* (2010)[139] indicates that camera-based systems paired with audible warnings were most effective: In experiments only 20% of drivers looked at the rear-view camera before backing. Of those who did not look at the rear-view camera before backing, 46% looked after the sensor warned the driver.

[137] http://www.swov.nl/rapport/R-2012-18.pdf

[138] http://hfs.sagepub.com/content/early/2014/10/01/0018720814553028.full.pdf+html

[139] http://injuryprevention.bmj.com/content/16/2/79.abstract

- Mehler *et al.* (2014)[140] is a US review article that contains pertinent information on reversing cameras.
- Stakeholders provided comments regarding the situation in Japan, stating that reversing detection systems had been on the agenda for JNCAP for a long time.
- With regard to heavy vehicles and trailers, stakeholders raised concerns regarding technical feasibility around non-existent communication protocols (between vehicles and trailers) and procedural difficulties with multistage vehicles that are built by different manufacturers.

Considerations regarding potential technical requirements:

- US FMVSS 111 contains requirements and test requirements for US light vehicles. These could provide a basis for legislation, but are specifically requiring camera-monitor systems.
- WP.29 has agreed to proceed with discussions on requirements for reversing detection systems at UN level following an initiative from Japan.
- SMMT suggested that small and ultra-small-volume vehicle manufacturers could fulfil this measure (ultra-small: only if systems were available as bought-in units).
- Stakeholders suggested to consider expanding the scope to O2 trailers because these did more reversing on open roads than O3 and O4 trailers and thus might have a higher exposure.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: None
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Casualty reduction – reduction of pedestrian injury frequency.
  - Established technology (already fitted to production vehicles). Encouragement to bring existing systems up to a high safety standard.
  - Legislation can be drafted to encourage harmonisation with US legislation (FMVSS 111).
  - Increase equitable treatment of VRUs, in particular children and the elderly, in vehicle safety legislation.
  - Potential for decreased insurance costs, because of lower payouts to injured parties due to mitigation of injuries and obstacle collisions.
- Negative:
  - Increased cost/price of vehicle.
  - Potential for increased repair costs in some collisions.

[140] https://www.aaafoundation.org/sites/default/files/Evaluating%20Vehicle%20Safety%20Techs%20FINAL%20FTS.pdf

- Potential for increased service and maintenance costs.
- Potential need to adapt existing reversing camera systems to comply with legislation.
- Increased development and compliance costs.
- Increased vehicle mass from additional parts, so increased fuel use, emissions and waste.
- Potential for increased insurance costs, because of potentially increased repair costs.

Assessment of available body of evidence:

- There were 20 articles included for a detailed quality analysis, of which 11 were research-related articles, four were cost-related articles, two were important review articles and four were found to include both cost and benefit data. Critically, a total of two longitudinal cost-benefit analyses were found (both from the USA from different points in time; latest one linked below). Of the 20 articles, nine had data relating to the technological costs, whilst 16 had data related to the benefits. There were also a large number of articles, not included in this analysis, which presented accident data for particular regions.

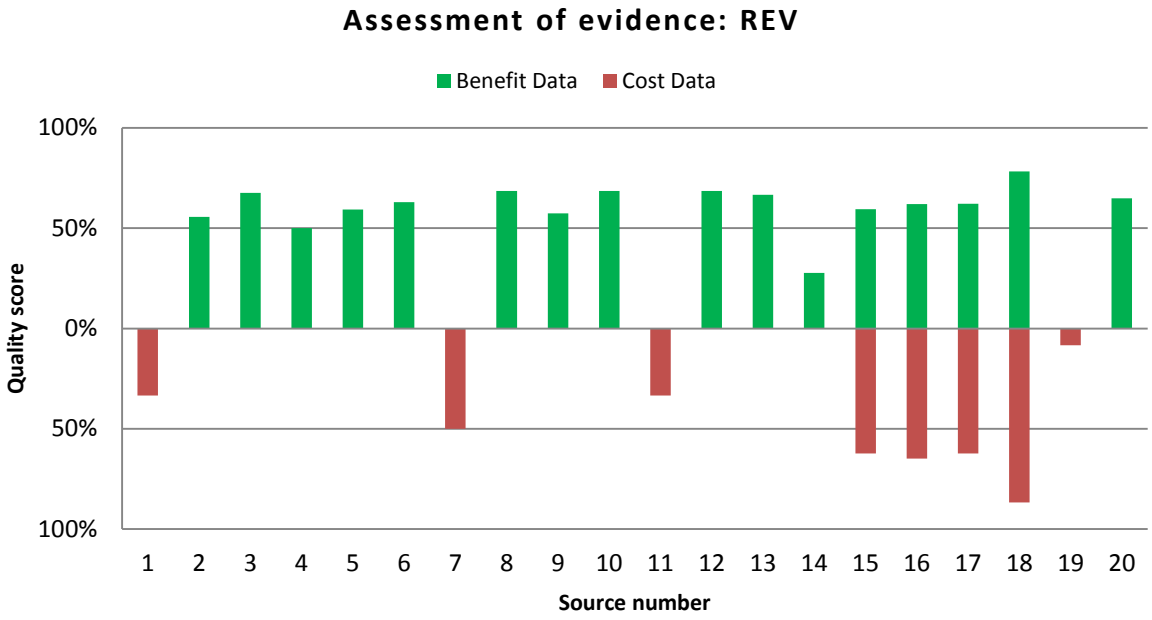


Figure 25: Level of available evidence for REV

- The key conclusion of US research is that, when using historical costs, there is currently no net benefit to society associated with the use of either camera or ultra-sonic sensor systems. Despite this, and as a result of the majority of victims being children (causing a large number of years of life lost), NHTSA recommended that such technology is made mandatory in the US. The rationale for this was that NHTSA believed the future costs of technology would drop significantly over time, improving the system cost effectiveness, and that this could be stimulated through mandating more stringent rear-view visibility requirements.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to estimate values based on description of target population.
  - Combined with the following sources for cars and vans:
    - Decker *et al.* (2016) Injury severity of pedestrians, bicyclists and motorcyclists resulting from accidents with reversing cars[141].
    - Davidse and van Duijvenvoorde (2012) Bestelauto-ongevallen: karakteristieken, ongevalsscenario's en mogelijke interventies[142].
    - Kühn (2016) Car to Pedestrian Accidents Caused by Reversing[143].
    - Kühn *et al.* (2017) VRU impact with cars – is there more to address than the vehicle front alone?[144]
    - Hynd *et al.* (2015) Benefit and Feasibility of a Range of New Technologies and Unregulated Measures in the fields of Vehicle Occupant Safety and Protection of Vulnerable Road Users[145]
  - Combined with the following sources for heavy vehicles:
    - Volvo Trucks (2013) European Accident Research and Safety[146].
    - National or European Health & Safety statistics.
- Fleet penetration:
  - No sources identified; suggest to purchase fitment data from a specialised market analysis provider.
- Benefit data:
  - Keall *et al.* (2017) Real-world evaluation of the effectiveness of reversing camera and parking sensor technologies in preventing backover pedestrian injuries[147]; or
  - NHTSA (2014) Final Rule Federal Motor Vehicle Safety Standards – Rear Visibility 49 CFR Part 571, 79 FR 19177[148].
- Cost data:

[141] https://www.ncbi.nlm.nih.gov/pubmed/27240128

[142] http://www.swov.nl/rapport/R-2012-18.pdf

[143] Unpublished, see Appendix to this report

[144] ESV 2017 paper, not yet published, private communication

[145] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

[146] http://www.volvotrucks.com/SiteCollectionDocuments/VTC/Corporate/Values/ART%20Report%202013.pdf

[147] http://www.sciencedirect.com/science/article/pii/S0001457516303992

[148] https://www.gpo.gov/fdsys/pkg/FR-2014-04-07/pdf/2014-07469.pdf

- NHTSA (2014) Final Rule Federal Motor Vehicle Safety Standards – Rear Visibility 49 CFR Part 571, 79 FR 19177.

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

Vehicle categories M1 and N1:

- Target population (description):
  - 'Injurious car- or van-to-VRU collisions where the motor vehicle was reversing'.
  - In-depth data from Germany (GIDAS) showed that about 0.9% of all collisions (including damage-only) were reversing-car-to-VRU collisions (234 of 25,822 collisions), based on Decker *et al.* (2016).
  - A study of in-depth data from the Netherlands showed that 8.3% of traffic collisions involving vans (and where an ambulance was called) were cases where the van reversed into a non-visible vulnerable road user (5 out of 60 cases), based on (Davidse and van Duijvenvoorde, 2012). Note that the sample size of the study was limited and it is not clear whether the sampling strategy is representative of the entire country.
  - There is a large potential for underestimating the target population of this measure when using official accident statistics or in-depth data such as GIDAS or RAIDS. These statistics only record accidents on public roads, which does *not* include car parks, private driveways, company yards, etc.
  - GDV submitted evidence from German insurance claim records (which include some of the collisions not reported in official statistics). The research included only cases that involved personal injury and at least €15,000 total claims value. The research (Kühn, 2016) showed that 23% of cases occurred in a driving manoeuvre in traffic, 31% occurred during parking manoeuvres on or near the street, and 46% of cases occurred during parking manoeuvres on private or commercial property (this category would likely not show up in official accident statistics).
  - This data leads TRL to conclude that the official collision statistics (such as GIDAS) of serious cases might represent about half of the actual number. This relates to car-to-pedestrian collision (i.e. no vans, no cyclists analysed).
  - ACEA commented that damage-only collisions should not be included in cost-benefit calculations because these were cost of ownership. Note that the proposed target population definition does not include damage-only collisions.
- Fleet penetration:
  - Unknown; it could be considered to purchase accurate fleet fitment data and projections from a specialised market analysis provider.
  - ACEA estimated the fleet penetration to be 'very high'.
- Effectiveness (percentage of target population affected, benefit):
  - Camera-based systems: 41% (95% confidence interval: 12% to 61%), based on Keall *et al.* (2017).
  - Proximity sensor-based systems: 31% (95% confidence interval: minus 3% to 53%), based on Keall *et al.* (2017).

- The study by Keall *et al.* (2017) was published after the stakeholder consultation, so stakeholders did not have opportunity to comment on these values. The initially proposed values were 28-33% and 8%, respectively, based on (NHTSA, 2014). Stakeholders did not raise concerns regarding these values. Considering that Keall *et al.* (2017) is based on recent, real-word retrospective data, TRL recommend this as a source.

- Cost per vehicle at time of mandatory implementation:
  - Camera-based systems: €121–130 (full system: camera and display, equals $132–142) or €39–41 (camera-only, use existing display, equals $43–45), based on NHTSA (2014).
  - Proximity sensor-based systems: €72–126 (ultrasonic sensor-based system, equals $79–138), based on NHTSA (2014).
  - No concerns against these values were raised by stakeholders.

Vehicle categories M2, M3, N2, N3, O3 and O4:

- Target population (description):
  - 'Injurious heavy vehicle- or trailer-to-VRU collisions where the motor vehicle was reversing'.
  - Research by Volvo Trucks showed that approximately 5% of all truck-to-VRU collisions in Europe occurred when the vehicle was reversing (Volvo Trucks, 2013).
  - There is a large potential for underestimating the target population of this measure when using official accident statistics or in-depth data such as GIDAS or RAIDS. These statistics only record accidents on public roads, which does *not* include car parks, private driveways, company yards, etc.
  - TRL therefore suggest to investigate the target population for commercial vehicles also on national Health & Safety statistics, because even when reversing accidents occur on private ground many will be recorded as occupation/work accidents.
- Fleet penetration:
  - Negligible (assumption).
  - ACEA expected a low fleet penetration if not mandatory.
- Effectiveness (percentage of target population affected, benefit):
  - Initially, TRL suggested to use the same effectiveness numbers as proposed for light vehicles, based on NHTSA (2014). However, stakeholders reasoned that the accidentology was not comparable because many heavy vehicles had external audible reversing warnings (depending on regional legislation; Germany proposed mandatory reversing alarm at UN level) and sometimes a banksman supervising the reversing manoeuvre (depending on regional legislation).
  - Considering these comments TRL cannot estimate the potential effectiveness based on existing data. Note that ACEA commissioned further research by TRL into this subject which will be published early 2017.
- Cost per vehicle at time of mandatory implementation:
  - Initially, TRL suggested to use the same cost numbers as proposed above for light vehicles (€121–130 and €72–126). However, stakeholders reasoned that costs for trucks and trailers was higher than for cars because of a need for standardisation of

communication, transmission technology from trailer to vehicle, and higher durability/reliability requirements.

- One stakeholder (supplier) provided a cost estimate of €250 for proximity sensor-based systems for heavy vehicles. Confidential costing information received from OEMs for trucks and trailers suggested much higher costs than the estimates above (in relation to cameras and to detection systems). A smaller effect of economies of scale in these categories (smaller production volume) might be a reason for this.

Table 21: PESTLE analysis for REV

PESTLE Analysis: Reversing Detection or Camera Systems (REV)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Increases equitable treatment of VRUs, in particular children and the elderly, in vehicle safety legislation	n/a
Economic	Current market systems are produced by many different EU companies; regulation mandating these systems will improve employment numbers	n/a
	Reduced cost to the economy of VRU fatalities and casualties	
	Reduction in emergency service requirements	
Societal and Safety	Reduction in fatalities and serious casualties	Increased purchase price of vehicles
	Potential for reduced costs to insurance firms through reduced collision rates and casualty costs	Increased fuel costs due to increased vehicle mass
	Enabling technology for drivers (especially elderly drivers) that may have a restricted head/neck range of motion	Potential for increased costs to insurance firms through increased repair costs especially when involved in non-VRU collisions
Technological	Established technology (already fitted to production vehicles). Encouragement to bring existing systems up to a high safety standard	Potential need to adapt existing reversing camera systems to comply with legislation
		Increase in servicing/maintenance requirements due to new system
Legislative	Encourages harmonisation with regions and between OEMs by aligning with US legislation (FMVSS 111)	Risk of differences between US and EU regulations causing issues with harmonisation
		Increase in legislative costs
		Increased vehicle development and OEM compliance costs
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass
		Increased waste due to increased vehicle parts

5.18 Rear Impact Protection of the Fuel Tank (RFT)

Rear Impact Protection of the Fuel Tank (RFT)

UN Regulation No. 34 (R34) on the prevention of fire risks contains different requirements regarding the safety of fuel tanks, only some of which are currently compulsory for the approval of motor vehicles in the EU (component level tests). The rear-end collision test procedure defined in Part II-2 of the regulation (using a steel impactor) is not mandatory at the moment.

Make rear-end collision test in R34 mandatory for M1 and N1 vehicles:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Add exemptions for vehicles that do not have fuel storage, fuel supply lines and/or high voltage components located near the rear axle.

Consider modification to R34 to add an assessment of post-crash electrical safety in the rear-end collision test (as is included in UN Regulations No. 94 and 95 already).

Notes on measure:

- The potential injury mitigation under this measure is for fire related injuries (and potentially electric safety). Other possible injuries due to rear impact, such as whiplash, are not covered in this measure.
- The R34 rear-end collision test involves a rigid steel impactor of 1,100 kg mass striking the subject vehicle under full overlap at 48–52 km/h (moving barrier) or 35–38 km/h (pendulum). The corresponding US test (US FMVSS 301 on fuel system integrity) is carried out at a higher impact speed (80 km/h) using a mobile deformable barrier impactor of 1,368 kg at 70% overlap. Results from US tests are therefore not directly comparable.

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in UN Regulation No. 34, Part II-2 (Approval of vehicle with regard to the prevention of fire risks in the event of rear collision).
- ACEA provided the opinion that implementation should only apply to new types and suggested that exemptions should be added for vehicles where the test is not efficient (e.g. that do not have fuel storage, fuel supply lines and/or high voltage components located near the rear axle).
- SMMT suggested that small-volume vehicle manufacturers could fulfil this requirement (as per US FMVSS 216), but ultra-small-volume vehicle manufacturers should be exempt because it would be expensive to introduce and require destructive testing (currently exempt from under ECSSTA).
- The procedure in R34, Part II-2 does not include an assessment of post-crash electrical safety, which might need to be added so that consistency is ensured with UN Regulations No. 94 and 95.
- ACEA further provided the opinion that the assessment of post-crash electrical safety in the rear-end collision test (as is included in UN Regulations 94 and 95) should be

discussed by the experts of GRSG. If any electrical safety requirement was added, there was a need for international consensus (harmonisation with Japan).

Overlaps in benefits and technology:

- Technology layer: Passive Safety Rear
- Overlaps in benefits to consider: DDR, ISA, AEB, ESS
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Casualty reduction – Potential reduction in vehicle fire-related injuries (and perhaps electric shock-related injuries)
- Negative:
  - Increased OEM development, production and compliance costs
  - Potentially increased price of vehicle
  - Increased vehicle mass, so increased fuel use and emissions

Assessment of available body of evidence:

- There were five articles included for a detailed quality assessment, of which four were research-related articles and one article covered implementation costs (related to the US test).

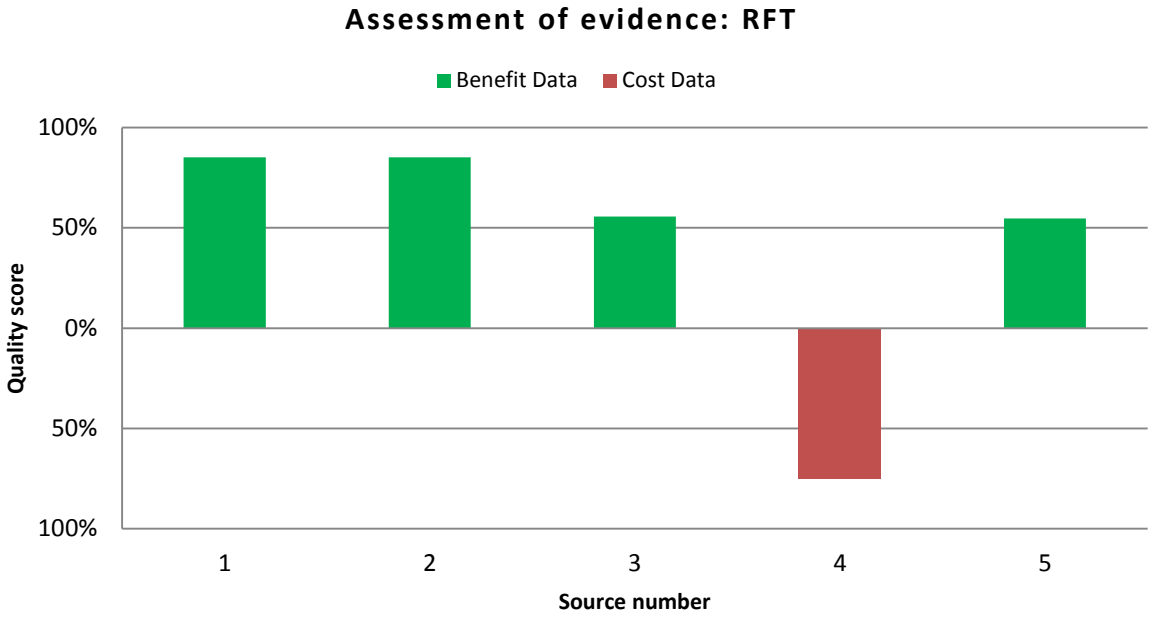


Figure 26: Level of available evidence for RFT

- The data identified for the EU might allow a broad estimate of the target population, but there was a paucity of evidence related to the effectiveness of and costs for meeting R34 rear-end collision requirements.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to extract values based on description of relevant rear-impact population. Use in-depth data or combine with the following source to estimate prevalence of resulting vehicle fires:
    - Viklund *et al.* (2013) Car Crash Fatalities Associated With Fire in Sweden[149].
  - Use in-depth data or combine with the following source to estimate delta-v distribution:
    - Eis *et al.* (2005) A detailed analysis of the characteristics of European rear impacts[150].
- Fleet penetration:
  - No sources identified.
- Benefit data:
  - EU: No sources in relation to R34 test identified.
  - USA: Pai (2014) Evaluation of FMVSS No. 301, Fuel System Integrity, as Upgraded in 2005 to 2009[151].
- Cost data:
  - EU: No sources in relation to R34 test identified.
  - USA: Ricardo (2014) Cost and Weight Analysis of FMVSS 301 Fuel System Integrity Rear Impact Test Upgrade[152].

No specific concerns regarding these sources were raised by stakeholders (although, note that the US test specification is different and values are therefore not directly transferrable).

Input values for cost-benefit model:

Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Injurious rear-impact collisions that result in a vehicle fire of the struck car or van'.
  - No concerns regarding this description were raised by stakeholders. ACEA stressed that the quoted study (Viklund *et al.*, 2013) found two fuel tank fires out of 133 fire-related crashes to be caused by a rear-end impact, and hence only 1.5% of fire-related crashes were relevant to the proposed measure.
- Fleet penetration:
  - Unknown what proportion of fleet would pass the R34 test.
  - Stakeholders did not comment or provide input on this aspect.

[149] http://www.tandfonline.com/doi/pdf/10.1080/15389588.2013.777956

[150] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.613.6366&rep=rep1&type=pdf

[151] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812038

[152] https://www.regulations.gov/document?D=NHTSA-2011-0066-0089

- Effectiveness (percentage of target population affected, benefit):
  - Unknown
  - NHTSA have undertaken an evaluation of the effectiveness of the US FMVSS 301 test. It is uncertain to what extent the results on effectiveness of the US test are transferable to those potentially achieved by implementation of R34 (more severe test in US).
  - Stakeholders did not comment or provide input on this aspect.
- Cost per vehicle at time of mandatory implementation:
  - Unknown
  - A detailed engineering analysis carried out on behalf of NHTSA (Ricardo, 2014) found an average cost of $38 per car, to achieve compliance with US FMVSS 301 for models that had previously failed. The US test configuration is more severe than R34, so the cost involved to upgrade vehicles designs for the European requirements might be less than the value quoted.
  - Stakeholders did not comment or provide input on this aspect.

Table 22: PESTLE analysis for RFT

GENERAL SAFETY REVIEW 2: Rear Impact Protection of the Fuel Tank (RFT)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Potential reduction in vehicle fire-related injuries and fatalities	n/a
	Potential reduction in electric shock-related injuries and fatalities	
	Aid international harmonisation. US and Japan have mandated rear Impact tests; however, test configurations are different	
Economic	Potentially reduced cost to the economy of casualties in vehicle fires resulting from rear impacts	Increased cost of vehicle due to additional design and material cost
Societal and Safety	Potential reduction in fatalities and causalities	Increased purchase price of vehicles
		Additional fuel costs due to increased vehicle mass
Technological	n/a	n/a
Legislative	Some level of harmonisation with US and Japanese requirements	Increased OEM compliance costs
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass

5.19 Rear Underrun Protection (RUR)

Rear Underrun Protection (RUR)

For better performance of rear underrun protection systems (RUPS), improvements in the strength of these devices and better vertical geometric alignment with the main structures of M1 vehicles are needed. The relevant legislation (UN Regulation No. 58) is currently undergoing a parallel update (reducing exemptions, changing test loads and ground clearance) that is supported by this review process of the General Safety Regulation.

Make 03 Series of amendments to R58 mandatory for N2, N3, O3 and O4 vehicles:

- 01/09/2020 new approved types
- 01/09/2022 new vehicles

Notes on measure:

- The target population of this measure are predominately car occupants in front-to-rear shunt accidents. The size of the target population of this measure will therefore be influenced by the application of AEB to the car fleet. This will have a reducing effect (prevented impacts), which will be compensated (at least partially) by a group of high speed impacts where even upgraded RUPS would currently fail, but which AEB could bring down to an impact speed where RUPS are effective.
- RUPS protects any following small vehicle in a front-to-rear impact, i.e. is also beneficial for the legacy fleet. AEB in new cars/vans is therefore not a valid replacement for implementation of RUR.
- A certain proportion of HGVs which are involved in car to rear of HGV impacts are currently exempt from having to be equipped with a RUPS. These vehicles will require special designs specific for their roles. The size of the positive economic benefits will be determined by how many types of HGVs will require a specialist design to meet the new requirements and overcome restrictions created by this.

Considerations regarding potential technical requirements:

- Requirements and type-approval test procedure are defined in the 03 Series of Amendments to UN Regulation No. 58 (close to finalisation; contains reduced exemptions, reduced ground clearance and increased test forces compared to 02 Series of Amendments).
- In addition, it might be considered in the future to introduce an additional load condition of 100 kN applied simultaneously to three points, as suggested by Smith *et al.* (2008)[153] and Minton & Robinson (2010)[154], in order to ensure adequate strength of the RUP device. Stakeholders commented that this would not be included in 03 Series of Amendments (which was close to finalisation), and this discussion would rather be relevant for the next Series.

[153] https://circabc.europa.eu/sd/a/bf5be9b8-54d5-42be-866d-a1c47e81cad4/20140903-121938_PPR317_RUP_Final_report_March_08.pdf

[154] https://trl.co.uk/reports/PPR517

Overlaps in benefits and technology:

- Technology layer: Passive Safety Rear
- Overlaps in benefits to consider: AEB, DDR and ISA (for M1, N1); ESS (for N2, N3, O3 and O4)
- Overlaps in technology to consider: None

Main Impacts:

- Positive:
  - Reduction in number of car passenger fatalities and serious injuries
  - Requirements already defined at UN level
- Negative:
  - A stronger design may well be heavier. If so this may reduce payload (impact on operator profit if load is mass-limited rather than volume-limited) and will increase fuel consumption and emissions
  - Reducing the ground clearance of the RUPS may restrict some vehicle combinations due to having a lower angle of departure (boarding/disembarking ferry or off road)

Assessment of available body of evidence:

- There were nine articles included for a detailed quality assessment, eight of which were research-related articles (two of which also contained cost information) and one were a cost-benefit study.

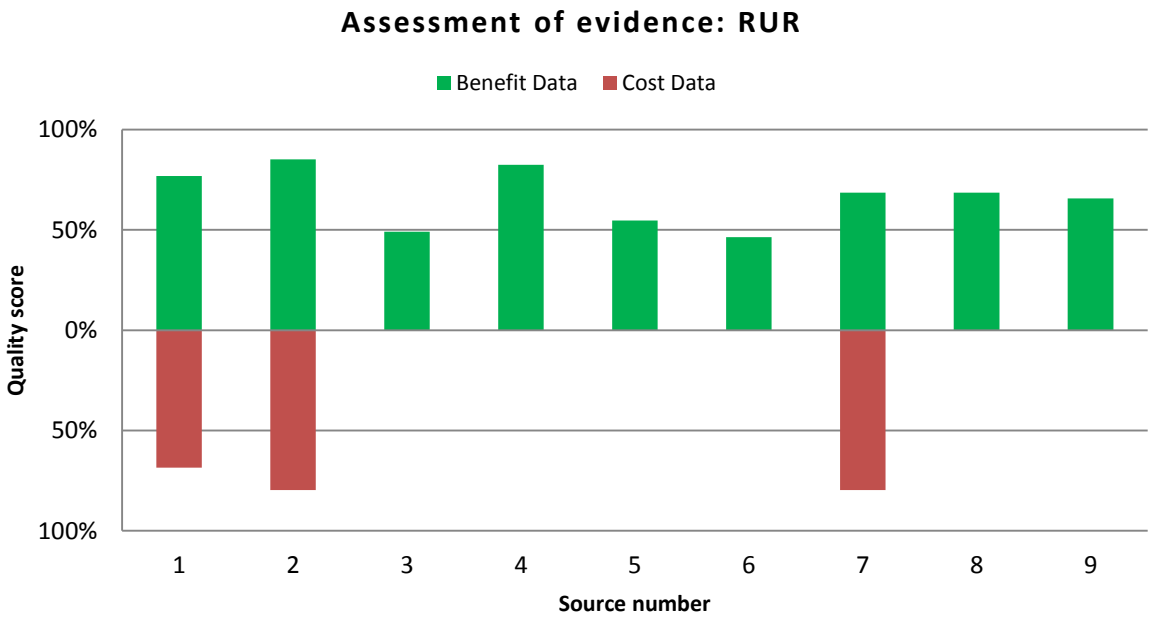


Figure 27: Level of available evidence for RUR

- There is a large amount of data available on potential benefits of this measure from predictive studies, crash tests and real-world collisions. The available cost-benefit study for an additional load condition was performed for Europe by Smith *et al.* (2008). Most of the UK data on rear impact protection was conducted before 2010. New information on RUPS is available; however, the majority of it comes from NHTSA in the USA which cannot directly be transferred to the EU situation due to the differences in the fleet.

- The cost-benefit study for the 03 Series of Amendments to R58 was performed by BASt in 2013. This is summarised comprehensively in the document (GRSG/Germany, 2013).

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

For 03 Series of Amendments to UN Regulation No. 58:

- GRSG/Germany (2013) Proposal for draft amendments to Regulation No. 58 – Justification for amendments proposed in document GRSG/2013/27 – Informal document GRSG-105-23[155].

For additional load condition:

- Target population:
  - Use CARE database, scaled-up national data from member states' police records and/or in-depth data to extract values based on description of target population, in combination with:
    - Smith *et al.* (2008) Development of test procedures, limit values, costs and benefits for proposals to improve the performance of rear underrun protection for trucks[156].
    - Minton and Robinson (2010) Rear underrun protection for heavy goods vehicles – The potential effects of changes to the minimum technical requirements[157].
- Fleet penetration:
  - No sources identified
- Benefit data:
  - Smith *et al.* (2008) Development of test procedures, limit values, costs and benefits for proposals to improve the performance of rear underrun protection for trucks.
- Cost data:
  - Smith *et al.* (2008) Development of test procedures, limit values, costs and benefits for proposals to improve the performance of rear underrun protection for trucks.

Stakeholders did not raise concerns regarding these sources, but suggested that additional load conditions should not be considered for 03 Series of Amendments which was close to finalisation.

Input values for cost-benefit model:

It is recommended to consider implementation of the 03 Series of Amendments to UN Regulation No. 58 based on the cost-benefit results from:

[155] https://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grsg/GRSG-105-23e.pdf

[156] https://circabc.europa.eu/sd/a/bf5be9b8-54d5-42be-866d-a1c47e81cad4/20140903-121938_PPR317_RUP_Final_report_March_08.pdf

[157] https://trl.co.uk/reports/PPR517

- GRSG/Germany (2013) Proposal for draft amendments to Regulation No. 58 – Justification for amendments proposed in document GRSG/2013/27 – Informal document GRSG-105-23[158]

If the additional load condition should be investigated, the following preliminary input values for a cost-benefit model are suggested based on the studies referenced above.

- Target population (description):
  - 'Car-to-HGV front-to-rear impacts where the car occupants suffered fatal or serious injuries'.
  - Stakeholders raised no concerns regarding this description.
- Fleet penetration:
  - Unknown what proportion of the current fleet would pass the amended requirements.
  - Stakeholders did not comment or provide additional data on this aspect.
- Effectiveness (percentage of target population affected, benefit):
  - 22.6–34.1% for fatalities, 52% for serious casualties, based on Smith *et al.* (2008)
  - Stakeholders did not raise concerns regarding these values.
- Cost per vehicle at time of mandatory implementation:
  - €100–200 for vehicle already fitted with fixed RUPS.
  - Confidential costing information received from OEMs confirmed the order of the estimates above (they lie within the range provided by OEMs) for updating geometry and strength.
  - €850–1,600 (folding RUPS) or €1,900–4,600 (sliding or extending RUPS) for vehicles currently exempt and requiring special RUPS design, based on Smith *et al.* (2008).
  - Stakeholders did not raise concerns regarding these values.

[158] https://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grsg/GRSG-105-23e.pdf

Table 23: PESTLE analysis for RUR

GENERAL SAFETY REVIEW 2: Rear Underrun Protection System (RUR)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Increased HGV safety for cars	n/a
Economic	Reduced cost to the economy of car passenger fatalities and injuries	Possible Increase in cost/price of vehicle
	Reduction in emergency service requirements	
	Reduction in road closures/congestion leading to increase in productivity	
Societal and Safety	Reduction in fatalities/serious casualties	Increase in vehicle complexity/maintenance costs for HGVs requiring a specific RUPS design for their role (e.g. tipper-trucks)
Technological	n/a	n/a
Legislative	Requirements already defined	Increased OEM compliance costs
Environmental	n/a	Increased CO_2 and other emissions due to increased vehicle mass
		Reduce payload due to increased vehicle mass (impact on operator profit)

5.20 Regulation 95 Side Impact Occupant Protection – Removal of Exemptions (S95)

Regulation 95 Side Impact Occupant Protection – Removal of Exemptions (S95)

UN Regulation 95 (R95) consists of a mobile deformable barrier side impact test which represents being impacted by another vehicle. Currently this is only performed with M1 and N1 vehicles with an R-point of the lowest seat of ≤700 mm.

Expand scope to include all M1 and N1:

- 01/09/2020 new approved types
- 01/09/2022 new vehicles

Notes on Measure:

- There is currently an exemption for vehicles with high seating positions (e.g. SUVs). Exemption is because the barrier impacts low down below the height of the seated ATD and therefore ATD injury metrics are unlikely to be exceeded. However, fuel system integrity, protection against electrical shock and door opening are also assessed as part of the test, which might be a reason to consider removing the exemption.
- ACEA reasoned that the benefits for N1 vehicles with higher seating position would be very limited and pointed out that SUVs and pick-ups generally scored high in Euro NCAP side impact tests (89% of tested vehicles score maximum points).
- It should be closely investigated how big the remaining benefit is if R135 (pole side impact) is also made mandatory: ACEA reasoned that the R135 pole impact test was more relevant for structural integrity than the R95 barrier side impact test for high vehicles. Note that R135 itself contains exemptions for some N1 vehicles based on geometric vehicle measures (different from the R-point height).
- VTI provided input motivating the development and use of female crash test dummies. The documents included a research review that confirms an elevated injury risk for females compared to males. The specific suggestion made is to use a male in one of the side impact tests (R95 and R135) and an (average) female dummy in the other side impact test. The authors acknowledge that a female average dummy would still need to be developed.

Considerations regarding potential technical requirements:

- Note that the test to verify fuel system integrity, protection against electrical shock and door opening for currently exempted vehicles could be performed without an ATD to reduce cost.
- Stakeholders commented that all electrically propelled vehicles must already fulfil the impact test requirements of R100 with regard to electrical safety, also those M and N vehicles that are exempted from R95. Note that R100 does not cover conventional (i.e. petrol- or diesel-powered) vehicles.
- SMMT reasoned that small-volume vehicle manufacturers could fulfil this measure but that ultra-small-volume vehicle manufacturers should be exempt because it would be expensive to introduce, and require destructive testing – which currently exempt from under ECSSTA.

Overlaps in Benefits and Technology:

- Technology Layer: Passive Safety Side
- Overlaps in benefits to consider: Target population may be reduced by ISA, DDR, LKA. SBR might increase the population being potentially protected by this measure
- No overlaps in technology

Main Impacts:

- Positive:
  - Reduction of car-to-car side impact fatalities and injuries
  - Ensuring minimum protection levels for all M1 and for N1
  - Ensuring that all M1 and N1 meet consumer expectations for side impact crash safety
- Negative:
  - Increased cost/price of vehicle due to the development cost for any vehicles that do not already meet the requirements
  - Compliance costs for vehicles that do meet the requirements despite not being required to perform the test yet
  - Potentially increased vehicle mass, so increased fuel use and emissions, for any vehicles that do not already meet the requirement

Assessment of available body of evidence:

- There were five articles included for a detailed quality assessment, of which four were research-related articles, and one was found to include both cost and benefit data, which was an Australian study to estimate the benefits from proposed ECE regulation; however, there was no evaluation of extending the scope to include R-points >700 mm.

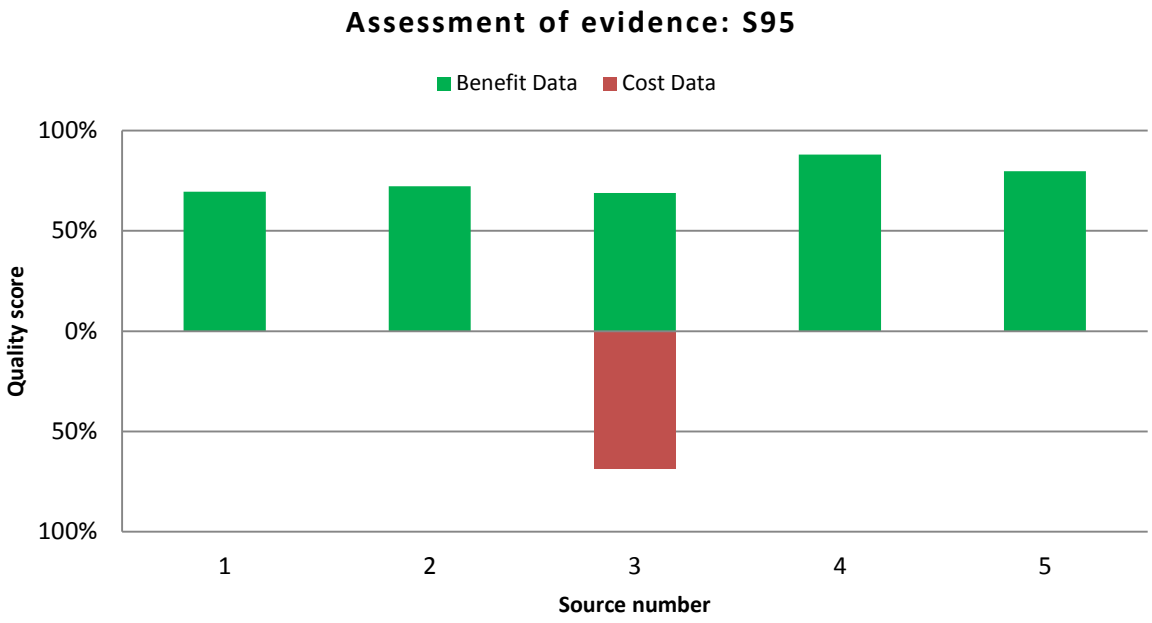


Figure 28: Level of available evidence for S95

Appropriate sources for input data:

- It should be noted that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly. This study will provide further information on the size of the target population, fleet penetration and potential effectiveness.

Input values for Cost-benefit Model:

- Target population:
  - Values from TRL/CEESAR study (to be published shortly).
- Fleet penetration:
  - Values from TRL/CEESAR study (to be published shortly).
- Benefit data (effectiveness):
  - Values from TRL/CEESAR study (to be published shortly).
- Cost data:
  - No specific values identified.
  - Stakeholders did not provide additional input.

Table 24: PESTLE analysis for S95

GENERAL SAFETY REVIEW 2: Side Impact R95 – Removal of Exemptions (S95)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Removal of exemptions for M1 vehicles so that consumers have the minimum level of side impact crash safety that they would expect for a car	n/a
	Ensuring that all M1 and N1 meet minimum side impact standards	
Economic	EU Benefits of saving fatal, serious and slight injuries/overall reduction in casualties	Increased cost of vehicles that don't already comply
Societal and Safety	Reduction in the number and cost of fatal and serious injuries	Potentially increased purchase price of vehicles that don't already comply
Technological	The technology required to meet R95 requirements is very well established and understood	n/a
Legislative	n/a	Compliance cost for vehicles that do and don't already meet the requirements
		Definition of new legislative requirements if no ATD was used
Environmental	n/a	Potential increase of vehicle mass and therefore fuel use and emissions, for vehicles that require modification

5.21 Seat-Belt Reminders (SBR)

Seat-Belt Reminders (SBR)

From 2014, the General Safety Regulation has required the fitment of SBR for driver's seats of M1 vehicles (currently applicable 06 Series of Amendments to UN Regulation No. 16). A joint proposal by the EC, Japan and the Republic of Korea for the 07 Series of Amendments to UN Regulation No. 16 has been presented to GRSP in 2015 to expand fitment to other vehicle categories and seating positions.

Make SBRs mandatory for M1 and N1 vehicles (all front and rear seats) and for N2, N3, M2 and M3 vehicles (front seats):

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Notes on measure:

- An assessment protocol for SBR exists in Euro NCAP, updates to which will be published early 2017. Euro NCAP intends to incentivise SBRs with occupancy detection for rear seats from 2018. This increases both system cost and effectiveness compared to the more simple systems proposed at UN level.

Considerations regarding potential technical requirements:

- A joint proposal by the EC, Japan and the Republic of Korea for the 07 Series of Amendments to UN Regulation No. 16 has been presented to GRSP in 2015 (ECE/TRANS/WP.29/GRSP/2015/19)[159]. It contains proposed technical requirements for SBRs on the front row seats of all M and N category vehicles and additionally on the rear seats of M1 and N1 vehicles (unbuckling test only, no occupancy detection).
- ACEA suggested that additional exemptions should be considered for removable seats and seats in a row with suspension seating.
- SMMT reasoned that small-volume vehicle manufacturers and ultra-small-volume vehicle manufacturers could fulfil this measure but mentioned difficulties for 4-point harnesses and issues with two-seater vehicles where the passenger seat was often used to carry luggage/helmet which might activate seat sensors.

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: Can enhance the effectiveness of most passive safety measures
- Overlaps in technology to consider: None

Main impacts:

- Positive:
  - Reduction in casualties through increased seat-belt wearing rates

[159] http://www.unece.org/fileadmin/DAM/trans/doc/2015/wp29grsp/ECE-TRANS-WP.29-GRSP-2015-19e.pdf

- Negative:
  - Implementation and compliance costs

Assessment of available body of evidence:

- TRL's recent study (McCarthy and Seidl, 2014)[160] on the benefit of fitment of seat belt reminders provides a detailed analysis of predicted casualty savings (and monetisation of those) for mandatory introduction across EU-28. Data from a recent Norwegian study (Høye, 2016)[161] might be used to update or confirm some of the input values used for TRL's study if needed.

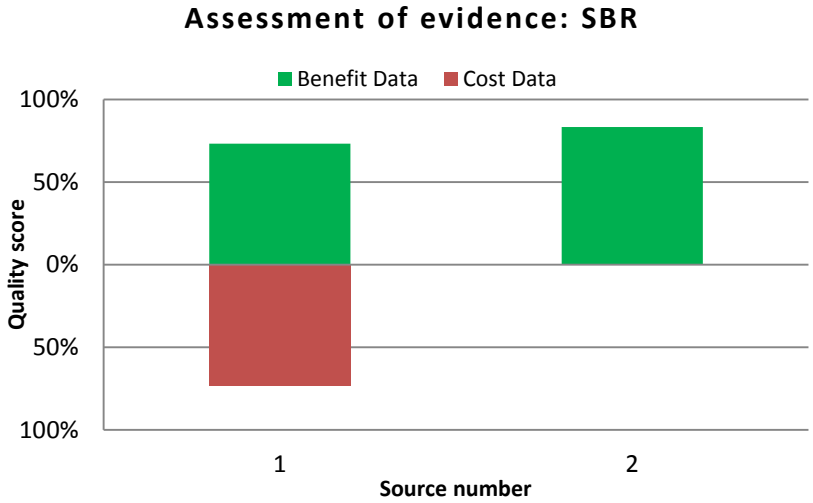


Figure 29: Level of available evidence for SBR

- No new data on implementation costs could be identified, although the aforementioned TRL study provides estimates of component costs, which could be used as indicative values. The outcomes of this study, combined with more detailed cost figures (if available), would allow a cost-benefit assessment of the proposed measure.

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Cost-benefit calculations:
  - McCarthy and Seidl (2014) Benefit assessment for fitment of Seat Belt Reminder (SBR) systems to M1 passenger seat positions and to other vehicle types[162].
  - No concerns were raised by stakeholders regarding using this source.

[160] http://bookshop.europa.eu/en/benefit-assessment-for-fitment-of-seat-belt-reminder-sbr-systems-to-m1-passenger-seat-positions-and-to-other-vehicle-types-pbNB0214430/

[161] https://www.ncbi.nlm.nih.gov/pubmed/26788959

[162] http://bookshop.europa.eu/en/benefit-assessment-for-fitment-of-seat-belt-reminder-sbr-systems-to-m1-passenger-seat-positions-and-to-other-vehicle-types-pbNB0214430/

Input values for cost-benefit model:

It is recommended to consider implementing SBR legislation based on the cost-benefit results from McCarthy and Seidl (2014). M1 rear seats showed a low break-even cost, but should be included in order to guarantee safety equivalence across different price segments and across different European regions. No concerns were raised by stakeholders regarding this.

- The low break-even cost might suggest that basic systems without occupancy detection are most appropriate for legislation for rear seats. However, stakeholders pointed out that the cost estimates of the TRL study were based on current technologies for occupancy detection (seat mats) and new technologies (e.g. based on cameras shared with other systems) might make occupancy detection cheaper. Therefore, the low break-even should not be considered prohibitive of requiring occupancy detection for rear seats in legislation.
- Note that confidential costing information received from OEMs for N2 and N3 vehicles suggests that the costs for passenger seats in these vehicles could be greater than the break-even cost calculated by McCarthy and Seidl (2014). Stakeholders did not have a chance to comment on this information. A smaller effect of economies of scale in these categories (smaller production volume) might be a reason for this. However, as these values are much greater than any estimates performed by TRL for the McCarthy and Seidl (2014) study, more justification/evidence is required in TRL's view to take the high cost estimates into account.

Table 25: PESTLE analysis for SBR

GENERAL SAFETY REVIEW 2: Seat-Belt Reminders (SBR)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Increased belt use will improve protection during collisions, thereby reducing casualties	n/a
Economic	Reduction in emergency service requirements: Reduced casualty numbers	n/a
Societal and Safety	Reduction in fatalities/casualties: Increased belt use will improve protection during collisions, thereby reducing casualties	Potential acceptance issues among certain driver groups, potentially in particular in commercial vehicles
Technological	n/a	n/a
Legislative	n/a	n/a
Environmental	n/a	Increased vehicle mass leading potentially to increased CO_2 emissions

5.22 Side impact collision protection for Far-Side occupants (SFS)

Side impact collision protection for Far-Side occupants (SFS)

Approximately 40% of fatalities in side impact collisions are seated on the non-struck side of the vehicle. This measure concerns the addition of far-side occupant protection, noting that a suitable test protocol needs to be established.

Make mandatory for M1 and N1 vehicles:

- 01/09/2022 new approved types
- 01/09/2024 new vehicles

Notes on measure:

- Euro NCAP plan to introduce assessment of far-side occupant protection in 2018.
- ACEA raised the concern that no design solutions were proven to be effective.
- One manufacturer (Chevrolet) has far-side occupant protection (front centre side airbag) in current (US-market) production vehicles.
- Research by GDV (Kühn and Bende, 2016)[163] based on German in-depth data found no clear evidence for an increased injury risk due to contact between driver and front seat occupant. However, some driver injuries (e.g. lumbar vertebra, liver, spleen) that were caused by the seat belt or by the upper body movement towards the centre console might be an indication for a possible reduction of these injuries by an advanced device (more stable centre airbag compared to Chevrolet solution).
- Yoganandan *et al*. (2014)[164] studied far-side crash characteristics. Their findings show for example, the cumulative distribution of changes in velocities at the 50% level for the struck vehicle for all occupants, MAIS 2+ and MAIS 3+ occupants were 19, 34 and 42 km/h, respectively.
- Bahouth *et al.* (2015)[165] studied characteristics of far-side crashes that are associated with serious injuries among belted front seat occupants in the US. Stakeholders commented that the study was based on US NASS data and might be considered biased towards having more pick-ups and vans as bullet vehicles, but much of the potential benefits were general.

Considerations regarding potential technical requirements:

- A defined legislative test protocol is not yet available and needs to be established. A test protocol from Euro NCAP is likely to be available in a suitable timescale.
- Stakeholders raised concerns about the feasibility to design a representative test procedure and the suitability of existing ATDs, which were designed for near-side tests.

[163] Presented by GDV at crash.tech-Conference, April 19th, 2016, Munich; see annex to this report

[164] https://www.ncbi.nlm.nih.gov/pubmed/25307394

[165] http://www-esv.nhtsa.dot.gov/Proceedings/24/files/Session%2019%20Written.pdf

- SMMT reasoned that small and ultra-small-volume vehicle manufacturers should be exempt from this measure because it would be very difficult to fit in convertibles/vehicles with no roof, as it requires airbags in middle of vehicle. This would be costly to introduce and require redesign of vehicles interior dimensions, layout and structure.

Overlaps in benefits and technology:

- Technology layer: Passive Safety Side
- Overlaps in benefits to consider: Target population may be reduced by ISA, DDR, LKA. SBR might increase the population being potentially protected by this measure
- No overlaps in technology

Main impacts:

- Positive:
  - Reduction of side impact fatalities and injuries
- Negative:
  - Increased cost/price of vehicle
  - Increased development and compliance costs
  - Increased vehicle mass, so increased fuel use and emissions

Assessment of available body of evidence:

- There were 10 articles included for a detailed quality assessment. All were research articles related to benefit information; one of them also contained cost data. There is a decent amount of evidence regarding the target population, but a paucity of evidence regarding real-world effectiveness of potential solutions.

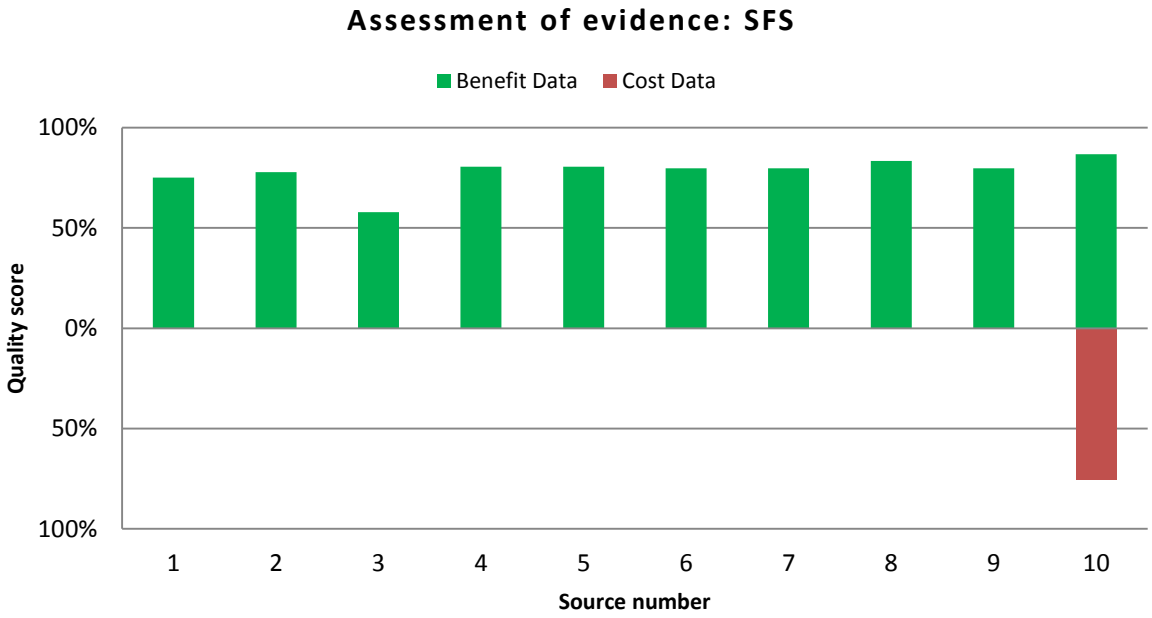


Figure 30: Level of available evidence for SFS

- The key conclusion of this research is that it is highly important to focus on the far-sided occupants as the injury rates are equally high as the near side occupants in a side impact.

Appropriate sources for input data:
The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from Member State's police records to extract values based on description of target population. Use in-depth data to estimate the prevalence of far-side occupants. Combined with:
    - Thomas *et al.* (2009) Priorities for Enhanced Side Impact Protection in Regulation 95 Compliant Cars[166].
    - Sander *et al.* (2010) Analysis of far-side impacts in Europe – Occurrence, injury outcome and countermeasures[167].
    - Kühn and Bende (2016) Side impact accidents with cars – Research questions and answers from the view of the German Insurers Accident Research[168].
- Fleet penetration:
  - No sources identified.
- Benefit data:
  - Fildes and Digges (2010) Occupant Protection in Far-Side Crashes[169].
  - Boström *et al.* (2008) Injury Reduction Opportunities of Far Side Impact Countermeasures[170].
- Cost data:
  - No sources identified.

No concerns were raised by stakeholders regarding these sources.

Input values for cost-benefit model:
Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - 'Side impact collisions where far-side occupants in cars or vans are killed or seriously injured'.
  - In 28% of all injurious M1 side collisions in Germany a second front seat occupant was present in the car. 29% of these front seat occupants are MAIS 2+ injured and in 20% of these MAIS 2+ cases front seat occupants are far side occupants; based on Kühn and Bende (2016).

[166] www-nrd.nhtsa.dot.gov/pdf/esv/esv21/09-0156.pdf

[167] Ulrich Sander, Ola Boström. Analysis of far-side impacts in Europe – Occurrence, injury outcome and countermeasures. 10th International Symposium and Exhibition on Sophisticated Car Occupant Safety Systems, Conference "Airbag2010", 2010.

[168] Presented by GDV at crash.tech-Conference, April 19th, 2016, Munich; see annex to this report

[169] www.monash.edu/__data/assets/pdf_file/0020/216830/muarc294.pdf

[170] www.ncbi.nlm.nih.gov/pubmed/19026245

- 4% of all injurious M1 side collisions in Germany showed injury characteristics that could potentially be addressed by an advanced device (more stable centre airbag compared to Chevrolet solution), based on Kühn and Bende (2016).
- Fifty-six percent of MAIS 3+ injured far-side occupants sustain severe injuries to the thorax and 50% to the head due to contact with the (intruded) far-side structure, the seat belt, the adjacent seat structure or, if applicable, the adjacent occupant; based on Sander *et al.* (2010).
- No data available on N1 occupants; stakeholders commented that occupancy of front passenger seat was likely lower than for M1.

- Fleet penetration:
  - Currently negligible (assumption)
  - No concerns were raised by stakeholders against this assumption.
- Effectiveness (percentage of target population affected, benefit):
  - 18–57% serious and fatal injury reduction in far-side impacts, based on Boström *et al.* (2008) and Fildes and Digges (2010)
  - No specific concerns were raised against these values. However, stakeholders questioned the effectiveness of existing design solutions (front centre side airbags).
- Cost per vehicle at time of mandatory implementation:
  - No definitive costs available, but approximately €100 based on similarity with existing head/thorax airbags and vehicle recall information from the USA.
  - No concerns were raised by stakeholders against this value.

Notes:

- ACEA suggested that an accident analysis should compare the rate of serious/fatal injury on near side and far side (not just general injury rate).

Table 26: PESTLE analysis for SFS

GENERAL SAFETY REVIEW 2: Side impact collision protection for Far-Side occupants (SFS)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Reduction of injuries and fatalities in EU	n/a
	Harmonising with Euro NCAP to ensure a minimum far-side occupant protection level for all M1	
Economic	Reduction in the cost of fatal and serious and injuries	Increased cost of vehicles due to including injury mitigation technology
Societal and Safety	Reduction in the number of fatal and serious injuries	Increased purchase price of vehicles
Technological	Technology to mitigate far-side collision injuries is established and in limited production	n/a
Legislative	Potential to harmonise requirements with other regions that are interested in far-side occupant protection	Cost of defining legislative requirements (although likely to be able to base requirements on expected Euro NCAP protocols)
		OEM compliance cost
Environmental	n/a	Increase of vehicle mass and therefore fuel use and emissions

5.23 Tyre Pressure Monitoring System (TPM)

Tyre Pressure Monitoring System (TPM)

Tyre Pressure Monitoring Systems (TPMS) report tyre-pressure information to the driver of the vehicle, either via a gauge, a pictogram display, or a simple low-pressure warning light.

TPMS compliant with UN Regulation No. 64 (R64) have been mandatory for all new M1 vehicles sold since 2014.

Ideally, TPMS should:

- be capable of detecting over a wide range of road and environmental conditions;
- not be possible to deactivate;
- detect a pressure of less than 1.5 bar or detect incorrect set/reset attempt (for M1 and N1);
- cover any tyre of approved size, including after-market replacement tyres;
- react quicker than 10 minutes to a puncture.

Make TPMS mandatory for all M and N vehicles and O3 and O4 trailers:

- 01/09/2020 for new approved types
- 01/09/2022 for new vehicles

Consider amendments to the technical requirements in R64 to reflect the aspects above.

Notes on measure:

- There are two different technological solutions for TPMS: Direct TPMS (dTPMS), which rely on direct measurement via additional pressure sensors in the wheels, and indirect TPMS (iTPMS), which analyse rotational wheel speed patterns measured via existing ABS/ESC sensors to determine underinflation. Both technologies can detect deflation of an individual tyre and simultaneous deflation of up to four tyres. dTPMS are suitable for all vehicle categories. iTPMS can be used on cars and most vans, but not on vehicles with more than four wheels or twin-wheels (van Zyl *et al.*, 2013)[171].
- With regard to the level of technical maturity of dTPMS solutions for heavy vehicles and trailers (N2, N3, O3, O4, M2, M3), stakeholders expressed opposing views: According to a TNO study, technically mature dTPMS solutions for commercial vehicles are available on the market (van Zyl *et al.*, 2013). Commercial vehicles do have some additional requirements compared to passenger cars, related to greater transmission distance of the sensors, multiple trailers used in HGV fleets and differences in tyre management (TyrePal, 2013)[172]. ACEA raised the concern that the technology was not

[171] http://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf

[172] http://www.tyrepal.co.uk/wp-content/uploads/Truck-white-paper-201306251.pdf

mature and pointed out that standards for communication between the trailers and vehicles do not exist.

- Tyre inflation pressure is not only related to fuel efficiency but also to road safety: Underinflated tyres can lead to bad vehicle handling and increased stopping distances, and can be related to catastrophic tyre failure (through increased stress and heat build-up). Choi (2012)[173] undertook research into the role of tyre pressure in collisions involving US light vehicles. He found that tyres that were severely underinflated (by more than 25%) were three times as likely to be a critical element in the pre-crash phase compared to properly inflated tyres. An earlier study by MacIsaac and Garrott (2002)[174] showed that the coefficient of friction reduces for severely underinflated tyres on dry roads.
- A US study on an on-road light vehicle sample (Sivinski, 2012)[175] found that the presence of TPMS in a vehicle resulted in a 55.6% reduction in the likelihood of one or more tyres being severely underinflated. Note that all vehicles included in this study featured dTPMS systems. Note further that the reasons for the effectiveness not reaching 100% were not investigated in the study and could be related to technical capabilities of the TPM systems and/or to the way drivers use and maintain the systems (whether they act on warnings, repair malfunctioning sensors, etc.).
- Sivinski (2012) found that TPMS are equally effective in light trucks and vans compared to passenger cars for moderate levels of underinflation and even more effective for severe underinflation. TPMS were also significantly effective at preventing overinflation. This might be an unintended benefit of the technology improving vehicle handling and reducing tyre wear in otherwise overinflated tyres.
- The NHTSA study on a collision sample of light vehicles cited above (Choi, 2012), found that significantly fewer tyres were severely underinflated in vehicles where a TPMS was in use. This indicates a positive effect of TPMS on road safety.
- DVR provided the opinion that drivers should be informed which measures have to be taken to ensure permanent performance of indirect and direct TPMS (e.g. information in car owner's manuals, public relations by DVR and others), because they might not currently understand well the alerts and the reset procedures necessary. DVR further recommended to include TPMS as a topic in driver education and driving tests. NIRA Dynamics also stressed the importance of raising driver education and awareness.
- Bridgestone reasoned that the potential economic benefits for commercial vehicles from reduced breakdown time were large: "*The presence of TPMS on all vehicles offers the possibility to implement preventive trends analysis to detect imperceptible air leakages from monitored tyres; in fact, pressure related roadside breakdowns are mainly coming from pressure losses that can be traced back more than one day. Therefore, the connection of the TPMS into the Telematics data may allow an improved service model where the fleet shares the information with a service provider, who monitors the trends of pressures during the time and alerts in case of inflation needs as timely as possible.*"

[173] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811617

[174] https://www.nhtsa.gov/DOT/NHTSA/NRD/Multimedia/PDFs/VRTC/ca/capubs/tireinflationpressure.pdf

[175] https://crashstats.nhtsa.dot.gov/Api/Public/Publication/811681

Considerations regarding potential technical requirements:

- The currently applicable legislation for M1 and N1 (if fitted) vehicles is the 02 series of amendments to R64, which requires a warning activation within a timeframe of 10 minutes for rapid deflation (for one tyre) and a 60 minute timeframe for diffusion (for two or more tyres). UN R64.02 has an activation tolerance of 20% below the tyre's warm pressure (in relation to an initial setting in accordance with the vehicle manufacturer's recommended cold inflation pressure). There are proposals in Geneva to move these requirements to a separate TPMS regulation[176].
- There is an ongoing technical discussion on the effectiveness of TPMS in real-world scenarios differing from those tested in regulation. Stakeholders provided opposing views on this issue. It is beyond the scope of this study to settle these technical arguments (which go beyond cost/benefit questions of introducing new measures into the General Safety Regulation) and they would best be addressed by technical experts in a working group. For detailed stakeholder input on this aspect please refer to the corresponding submissions from Transport & Environment, NIRA Dynamics and Audi in annexes to this report.
- With regard to reducing detection times in existing technical requirements, stakeholders provided the following input:
  - NIRA Dynamics reasoned that the puncture test in legislation was not designed to focus on blowouts, but rather punctures which can take between 5 minutes up to days to deflate a tyre. Blowouts, which are extremely high-rate punctures, were not in scope of a TPMS because a TPMS warning might even be distracting from necessary attention in these cases. Shortening puncture warning times would have drawbacks, such as higher risk of false alarms, higher battery consumption for dTPMS and compromising customer credibility in the long run.
  - ACEA provided the opinion that any amendments to existing requirements should be carefully analysed and discussed with experts in GRRF at UN level.
- With regard to new technical requirements for heavy vehicles and trailers (M2, M3, N2, N3, O3 and O4), stakeholders provided the following input:
  - DVR stated that R64 would need to be adapted for heavy vehicles taking into consideration compatibility between tractor and trailer systems. Systems should provide an actual tyre pressure readout.
  - ACEA raised concerns regarding operational difficulties for multi-stage vehicles (in category N2 and N3) and compatibility between trailers and tractor units. Also, the high numbers of tyre types for commercial vehicles and the high prevalence of re-treaded tyres increased complexity for commercial vehicles compared to passenger cars.
  - ETRMA conceded that compatibility between the trailers and the tractors would lead to some supplementary costs and require standardised solutions for trailers and tractors that do not always belong to the same fleet. To lower this hurdle, different trailer solutions could be put in place, such as: (1) stand-alone trailer system with an indicator light on side of trailer to signal tire status in case of e.g. under-inflation; (2) supervision by tractor: on trailer side, only sensors in tires are necessary, they will be received by receiver on tractor; or (3) trailer system connected to CAN bus. ETRMA also pointed out that compatibility/communication

[176] http://www.unece.org/fileadmin/DAM/trans/doc/2016/wp29grrf/GRRF-81-22e.pdf

needs have been resolved for other systems in the past (lights, air pressure, braking system/ABS).

- SMMT reasoned that small-volume vehicle manufacturers could fulfil this measure and that ultra-small-volume vehicle manufacturers could fulfil this measure if systems were available as bought-in units.

Overlaps in benefits and technology:

- Technology layer: Driver Assistance
- Overlaps in benefits to consider: None
- Overlaps in technology to consider: For dTPMS no overlap; for iTPMS overlap with existing sensors for ABS/ESC

Main impacts:

- Positive:
  - Economic benefits: Reduced fuel costs, reduced tyre replacement costs (increased tyre life), reduced vehicle breakdown time
  - Environmental benefits: Increased fuel efficiency and reduction in emissions and waste
  - Safety benefits: Potential reduction in tyre-related fatalities/serious casualties
- Negative:
  - Increased purchase price of vehicles and trailers
  - Increase in vehicle complexity/maintenance requirements

Assessment of available body of evidence:

- There were six articles included for a detailed quality assessment, of which two were research-related articles and four were cost-benefit studies (two European, two US studies):
  - EU (on TPMS for commercial vehicles): Van Zyl *et al.* (2013) Study on Tyre Pressure Monitoring Systems (TPMS) as a means to reduce Light-Commercial and Heavy-Duty Vehicles fuel consumption and CO_2 emissions (TNO 2013 R10986)[177].
  - EU (on amended technical requirements for M1): Jansen *et al.* (2014) Study on some safety-related aspects of tyre use (TNO 2014 R11423)[178].
  - USA (light vehicles): NHTSA (2005) Tire Pressure Monitoring System FMVSS No. 138 – Final Regulatory Impact Analysis[179].
  - USA (heavy vehicles): Ogunwemimo (2011) Economic Analysis of Continuous Monitoring of Commercial Truck Tire Pressure Using Tire Pressure Monitoring Systems (TPMS) and RFID Technologies[180].

[177] http://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf

[178] https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/vehicles/study_tyres_2014.pdf

[179] https://www.nhtsa.gov/DOT/NHTSA/Rulemaking/Rules/Associated%20Files/TPMS-2005-FMVSS-No138.pdf

[180] http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1027&context=imsediss

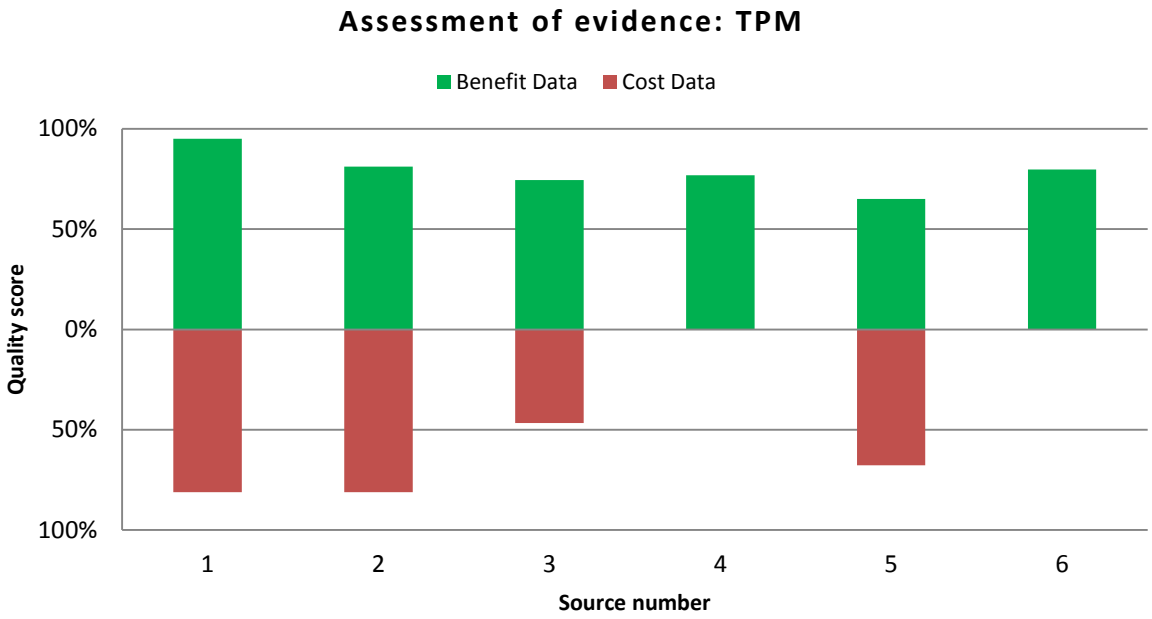


Figure 31: Level of available evidence for TPM

- The European cost-benefit studies have taken into account environmental, economic and safety aspects of TPMS and provide a strong evidence base for the measure under consideration. The relative contribution of these individual aspects to the overall cost savings associated with TPMS were as follows (calculations by TRL, based on Table 4 of van Zyl *et al.* (2013); range represents estimates for different vehicle categories and applications):
  - Extended lifetime of tyres: 31–57%
  - Fuel savings: 23–40%
  - Reduced vehicle break-down: 3–25%
  - Reduced accidents (safety aspects): 4–8%
  - Reduced emissions: 1–4%

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Cost-benefit calculations (implementation on M2, M3, N1, N2, N3, O3 and O4):
  - Van Zyl *et al.* (2013) Study on Tyre Pressure Monitoring Systems (TPMS) as a means to reduce Light-Commercial and Heavy-Duty Vehicles fuel consumption and CO_2 emissions (TNO 2013 R10986)[181].
  - NIRA Dynamics announced publication of a lifecycle analysis on dTPMS, which could inform the discussion on this measure, to be published early 2017.
- Cost-benefit calculations (amendment to reduce detection times in existing technical requirements for M1):
  - No appropriate sources identified.

[181] http://ec.europa.eu/clima/policies/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf

- NIRA Dynamics announced publication of a field study on real-world effectiveness of TPMS (for preliminary results see annex), which could inform the discussion on this measure, to be published early 2017.
- Note that TRL originally suggested using Jansen *et al.* (2014) Study on some safety-related aspects of tyre use (TNO 2014 R11423)[182]. Following stakeholder criticism of specific aspects of this study (see below) TRL would suggest that further detailed investigation is necessary in addition to the results from this study.

Some stakeholders, including CLEPA, Bridgestone, Schrader and Sensata Technologies, were supportive of the findings and methods used in the TNO studies. Other stakeholders, including ACEA, indvidual OEMs and NIRA dynamics, raised concerns against using these TNO studies.

Specific concerns were raised in relation to the treatment of vehicle safety aspects in these studies. These were related to general issues regarding the quality of research of the studies and also the lack of retrospective, real-world evidence of tyre-inflation-related collisions (see next section on trucks and trailers for more details).

Considering the comments received, it appears that more investigation into safety aspects, on top of the TNO studies cited above, is advisable if safety should be made an essential aspect of any cost-benefit analysis. Note that safety aspects only represented a small proportion of the identified benefits in the TNO studies.

Input values for cost-benefit model:

Mandatory implementation for N1 vehicles:

Mandatory implementation for N1 vehicles (in the study referred to as 'OEM-fitted TPMS' for 'LCV') was found to be cost-effective by Van Zyl *et al.* (2013): *"Mandatory fitment for LCVs only could be considered as cost-effectiveness for this application is robust to all considered scenario variations."* The break-even period (the time required for the investment costs to be earned back) was found to be approximately 0.5 to 3 years (depending on scenario; see van Zyl *et al.* (2013), Figures 37, 41, 45 and 49), which was always shorter than the estimated lifetime of a TPMS system of 7 years. Note that both, iTPMS and dTPMS, were found to be cost-effective. Technical requirements for N1 already exist within R64 (included in scope if fitted with TPMS).

- CLEPA and Bridgestone explicitly supported the cost estimates used in the study (see Section 3.4, Table 16 ('Prospective costs', 'OEM-fitted') of the report van Zyl *et al.* (2013)).
- Apart from that, stakeholders did not comment specifically on the cost-benefit results for implementation on N1 vehicles and no concerns were raised specifically against fitment on N1 vehicles.
- However, please consider the general criticism raised in relation to the validity of vehicle safety assumptions in these studies (see below).

Amendment to reduce detection times in existing technical requirements for M1 and N1:

The question whether the detection times in the current technical requirements for M1 are fit for purpose to ensure the safety of vehicle occupants remains open. Some stakeholders (including Schrader, FIA, T&E, ETRMA) were in favour of reducing detection times for punctures from 10 minutes to 5 minutes and/or for diffusion from 60 minutes

[182] https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/vehicles/study_tyres_2014.pdf

to 10 or 20 minutes. The option Jansen *et al.* (2014) analysed in their cost-benefit study was to "*include a requirement for quick deflation detection in TPMS regulation with a short reaction time (e.g. several seconds rather than minutes)*". Such extremely short timespans were contested by stakeholders based on technical grounds (see input from NIRA Dynamics, annex). It is beyond the scope of this study to settle these technical arguments and they would best be addressed by technical experts in a working group.

With regard to cost-benefit aspects of amendments to existing technical requirements additional research is needed:

- The benefit-to-cost ratio found by Jansen *et al. (*2014) was larger than one (between 1.08–1.26), but by a rather narrow margin.
- The scenario definition by Jansen *et al.* (2014) was somewhat unspecific ("*performance requirements […] are made stricter so that higher detection rates for deflated tyres can be found*"), which makes it uncertain whether any changes would reflect this scenario.
- NIRA dynamics criticised the cost estimates for this scenario as too low: Assuming that dTPMS would be required, NIRA estimates an additional cost of €200 per car, which would equate to around 8 Billion Euros per annum (compared to 0.3–0.7 Billion Euros estimated by Jansen *et al.*).
- Some of the benefit assumptions taken by the researchers do not appear to be very well-founded or -motivated: The researchers assume, for example, an increase in effectiveness of TPMS from 55.6% to 80% (see Report Section 1.3.3.3). The 80% value is not justified any further and it is not explained how this could be achieved with technical means. The base value of 55.6% was found in a study on dTPMS systems (Sivinski, 2012) and the reasons for the effectiveness not reaching 100% to the way drivers use and maintain the systems rather than technical aspects. NIRA Dynamics criticise that there was no evidence that stricter TPMS requirements would have a positive impact on inflation in the real-world. Please regard the detailed comments received from NIRA dynamics in this regard (see annex).

In conclusion, in TRL's view the cost-benefit situation for reducing the detection times in existing technical requirements remains unknown at present because no appropriate studies are available.

<u>Vehicle categories M2 and M3:</u>
For vehicle categories M2 and M3, van Zyl *et al.* (2013) found a positive cost-benefit case for OEM-fitted TPMS (assumption for costs was dTPMS) in most scenario variations. The only variation where the case is not clear is 'Current costs/low savings potential' (see van Zyl *et al.* (2013), Figure 44 and 45). The outcome in this case depends on assumptions about the future oil price level which presents a considerable uncertainty. However, if reduced cost of TPMS due to economies of scale of production are taken into account ('Prospective costs'), TPMS for M2 and M3 were found to be cost-beneficial by a comfortable margin with a break-even period of less than 2 years (see Figures 41 and 49), which is shorter than the estimated lifetime of a TPMS system of 7 years. Technical requirements for M2 and M3 vehicles do not yet exist, but could be defined based on R64.

- CLEPA and Bridgestone explicitly supported the cost estimates used in the study (see Section 3.4, Table 16 ('Prospective costs', 'OEM-fitted') of the report van Zyl *et al.* (2013)).

- Apart from that, stakeholders did not comment specifically on the cost-benefit results for implementation on M2 and M3 vehicles and no concerns were raised specifically against fitment on M2 and M3 vehicles.
- However, please consider the general criticism raised in relation to the validity of vehicle safety assumptions in these studies (see below).

Vehicle categories N2, N3, O3 and O4:

For vehicle categories N2, N3, O3 and O4, van Zyl *et al.* (2013) found a positive cost-benefit case for OEM-fitted TPMS (assumption for costs was dTPMS) in most scenario variations. For vehicles in long-haul applications the cost-benefit case was always positive. For other applications, the only variation where the case is not clear is 'Current costs/low savings potential', in particular for vehicles in construction, municipal and regional applications (see van Zyl *et al.* (2013), Figure 44 and 45). The outcome in these cases depends on assumptions about the future oil price level which presents a considerable uncertainty. However, if reduced cost of TPMS due to economies of scale of production are taken into account ('Prospective costs'), TPMS for all applications were found to be cost-beneficial by a comfortable margin with a break-even period of less than 3.5 years (see Figures 41 and 49), which is shorter than the estimated lifetime of a TPMS system of 7 years. Technical requirements for N2, N3, O3 and O4 vehicles do not yet exist, but could be defined based on R64.

With regard to cost-benefit aspects of mandatory implementation, additional research is needed:

- CLEPA and Bridgestone explicitly supported the cost estimates used in the study (see Section 3.4, Table 16 ('Prospective costs', 'OEM-fitted') of the report van Zyl *et al.* (2013)). On the other hand, confidential costing information received from OEMs for N2 and N3 vehicles suggests that the costs per vehicle could be much greater than these estimates. ACEA reasoned in general that cost for trucks and trailers was high because of higher durability/reliability requirements; high number of sensors required (12–30 sensors); need for different technical solutions for different applications (nominal pressure for a given tyre could vary from e.g. 6 to 9 bars, depending on usage and load).
- ACEA and individual OEMs raised strong concerns regarding the validity of the study (van Zyl *et al.*, 2013) for N2, N3, O3 and O4 vehicles. The main arguments concerned a lack of real-world evidence of safety-relevance of tyre pressure underinflation in these vehicles (comments can be found in full in the relevant annexes to this report). Van Zyl *et al.* calculated safety benefits by assuming improvements in tyre grip (due to proper inflation) and applying this as a virtual driving speed reduction into general prediction models of speed-collision correlations. Stakeholders questioned the real-world validity of this approach. ACEA reasoned that low tyre pressure was not a major cause for tyre blow outs, but in fact other factors such as mechanical damage were more important. Volvo Trucks referred to their own accident research showing that tyre explosions were very rare. MAN provided extracts of German federal accident statistics, which contained only a relatively small number of fatal and serious collisions attributed to tyre-related issues. Note, however, that tyre underinflation is difficult to detect in post-accident investigations, because often it is not possible to take inflation level due to tyre damage.

In conclusion, it appears that more investigation into safety aspects, on top of the TNO studies cited above, is advisable if safety should be made an essential aspect of any cost-benefit analysis for N2, N3, O3 and O4 vehicles.

Table 27: PESTLE analysis for TPM

GENERAL SAFETY REVIEW 2: Tyre Pressure Monitoring System (TPM)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Contribute to the objective of minimising fuel consumption, emissions and waste	n/a
	Reduce the number of casualties	
Economic	Reduced fuel costs	Increased purchase price of vehicles and trailers
	Reduced tyre replacement costs (increased tyre life)	Increase in vehicle complexity/maintenance requirements
	Reduced vehicle breakdown time	
	Maintaining the correct tyre pressure helps ensure sufficient quality of tyre carcass for subsequent re-treading	
Societal and Safety	Potential reduction in tyre-related fatalities/serious casualties	n/a
Technological	Potential to maximise effectiveness of some active safety systems by ensuring proper tyre pressure	n/a
Legislative	n/a	Cost of updating legislation
		OEM compliance costs
Environmental	Minimising fuel consumption and emissions	n/a
	Increased tyre life, which reduces waste	

5.24 Direct Vision and VRU detection (VIS)

Direct Vision and VRU Detection (VIS)

Reducing blind spots around HGVs and buses/coaches to improve safety for VRUs, such as pedestrians and cyclists, by introducing direct vision requirements (long-term measure) and cameras and VRU detection systems (short-term measure). Focus on direct vision requirements to reduce blind spots, but deploy cameras and detection systems earlier as a complementary measure.

Make mandatory for M2, M3, N2 and N3 vehicles:

- 01/09/2020 for new approved types – Camera and Detection
- 01/09/2022 for new vehicles – Camera and Detection
- 01/09/2028 for new approved types – Direct Vision
- No new vehicles date foreseen due to impact on overall truck cab designs

These measures apply to M2, M3, N2 and N3 irrespective of the changes to the Weights and Dimensions Directive (EU) 2015/719. Early fulfilment of direct vision requirements could be incentivised through a permission for extended length.

Notes on measure:

- Phase 1 of TRL's General Safety project (Hynd *et al.*, 2015)[183] gave a first indication of a potential break-even cost. Further reliable data will be required to come up with a refined figure. Further research will be required to assess the impacts of future trends in road casualty numbers and the depreciation of future costs and benefits, and to quantify the monetary benefits that can be expected from serious, slight and damage-only accidents.
- Implementation of this measure will be kept separate from the Weights and Dimensions Directive (EU) 2015/719.
- Detailed direct vision requirements for heavy vehicles are yet to be defined. The real-world usage of vehicles in the affected categories (N2, N3, M2, M3) differs widely between trucks for construction, distribution and long haul transport, as well as buses and coaches. Vehicle usage affects the exposure to relevant scenarios, with VRU encounters more prevalent in urban environments. The size and type of vehicle also determines how challenging it could be to technically achieve a certain level of direct vision performance, for example considering aspects such as packaging of the engine will have different engineering and cost implications for different types of vehicles. The current aim is to apply a common direct vision standard to all N2, N3, M2 and M3 vehicles. However, it is worth considering an option where different direct vision performance requirements could be applied based on a vehicle size and/or application related classification, reflecting the different involvement rates in relevant collisions. Under this proposal, the most stringent direct vision requirements could then potentially be applied to vehicles with a high share of urban driving. This could also enable specific urban regions to apply a system-based approach for their region and to

[183] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

exclude or restrict trucks with poor direct visibility performance from their roads. This needs further consideration and evidence before a move away from a common direct vision standard for all vehicles could potentially be adopted.

- Work has been undertaken by TRL and by Loughborough Design School on behalf of Transport for London to develop methods for assessing the direct vision performance of HGVs: Robinson *et al.* (2016)[184] and Summerskill and Marshall (2015)[185].
- Added glazed areas might have a negative impact on cab strength and might thus lead to reduced protection for HGV drivers. However, cab-strength requirements have been increased recently and this minimum level would still need to be fulfilled. More detailed input from industry is required.
- VRU detection systems (based on ultrasonic or radar sensors) and cameras are available from a wide range of suppliers as aftermarket equipment (Cook *et al.*, 2011)[186]. Such systems are recommended as emerging practice for HGVs in London by CLOCS, the Construction Logistics and Cyclist Safety programme by Transport for London[187]. Side detection and warning systems are also mandated, for instance, for HGVs via contractor requirements for London's Crossrail[188], one of Europe's largest infrastructure construction projects.
- As part of the European Road Safety Pilot Project TfL, Richmond Council and Ealing Council have partnered with Cycle Safety Shield to trial incident prevention software. The results of this project are due to be released in December 2016[189].
- VRU detection systems have reached a level of sophistication that allows integration in certain series production trucks. Mercedes-Benz's Active Brake Assist 4, released in December 2016, will use radar sensors to monitor the vehicle's entire front and near-side length and alert the driver of VRUs moving in a critical zone and autobrake for pedestrians and cyclists in front if required[190].

Considerations regarding potential technical requirements:

<u>Camera and detection</u>

- VRU detection systems warn the driver of the presence of a VRU in close proximity to the vehicle only. It is important to note that, for the purposes of this GSR measure, VRU detection systems will not extend to AEB with cyclist and pedestrian detection for trucks.

[184] http://content.tfl.gov.uk/assessing-drect-vision-in-hgvs-technical.pdf

[185] https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/21029/3/UNDERSTANDING%20DIRECT%20AND%20INDIRECT%20DRIVER%20VISION%20FROM%20HEAVY%20GOODS%20VEHICLES_CLOCS%20summary%20report%20by%20LDS_v2.pdf

[186] https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/8874/3/DfT%20-%20Direct%20and%20indirect%20vision%20-%20Impact%20Assessment.pdf

[187] http://www.clocs.org.uk/wp-content/uploads/2016/05/CLOCS-Guide-vehicle-safety-equipment-MAY_16.pdf

[188] http://costain.com/media/1201/vehicle-safety-equipment_supplementary-guidance_v1-size-447kb.pdf

[189] http://safetyshieldsystems.com/wp-content/uploads/2016/08/Approved-Partners-Article-RS-Version.jpg

[190] http://media.daimler.com/marsMediaSite/en/instance/ko/Mercedes-Benz-Trucks-Safety-New-assistance-systems-Active-Br.xhtml?oid=12367326

- Implementation of pedestrian and cyclist VRU detection systems could potentially be considered separately due to the likely developmental lag of cyclist-specific solutions, as identified in the M1/N1 AEB with cyclist and pedestrian detection measure (PCD).
- The benefits of VRU detection systems are dependent on the direct vision performance of the particular vehicle that the system is fitted to (reducing target population) and on the effectiveness of the particular VRU detection system (in improving detection accuracy and reducing driver overload). It would therefore be expected that VRU detection system effectiveness will vary significantly across the EU HGV fleet.
- The potential target population and costs of the camera and detection system is dependent on system coverage. Systems that detect VRUs surrounding the front and sides of the vehicle will have a greater target population, and cost, than systems that only detect VRUs at the near-side of the vehicle.
- It is important to note that a number of stakeholders identified that AEB with cyclist and pedestrian detection for trucks is likely to follow the implementation of cyclist and pedestrian VRU detection systems within a couple of years. Such systems would also require regulation if implemented in the future.
- ACEA suggested that legislative requirements:
  - Should be discussed at UNECE level and that global harmonisation was desirable.
  - Should also cover avoidance of false positive activation. This was particularly relevant for this measure because pedestrian/cyclist movement was more erratic than vehicle movement, and this would make it easy to design a system that performs well under test but at the cost of many false positive activations.
- SMMT suggest that for small and ultra-small-volume vehicle manufacturers an exemption should be granted (because it was costly and complex to introduce; note that other stakeholders contested this view on the basis that there were off-the-shelf solutions available).

<u>Improved direct vision</u>

- A differentiated approach, that specifies direct vision requirements for different vehicle classes, could be taken into consideration when designing type-approval legislation:
  - With this approach, discussion surrounding the clear and appropriate categorisation of vehicles is required.
  - Three key HGV classes (within N2 and N3 categories) were identified by stakeholders based on vehicle application: urban delivery, large distribution and construction vehicles.
    - Transport & Environment proposed that N2 and N3 vehicles up to 26 tonnes gross vehicle weight should be designated as "vehicles for urban use", N3 vehicles over 26 tonnes gross vehicle weight should be designated "large distribution vehicles", and N3G vehicles should be designated "construction, off-road vehicles".
    - Other key differentiators were also suggested, including axle counts, engine power or VECTO types[191], which could be used either in isolation or in combination.

[191] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468172/hgv-emissions-testing.pdf

- Bus and coach (M2 and M3) categories were suggested based on current classification protocols (Classes I, II, III, A & B).

- In order to assess the direct vision performance of N2, N3, M2 and M3 vehicles an objective performance-based approach is required:
  - TfL and Transport & Environment suggested that the Direct Vision Standard rating[192] scheme, developed by TRL on behalf of TfL, form the basis of such an approach for EU regulatory purposes.
- Applying a best-in-class approach for each vehicle category or cab design (instead of a single high-visibility cab approach) could be used to benchmark requirements against current, feasible cab designs, reducing the need for a radical redesign of the cab:
  - Further discussions required on defining best-in-class vehicles.
  - High-visibility truck designs already exist (such as panoramic low-entry cabs, e.g. Mercedes Econic) for different vehicle categories, but a move to this cab design across the HGV fleet may not be the most cost-effective way of implementing this change.
- The benefits of improved direct vision are dependent on the performance of any VRU detection systems fitted to the vehicle (reducing target population). It would therefore be expected that direct vision effectiveness could vary significantly across the EU HGV fleet with the introduction of VRU detection systems.
- The timetable for introducing mandatory direct vision requirements was identified as potentially being conservative, with some stakeholders desiring a more ambitious timetable than the 2028 date for introducing mandatory direct vision standards for new truck types.
- ACEA suggested that legislative requirements should be discussed at UNECE level and that global harmonisation was desirable.

Overlaps in benefits and technology:

- Technology layer: Active Safety
- Overlaps in benefits to consider: DDR, LAT
- Overlaps in technology to consider: ISA (camera-based system, so potential to share sensors and/or ECUs with VRU detection cameras) or existing Lane Departure Warning system (front camera-based system)
- Additional benefit overlaps should be considered in regards to the mandatory roll-out of LDW and AEB systems across the HGV fleet

Main impacts:

- Positive:
  - Casualty reduction – reduction in fatalities and injuries due to increased vision
  - Competitive edge for EU companies (such as Mercedes Benz Trucks, Volvo Trucks, which have already implemented Low Entry Cabs in production vehicles)
  - Increase the perceived VRU safety of HGVs and buses/coaches, thereby encouraging cycling and walking as an alternative to car use in inner city

[192] http://content.tfl.gov.uk/assessing-drect-vision-in-hgvs-technical.pdf

environments – improving the health of participants and reducing emissions due to reduced car journeys

- Increase equitable treatment of VRUs in vehicle safety legislation
- Potential for decreased insurance costs, because of lower payouts to injured parties due to mitigation of injuries
- Acceptance among drivers could be high because better visibility will reduce perceived driver workload in urban driving scenarios

- Negative:
  - Possible increase in cost/price of vehicle
  - Potential for increased service costs due to more safety-critical systems/additional sensors
  - Increased legislative (type-approval regulation amendments), development and compliance costs
  - Potentially decreased cab strength, so potentially reduced protection for HGV drivers
  - Potential increase in vehicle mass, leading to increased fuel consumption
  - Acceptance among drivers could be reduced by the fact that additional view into the cab provided by larger glazed areas might be experienced as a reduced level of privacy

Notes on impacts:

- Improving direct vision will mainly mitigate low-speed collisions; these include pulling away from traffic lights and while turning
- Other accident types, such as side-swipe collisions with cars, could also be reduced by improving direct vision

Assessment of available body of evidence:

- There were 15 articles originally included for a detailed quality assessment, of which 13 were research-related articles, one was a cost-benefit study (Cook *et al.* (2011) on the related subject of implementing aftermarket blind spot cameras and detection systems in the UK) and one was pure cost information. Additional studies, including Arup (2016a) and Arup (2016b), were submitted during the stakeholder consultation.
- There is a large amount of studies on the potential benefits of reducing blind spots in HGV vision and some predictive estimates of potential casualty savings. However, there is a paucity of retrospective, real-world studies of the effectiveness of improvements to direct vision and detection systems, so the range of effectiveness estimates can be wide. High-vision vehicles exist in the form of panoramic low-entry cab trucks, which might provide a basis for effectiveness studies, even if this particular design may not be suitable for all applications. Detection systems and cameras are available from a wide range of suppliers as aftermarket equipment and also are now available as OEM-fitted solutions.
- No detailed cost estimates for the necessary design changes to different types of HGVs and buses/coaches were identified before the stakeholder consultation; however, the cost-benefit study (Arup, 2016a) and confidential costing information from OEMs was provided during the course of the consultation. A cost estimate for cameras and detection systems is also proposed below.

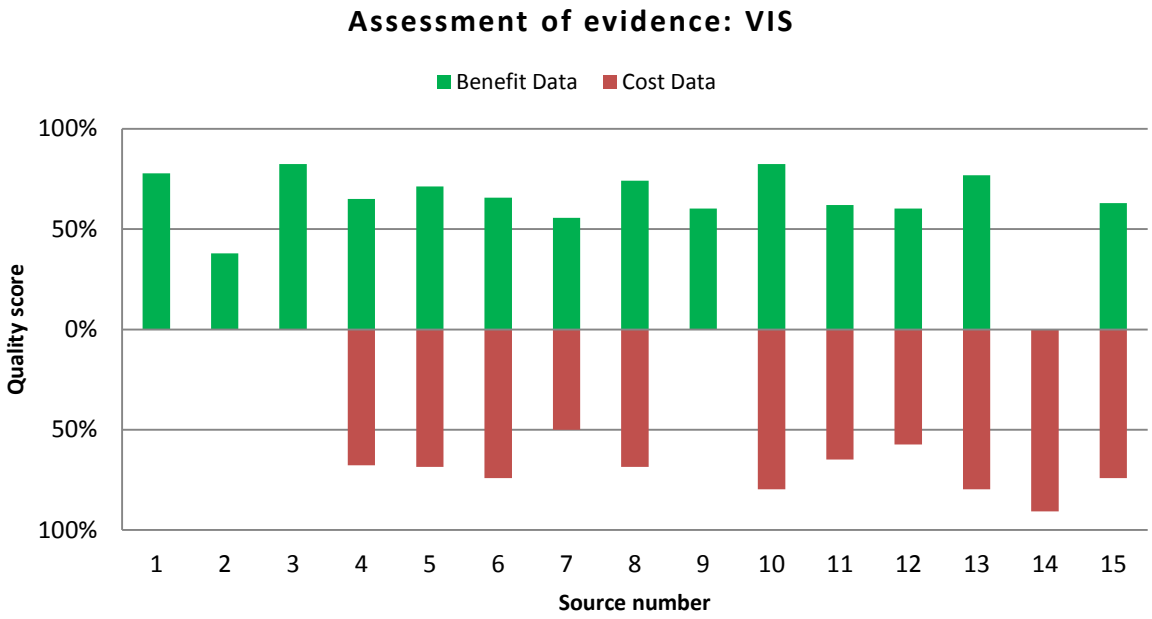


Figure 32: Level of available evidence for VIS

Appropriate sources for input data:

The following studies are recommended as sources for input data, based on the quality of research, quality of data, timeliness and relevance.

- Target population:
  - Use CARE database or scaled-up national data from member states' police records to extract values based on description of target population, in combination with:
  - Volvo Trucks (2013) European Accident Research and Safety[193].
  - Hynd *et al.* (2015) Benefit and feasibility of a range of new technologies and unregulated measures in the field of vehicle occupant safety and protection of vulnerable road users[194].
  - Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements[195].
- Fleet penetration:
  - Camera and detection:
    - No sources identified
  - Improved direct vision:
    - Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements.
- Benefit data:

[193] http://www.volvotrucks.com/SiteCollectionDocuments/VTC/Corporate/Values/ART%20Report%202013.pdf

[194] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

[195] Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements. Unpublished. Report provided via private author communication.

- Camera and detection:
  - Cook *et al.* (2011) The development of improvements to drivers' direct and indirect vision from vehicles – impact assessment[196].
- Improved direct vision:
  - Robinson *et al.* (2016) Definition of Direct Vision Standards for Heavy Goods Vehicles (HGVs)[197].
  - Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements.
  - Arup (2016b) Exploring the Road Safety Benefits of Direct vs Indirect Vision in HGV Cabs[198].

- Cost data:
  - Camera and detection:
    - Cook *et al.* (2011) The development of improvements to drivers' direct and indirect vision from vehicles – impact assessment.
  - Improved direct vision:
    - Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements.
- Stakeholder feedback on appropriateness of sources for input data:
  - Stakeholders did not raise concerns regarding these sources.
  - The following sources were submitted after stakeholder review, so stakeholders have not had a chance to comment on them:
    - Arup (2016a) Cost-benefit analysis for mandating Heavy Goods Vehicle Direct Vision requirements.
    - Arup (2016b) Exploring the Road Safety Benefits of Direct vs Indirect Vision in HGV Cabs.

Input values for cost-benefit model:
Based on these studies, the following preliminary input values are recommended for a cost-benefit model.

- Target population (description):
  - Injurious heavy vehicle-to-VRU collisions in low-speed manoeuvres: moving off, turning left, turning right, low-speed driving with VRU crossing road.
    - Note that any casualties prevented by either improved direct vision or camera or detection systems will reduce the target population for the other.
    - Note that camera or detection system target population is dependent upon the coverage of the system.

[196] https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/8874/3/DfT%20-%20Direct%20and%20indirect%20vision%20-%20Impact%20Assessment.pdf

[197] http://content.tfl.gov.uk/assessing-drect-vision-in-hgvs-technical.pdf

[198] Arup (2016b) Exploring the Road Safety Benefits of Direct vs Indirect Vision in HGV Cabs. Unpublished. Report provided via private author communication.

- Arup (2016a) provides target population ranges (for EU-28) for HGV-to-VRU collisions occurring in the "area of greatest risk" around the vehicle. These ranges have been corrected for underreporting and stratified for fatal (319–777 per annum), serious (1,094–2,670 per annum) and slight (4,410–10,761 per annum) casualties.
- Stakeholders raised no concerns regarding the above description, but did not have the opportunity to comment on the target population ranges provided by Arup (2016a).

- Fleet penetration:
  - Camera and detection:
    - Currently negligible (assumption) and unknown about future penetration trends.
    - Stakeholders did not comment or provide additional data on this aspect.
  - Improved direct vision (current fleet penetration values are highly dependent on the adopted regulatory approach):
    - Assuming the differentiated and best-in-class approach, current HGV fleet penetration may be approximately 2-10% for each category (assumption).
    - Assuming the non-differentiated, high-visibility cab approach, current fleet penetration will be negligible (assumption) with only low-entry trucks/buses with panoramic cabs and certain coaches already fulfilling these direct vision requirements. It should be noted that it is likely that the current fleet share for buses is likely to be higher than for trucks.
    - Arup (2016a) used previous trends in new HGV registrations to estimate future penetration trends for high-visibility trucks: Assuming the non-differentiated, high-visibility cab approach, Arup (2016a) assumed 2% market penetration of high-visibility HGVs in 2021, a 2% growth in market penetration across the entire EU-28 HGV fleet between 2022-2027 and then 4.8% growth from 2028 onwards.
    - Transport & Environment estimate the following future penetration trends based upon the differentiated best-in-class approach: Vehicles for urban use: 20% fleet penetration in 2022, 100% in 2030; Large distribution and construction, off-road vehicles: not specified.
    - Stakeholders did not have the opportunity to comment on the fleet penetration estimates provided by Arup (2016a) or on the suggested current and future fleet penetration rates for the differentiated and best-in-class approaches.
    - Stakeholders did not comment or provide additional data on the assumption of the currently negligible high-visibility cab fleet penetration.
- Effectiveness (percentage of target population affected, benefit):
  - Camera and detection:
    - Cook *et al.* (2011) estimate that all VRU accidents where the HGV was turning to the nearside and where there was some indication that driver blind spot might have been a contributory factor could be prevented by addition of cameras and detection systems to the nearside of the vehicle. Based on this, it was suggested to assume a high effectiveness for a single collision scenario (turning to nearside collisions, i.e. a subgroup of the target population), but the assumption of 100% effectiveness taken by this study appears too high.

- Stakeholders noted that the effectiveness of each VRU detection system will be based upon the detection accuracy of the system and the ability of the system to reduce driver overload. Hence the effectiveness is likely to vary widely between vehicles and certainly be less than 100%.

- Improved direct vision:
  - Effectiveness values are highly dependent on the adopted regulatory approach:
    - The differentiated and best-in-class approach will result in different levels of effectiveness associated with the different vehicle classes.
    - The non-differentiated, high-visibility cab approach will result in a single effectiveness level for the entire EU fleet.
    - So far, effectiveness levels have only been estimated for high-visibility cabs, see below.
  - Effectiveness for pedestrians in relevant scenarios: 66-90% (low assumption based on the fact that VRUs will be in a relevant zone near the vehicle for a long time because of low relative speed of pedestrians (Robinson *et al.*, 2016); high assumption based on Arup (2016a) estimations).
  - Effectiveness for cyclists in relevant scenarios: 0-66% (low assumption based on Arup (2016b) investigations into cyclist collisions during simulated HGV driving whilst performing cognitive tasks; high assumption based on Arup (2016a) estimates).
  - The effectiveness for buses/coaches would arguably be smaller than trucks in similar collision scenarios, based on the assumption that current buses/coaches already have a better standard of direct vision than HGVs.
  - Stakeholders did not have the opportunity to comment on the 90% pedestrian effectiveness level (only commented on ≥66% effectiveness value) and the 0-66% cyclist effectiveness range (only commented on ≈50% effectiveness value).
  - Stakeholders noted that the effectiveness of direct vision for pedestrian collisions is likely to be lower than 66%, although this could be due to perceptions of the target population that this measure will be preventing (all collisions with pedestrians vs. frontal collisions whilst pulling-off).
  - Stakeholders noted that the effectiveness of direct vision for cyclist collisions is likely to be lower than 50% - this has been reflected by the newly added sources.

- Cost per vehicle at time of mandatory implementation:
  - Camera and detection:
    - €136 for detection system (based on retail price estimate of £360 for aftermarket solution in Cook *et al.* (2011) reduced by a fixed factor to one third to determine OEM cost estimate).
    - €159 for camera system (based on retail price estimate of £420 for aftermarket solution in Cook *et al.* (2011) reduced by a fixed factor to one third to determine OEM cost estimate).
    - Economies of scale can be expected to reduce these prices further. Stakeholders commented, in a general context, that any effect of economies of scale in heavy

vehicle categories was smaller compared to light vehicle categories due to smaller production volumes.

- Confidential costing information provided by OEMs suggests that the current costs per vehicle of both camera and detection systems could be much greater than these estimates. Other stakeholders have not had the opportunity to comment on the confidential costing information from manufacturers.
- Other stakeholders did not raise concerns against the suggested costs or provide additional data.

- Improved direct vision:
  - Cost values are highly dependent on the adopted regulatory approach:
    - The differentiated and best-in-class approach will result in different design requirements associated with the different categories of vehicle and thus offer opportunities for relative cost reductions for vehicle categories with a lower regulatory requirement.
    - The non-differentiated, high-visibility cab approach will result in a single design requirement for the entire EU fleet, which will require large costs for redesigning vehicle cabs irrespective of application.
  - Costs should reflect the *additional* costs experienced by manufacturers when redesigning the chassis and tooling and in testing and certifying the new design. It is important to note that this is unlikely to be spread over a significant period of time. Arup (2016a) assumes that this additional cost will be spread over a period of 10 years only.
  - Assuming a non-differentiated, high visibility approach, Arup (2016a) estimated that the total *additional* costs of all manufacturers designing and manufacturing completely new HGV designs could be a total of 1.3–3.5 billion euros spread over a 10 year investment period.
    - Over 10 years Arup (2016a) projected that ~348,100 high-visibility vehicles will be manufactured, resulting in an average cost of €3,700-10,000 per vehicle during this time period
  - Also assuming a non-differentiated, high-visibility approach, confidential costing information provided by OEMs suggests that the current costs per vehicle for redesigning the cab are within the region of these estimates.
  - Assuming a differentiated and best-in-class approach, confidential costing information provided by OEMs suggests that the current costs per vehicle for redesigning the cab are considerably lower than that required for a high-visibility cab.
  - It should be noted that the average cost per vehicle will reduce significantly beyond the above proposed 10 year investment period.
  - Stakeholders have not had the opportunity to comment on this cost information.

Table 28: PESTLE analysis for VIS

GENERAL SAFETY REVIEW 2: Direct Vision and VRU detection (VIS)		
PESTLE	**Positive Impact**	**Negative Impact**
Political	Making HGVs safer for VRUs	n/a
	Lead development in this area so more likely to lead any international harmonisation initiative	
Economic	Reduced cost to the economy of VRU and car occupant fatalities and injuries	Possible Increase in cost/price of vehicle
	Reduction in emergency service requirements	Potential for increased insurance prices (increased repair costs)
	Could increase European industry competitiveness on European market - multiple Europe-based companies (Mercedes Benz and Volvo Trucks) have demonstrated that production of systems is possible	Increased vehicle development costs
	Potential for reduced insurance prices (reduced casualty costs)	
	Reduction in road closures/congestion leading to increase in productivity	
Societal and Safety	Reduction in fatalities/serious casualties	Potentially decreased cab strength, so potentially reduced protection for HGV drivers
	Encourages cycling/walking which in turn improves health of society and reduces congestion	Acceptance among drivers could be reduced by the fact that additional view into the cab provided by larger glazed areas might be experienced as a reduced level of privacy
	Acceptance among drivers could be high because better visibility will reduce perceived driver workload in urban driving scenarios	
Technological	Encouraging innovative technologies/R&D	
		Increased servicing/maintenance requirements (additional sensors)
Legislative	n/a	Increased OEM compliance costs
Environmental	n/a	Potential increase in vehicle mass, leading to increased fuel consumption

6 Conclusions

This study has reviewed, in detail, 24 candidate measures defined by the European Commission for potential inclusion in updates to the General Safety Regulation (Regulation (EC) No 661/2009) and the Pedestrian Safety Regulation (Regulation (EC) No 78/2009). An overview list of all measures and applicable vehicle categories can be found in Section 2.3.

TRL developed an approach for 'clustering' the measures by vehicle category and based on a principle of three layers of protection that allows to avoid double-counting of benefits or costs. See Section 4 for the proposed clusters and layers.

TRL performed a systematic review and standardised assessment of available evidence, performed a PESTLE analysis for each measure, and held a stakeholder consultation on the preliminary findings (in a face-to-face meeting and via written input). The information from all these steps was collated to produce a 'factsheet' for each measure which contains, as the main output of this study, proposed input values for a cost-benefit analysis, covering the target population, fleet penetration, effectiveness and cost of each measure. The factsheets can be found in Section 5.

The following summary in Table 29 provides an overview of the level of evidence found for each candidate measure (and highlights existing gaps in this context), the main concerns or objections raised by stakeholders, and a short list of considerations and open issues for implementation of technical requirements. Note that this summary table cannot replace the more complex content provided in Section 5 (it does, for instance, not contain the proposed values but only an assessment of the level of evidence). Note further that the considerations and open issues are a short list of the most relevant items that emerged during the course of this project and stakeholder discussions, but should not be taken as recommendations by TRL (defining technical requirement was outside the scope of this project; but Section 5 records the relevant items in more detail).

Table 29: Overview of level of evidence and relevant aspects identified for each candidate measure

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
AEB	- Good level of evidence for M1 target population, fleet penetration and effectiveness - Cost estimate proposed; not contested by stakeholders - No specific evidence for N1; proposed estimates based on M1 data	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests to be defined - Consider common implementation date for moving and stationary obstacles - Consider covering higher speeds than 80 km/h in requirements - Consider requiring detection of small vehicles (e.g. motorcycles) - Consider exemption for ultra-small-volume vehicle manufacturers
AEB-PCD	- Good level of evidence for M1 target population and effectiveness - Future voluntary uptake in the fleet remains unknown; consider purchasing fitment projections - Cost estimate proposed; not contested by stakeholders - No specific evidence for N1; proposed estimates based on M1 data	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests to be defined - Consider including low ambient lighting and high closing speeds in requirements - Consider including avoidance of false positive activation in requirements - Consider exemption for small and ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
ALC	- Good level of evidence for implementation: Existing cost-benefit analysis	- No substantial stakeholder objections regarding implementation if CBA positive	- Technical standard exists (EN 50436-7) - Consider exemption from the 'all new vehicles' date (year 2022) for vehicles "*where OEMs demonstrate that it is not feasible to install an AID without modification of the E/E architecture*"
BFS-AFE	- General paucity of quantitative evidence for this measure, but estimates for target population and benefits proposed - Fleet penetration remains unknown - No cost data available; consider estimating based on aftermarket prices	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level
BFS-CNG	- General paucity of quantitative evidence for this measure, but case reports make clear that relevant incidents do occur - Proposed to assume negligible cost; not contested by stakeholders	- No substantial stakeholder objections regarding implementation	- Type-approval requirements and tests developed at UN level
DDR	- Good level of evidence for target population for M1; estimate similar proportions for other categories - Future voluntary uptake in the fleet remains unknown; consider purchasing fitment projections - No high-quality evidence of the effectiveness from retrospective studies; predictive estimates for drowsiness detection available but highly uncertain; distraction detection needs more research - Cost estimates proposed; not contested by stakeholders for M1 and N1; much higher confidential estimates received from OEMs for N2 and N3	- Major objections from some stakeholders regarding implementation on M1, M2, M3, N1, N2 and N3 - Drowsiness recognition: No concerns regarding technical maturity but some concerns regarding real-world effectiveness in preventing collisions - Distraction recognition: Split stakeholder opinions on technical maturity	- Type-approval requirements and tests to be defined - Consider introducing drowsiness detection initially and expanding requirements later to distraction - Consider aligning timelines for distraction recognition with emergence of automated driving functions - Consider exemption for ultra-small-volume vehicle manufacturers
EDR	- Good level of evidence for Part 563-type EDR: Existing benefit study; however, benefits are difficult to monetise - No specific evidence identified for EDRs that also record VRU collisions - Proposed to assume negligible cost for Part 563-type EDR and very low cost for additional VRU collision recording; not contested by stakeholders	- No substantial stakeholder objections regarding implementation of Part 563-type EDR if CBA positive - Stakeholders stressed importance of harmonisation with US CFR 49 Part 563; (this can be interpreted as objection regarding recording of VRU collisions - Stakeholders suggested that privacy concerns around this measure needed to be resolved	- Type-approval requirements and tests to be defined - Consider harmonised requirements with US CFR 49 Part 563 or additional recording of VRU collisions - Consider exemption for small and ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
ESS	- Good level of evidence for effectiveness at reducing brake reaction times, but a model will be required to quantify target population and resulting casualty savings. Suggested a simulation approach. - Proposed to assume negligible fleet penetration and cost; not contested by stakeholders	- No substantial stakeholder objections regarding implementation if CBA positive - Some stakeholders strongly opposed standardising the choice of flashing direction-indicator or stop lamps	- Type-approval requirements and tests developed at UN level - Clarify whether/how trailers (category O) would be affected - Consider standardising activation threshold - Consider standardising the choice of flashing direction-indicator or stop lamps - Consider exemption for ultra-small-volume vehicle manufacturers
F94	- General paucity of quantitative evidence for this measure, but estimates for fleet penetration proposed - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - No cost estimate available; cost remains unknown	- Some stakeholder objections regarding implementation - Concerns that benefits to be expected were very limited (in particular for N1) and that introduction could introduce unwanted negative effects, such as reduced compatibility (higher front-end stiffness) for currently exempt vehicles	- Type-approval requirements and tests developed at UN level (removal of exemptions) - Consider investigating potential unwanted effects further - Consider exemption for ultra-small-volume vehicle manufacturers
FFW	- Good level of evidence for target population in M1 and N1 - Assume that majority of M1 fleet would already meet requirements as they are defined now; fleet penetration for N1 remains unknown - High-quality estimate of effectiveness for M1 from predictive study available; suggested to assume similar effectiveness for N1; no objections from stakeholders - Proposed cost estimate for M1 (not contested by stakeholders); no cost data available for N1 (cost remains unknown)	- No substantial stakeholder objections regarding implementation if CBA positive - Some stakeholders expressed reservations against introduction of the THOR ATD (would require specific analysis at UN GRSP level)	- Type-approval requirements and tests developed at UN level - Consider introduction of the THOR ATD into the test - Consider changes to encourage the introduction of adaptive restraint systems - Consider exemption for ultra-small-volume vehicle manufacturers
FSO	- Good level of evidence for target population - Proposed to assume negligible fleet penetration; not contested by stakeholders; but spillover effects from US possible - No quantitative evidence or estimates regarding effectiveness available; information from a potential second phase of the TRL/CEESAR study might become available in the future - No cost data available; cost remains unknown	- Major objections from some stakeholders regarding implementation - Concerns that active safety measures (in particular ESC, LDW/LKA and evasive steering) would reduce the target population in the future	- Type-approval requirements and tests to be defined (US test protocols exist) - Consider available test configurations to base the test on: IIHS or oblique MDB test - Consider testing both sides of the vehicle - Consider exemption for ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
ISA	- High-quality estimates of casualty savings for M1 and N1 from predictive studies available; single country-based but could be extrapolated to EU - High-quality estimates of casualty savings across EU for M2, M3, N3 and N3 from a predictive study available (study takes into account the effect of maximum speed limiters) - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - Initial cost estimates proposed, but closer definition of system function required for more specific estimate; much higher confidential estimates received from OEMs for N2 and N3	- Split stakeholder opinions on what form of system would be most appropriate (advisory, voluntary or mandatory) - Some stakeholder objections regarding implementation on M1 and N1. Area of concern: Unclear responsibility and costs for keeping map information up-to-date - Major objections from some stakeholders regarding implementation on M2, M3, N3 and N3. Areas of concern: Real-world evidence for HGVs was very limited; existing maximum-speed limiters would reduce the benefits	- Type-approval requirements and tests to be defined (Euro NCAP protocol available and due to be updated) - Consider what form of system should be mandated (advisory, voluntary or mandatory); consider phased introduction - Consider holding consultations with the police about this measure - Consider permitting short-time override and default-on after ignition-on - Consider exemption for ultra-small-volume vehicle manufacturers
HED	- Large body of research available, including predictive EU benefit studies - Range of effectiveness values for M1 and car-derived N1 proposed based on high-quality predictive studies; however, no retrospective evidence of effectiveness available; case number of cyclists in studies are somewhat limited; effectiveness for flat front-end N1 vehicles unknown - Note that additional information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - Proposed to assume negligible fleet penetration for M1 and N1; not contested by stakeholders - Proposed cost estimate; not contested by stakeholders	- Major objections from some stakeholders regarding implementation - Split opinions regarding technical feasibility/maturity of solutions - Some stakeholders raised concerns about potential negative side effects (driver's field of view, packaging issues) - Some stakeholder suggested they expected higher benefits from AEB-PCD, which would reduce the target population for HED more than assumed in studies	- Type-approval requirements and tests to be defined (pertinent proposals from BASt to be available shortly) - Combined positive effects of AEB-PCD and HED were shown to be larger than the effects of the individual measures added up - Consider exemptions for small and ultra-small-volume vehicle manufacturers
LAT	- Good level of evidence for target population and effectiveness (high-quality predictive estimates) - Proposed estimate for fleet penetration; value based on London only, applicability to EU uncertain - Cost estimates proposed and order confirmed by confidential costing information received from OEMs	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider removing any blanket permission for exemptions at the discretion of a type-approval authority to effectively address the existing issue

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
LKA	- Good level of evidence for target population and fleet penetration - High-quality, retrospective evidence available for effectiveness in M1; suggest to assume similar value for N1 - Cost estimate proposed for sensing technology (not contested by stakeholders); cost for actuation remains unknown and depends on requirements whether or not to upgrade vehicles with hydraulic steering assistance	- Some stakeholder objections regarding implementation - Concerns that the required design changes (and associated cost) for upgrading the steering system of vehicles with hydraulic steering assistance (including N-category vehicles) would be substantial - Suggestion that future emergency lane keeping systems (entering fleet from 2018) could be more appropriate for legislation than current systems	- Type-approval requirements and tests to be defined (pertinent discussions ongoing in IWG ACSF) - Consider what type of system should be mandated (CSF, B1, or emergency lane keeping system) - Consider permission to deactivate system by driver (depending on type of system) - Consider downgrading requirement to a pure warning function (LDW only) for vehicles with hydraulic steering assistance - Consider exemptions for small and ultra-small-volume vehicle manufacturers
PSI	- Good level of evidence with benefit estimates available from different regions; suggest to scale up to EU - Fleet penetration estimates proposed; not contested by stakeholders - Cost estimates proposed; not contested by stakeholders	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider additional requirement for assessment of the window curtain airbag coverage (ejection mitigation) - Consider exemption for ultra-small-volume vehicle manufacturers
REV	- Proposed ways to estimate target population for all vehicle categories - Future voluntary uptake in the M1 and N1 fleet remains unknown (consider purchasing fitment projections); fleet penetration in M2, M3, N2, N3, O3 and O4 fleet assumed negligible - High-quality, retrospective evidence available for effectiveness in M1 and N1 (however, based on data from Australia and New Zealand); no estimates currently possible for effectiveness in M2, M3, N2, N3, O3 and O4 (different accidentology; TRL study on this subject ongoing) - Proposed cost estimates for M1 and N1 (not contested by stakeholders); higher/much higher costs expected for M2, M3, N2, N3, O3 and O4	- No substantial stakeholder objections regarding implementation on M1, M2, M3 and N1 if CBA positive - Some stakeholder objections regarding implementation on N2, N3, O3, O4 - Concerns regarding technical feasibility (non-existent communication protocols for freely combined tractors and trailers) and procedural difficulties with multistage vehicles that are built by different manufacturers	- Type-approval requirements and tests to be defined (Japanese initiative at WP.29; US protocols for camera systems for light vehicles exist) - Consider expanding scope to O2 trailers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
RFT	- General paucity of quantitative evidence for this measure, but estimates of target population appear possible - Effectiveness and cost unknown; values from studies on the more severe US tests could give a first indication - Fleet penetration remains entirely unknown	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider adding an assessment of post-crash electrical safety - Consider applying only to new types (not all new vehicles) - Consider exemption for vehicles that do not have fuel storage, fuel supply lines and/or high voltage components located near the rear axle - Consider exemption for ultra-small-volume vehicle manufacturers
RUR	- Good level of evidence for implementation of 03 Series of Amendments to UN Regulation No. 58: Existing cost-benefit analysis	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level - Consider introducing introduce an additional load condition (100 kN applied simultaneously to three points) in the future
S95	- General paucity of quantitative evidence for this measure; no specific estimates could be proposed - Note that information from an accident study commissioned by ACEA and being performed currently by TRL and CEESAR will be available shortly - No cost estimate available	- Some stakeholder objections regarding implementation - Concerns that benefits to be expected were very limited considering high seating position of affected vehicles (in particular N1) and the positive effects on structural integrity expected from introduction of pole side impact test	- Type-approval requirements and tests developed at UN level (removal of exemptions) - Consider performing test without ATD for currently exempted vehicles to verify fuel system integrity, protection against electrical shock and door opening - Consider exemption for ultra-small-volume vehicle manufacturers
SBR	- Good level of evidence: Existing benefit study for EU-28 that determined break-even cost values and indicative costs - Stakeholders submitted confidential cost estimates for N2 and N3 passenger seats which were higher than the break-even cost estimates and indicative cost estimates	- No substantial stakeholder objections regarding implementation if CBA positive	- Type-approval requirements and tests developed at UN level (joint proposal by the EC, Japan and the Republic of Korea) - Consider requiring occupancy detection for rear seats - Consider exemptions for removable seats and seats in a row with suspension seating - Consider provisions for small and ultra-small-volume vehicle manufacturers with regard to 4-point harnesses and two-seater vehicles
SFS	- Good level of evidence for target population - No high-quality retrospective evidence of effectiveness; range of effectiveness values proposed based on good quality predictive estimates - Proposed to assume negligible fleet penetration; not contested by stakeholders - Proposed cost estimate; not contested by stakeholders	- Major objections from some stakeholders regarding implementation - Concerns that no design solutions were proven to be effective - Concerns that no suitable ATD would exist for far-side impact tests	- Type-approval requirements and tests to be defined - Consider exemptions for small and ultra-small-volume vehicle manufacturers

Measure	Level of evidence	Stakeholder concerns/objections	Considerations/open issues
TPM	- Good level of evidence for implementation for N1: Existing cost-benefit analysis (but validity of safety aspects unclear) - Existing cost-benefit analysis for implementation for M2, M3, N2, N3, O3 and O4, but validity of safety aspects unclear and cost assumptions used were contested by some of the stakeholders (supported by others) - No appropriate studies available regarding amendments to existing requirements for M1 (reduction of detection time); cost-benefit situation remains unknown; appears to be mostly a question of technical feasibility	- No substantial stakeholder objections regarding implementation for N1 if CBA positive - Split stakeholder opinions on implementation for M2, M3, N2, N3, O3 and O4. Areas of concern: Technical maturity of solutions seen differently by different groups; Communication standards for tractors and trailers to be defined; Operational difficulties for manufacturers of multi-stage vehicles - Split stakeholder opinions on amendments to existing requirements for M1	- Type-approval requirements and tests for M1 and N1 developed at UN level - Ongoing technical discussion on the effectiveness of TPMS in real-world scenarios - Ongoing technical discussion on potential reduction of detection time requirements in existing M1 regulation - Type-approval requirements and tests for M2, M3, N2, N3, O3 and O4 to be defined
VIS	- Large body of research available, including predictive EU benefit and cost-benefit studies - Target population estimates available - No high-quality retrospective evidence of effectiveness; wide range of effectiveness values proposed based on predictive estimates - Proposed cost estimates for camera and detection systems; much higher confidential estimates received from OEMs - Proposed range of cost estimates for direct vision cab-redesigns; however, the exact implementation of the requirements will have a large influence on cost (complete cab-redesign or more minor alterations for best-in-class) influence are considered uncertain	- Some stakeholder objections regarding implementation of camera and detection systems. Areas of concern: Technical maturity of solutions seen differently by different groups - Major objections from stakeholders regarding implementation of direct vision requirements via an undifferentiated approach (same performance requirement for all vehicle applications). Areas of concern: Major re-design of cabs required which might not be suitable for certain applications - Some stakeholder objections regarding implementation of direct vision via a differentiated approach (performance based on vehicle application). Closer definition required for more detailed discussion.	- Type-approval requirements and tests to be defined - For detection systems, consider including avoidance of false positive activation in requirements - For camera and detection systems, consider exemptions for small and ultra-small-volume vehicle manufacturers - For direct vision, consider a differentiated approach based on vehicle application. This could include different performance requirements for urban delivery, large distribution and construction vehicles, respectively. Consider a best-in-class approach for each vehicle category or cab design (instead of a single high-visibility cab approach). - Consider earlier introduction of direct vision requirements for new types if best-in-class approach is used

Annex 1 METHOD FOR ASSESSMENT OF EVIDENCE

6.1 Relevance of study

Step 1 is intended to ensure that the source is relevant for a subsequent impact assessment. This is assessed based on whether the type of study is appropriate to provide input data for an impact assessment and whether the research question of the source matches the measure discussed to a sufficient extent.

6.1.1 Categorisation of study type

The type of study used affects the robustness of the output. The study type may be determined by the availability of accident data, by prospective system fitment, but also may be affected by constraints on time and cost.

The main types of **accident research studies** are:

- Retrospective studies treat the feature under investigation as a risk factor and use statistical methods to compare the impact, such as the relative risk of accidents in real world accident data or the impact on fuel consumption or emissions based on real-world data where equipped vehicles can be identified and compared with unequipped vehicles. Where such an approach is possible, this approach the greatest potential for providing a rigorous and accurate assessment of benefits since it objectively measures the actual in-service effect, thus accounting for many of the factors that can confound predictive studies, including inclusion of driver behaviour and accurate quantification of system effectiveness.
- Predictive studies examine accidents where vehicles were not equipped with the specific feature under consideration and make calculations and/or judgements to assess whether the accident would have been avoided or mitigated if the safety feature had been present. This approach is necessary, for example, when considering assessment of effectiveness for new systems or those fitted to a only small percentage of the fleet, making retrospective assessment unfeasible. There are a number of different methods that can be used when carrying out a predictive study.
    - Case-by-case analysis involves the detailed review, reconstruction, and prediction of effects in a range of individual accidents. The predictions can be made in a number of ways:
        - An assessment of the effectiveness of the safety system can be made for each accident case based on the information available and engineering judgments. The availability of accident information on the detailed accident circumstances and system capabilities also influence the robustness of the outcome.
        - Mathematical modelling can be used on a case-by-case basis and is less subjective than the method described above. This involves creating a computer model of an accident and simulating the outcome with the fitting of the safety system. Such an approach has the advantage of being fully objective, but is more complex and time-consuming and, because it is firmly rule based, can miss some more subtle factors that influence outcomes. Also, this method is often unfeasible because the information required to accurately model the

accident situation and the behaviour and capabilities of the system are unknown. In such cases, the robustness of this approach is similar to a well-defined rule-based approach employing engineering judgement.

  - Parameter-based study is an extension of a target population assessment and involves interrogating an accident database to identify in more detail the casualties where a system is likely to be effective. The effectiveness calculation might further restrict the target population to exclude accidents not applicable to the measure under assessment (e.g. accidents that occurred in severe weather conditions where the system was known not to function well). The quality of this type of analysis depends on the detail, accuracy and representativeness of the data source used and any assumptions made to overcome limitations in the data.

- Target population study is a study which quantifies the accidents (or subsequent casualties) that could be influenced by the measure. This provides an initial evaluation of the potential benefit of a countermeasure and is usually based on high-level accident types without exclusion criteria.

Experimental studies are those studies performed in an experimental setup to create pieces of evidence indicative of the real-world effectiveness of a measure or safety system (For example, a reaction time study to identify the effect of different flashing patterns on the driver's brake reaction time could be relevant for emergency brake light display (EBD)). Experimental studies should be assigned to one of the following categories:

- Experimental studies using a driving simulator, i.e. performed in a setup that replicates closely the actual driving environment, including parts of the actual vehicle surrounding the participant.
- Experimental studies using a simple environment, not replicating the driving environment (e.g. reaction time tests using a setup of illuminating lights with participant sitting in front of a simple screen).

Cost-benefit studies are assigned to the category that was used to determine the *main* input for the benefit calculation. (For example, if a study is analysing the costs and benefits of mandating Autonomous Emergency Braking (AEB) for cars, the question is how the effectiveness of AEB in preventing collisions was estimated: Using a retrospective approach (or quoting studies that did so), i.e. based on real-world data from vehicles fitted with the system; or using a predictive approach, i.e. based on predictions about how previous collision could have changed with the system fitted; etc.) The quality of the cost-benefit study is assessed later.

Individual pieces of evidence:

- Major individual case report: Reports of individual collisions or incidents relevant to the measure discussed. These should be only be included if they are from reliable sources, i.e. more than 'anecdotal'.

- Cost information: This category is for individual pieces of cost-information, for example information about the fitment cost of a safety system per vehicle to the manufacturer.

Table 1: Type of study: assessment criteria

Description	Score
Accident research studies	
Retrospective study	3
Predictive study (case-by-case)	2
Predictive study (parameter-based)	1
Target population study	0
Experimental studies	
Driving simulator study	2
Simple environment	0
Cost-benefit studies	
Cost-benefit study based on retrospective benefit data	3
Cost-benefit study based on predictive benefit data (case-by-case)	2
Cost-benefit study based on predictive benefit data (parameter-based)	1
Cost-benefit study based on benefit data purely from target population estimates	0
Individual pieces of evidence	
Major individual case report	1
Cost information	1
Not applicable	
Not applicable (Explain in comment)	n/a

6.1.2 Relevance of study to proposed measure

Is the measure analysed in the source sufficiently relevant for the measure that is being proposed for legislation? Sometimes it will not be possible to find studies that match perfectly the proposed legislative change. Nevertheless, related studies can provide valuable input data, for example about similar systems but with differing performance specifications. Consider the examples in the table below and apply best judgement.

Table 2: Relevance of measure: assessment criteria

Description	Score
Measure discussed in the source matches the proposed implementation closely (e.g. source analyses effectiveness of autonomous emergency braking (AEB), where proposed measure is to mandate AEB; or cost information for fitment of AEB, where proposed measure is to mandate AEB).	3
Measure discussed in the source is directly related to the proposed implementation but does not match it exactly (e.g. different or unspecific performance criteria)	2
Measure discussed in the source is only indirectly related to the proposed implementation (e.g. source analyses effectiveness of fitting alcohol interlock devices to cars; proposed measure is only to standardise the electronic interface of the car to enable retro-fitment of alcohol interlocks)	1
Source is related to the issue but does not assess a specific measure (e.g. a target population study on drunk driving). Note: Sources not related to the measure at all should not be included in the review.	0
Not applicable (explain in comment)	n/a

6.2 Quality of the data

This step is an assessment of the quality of the source. This step is critical to distinguish between sources to determine which data is most robust, allowing a distinction to be made between studies of differing quality where there results might otherwise be taken at face value with no consideration of differences in the underlying evidence.

Quality shall be rated based on the following criteria:

6.2.1 Benefit (primary benefit of measure)

6.2.1.1 Timeframe of data sample

The timeframe of the input data for the study (i.e. the data sample used) will have a strong effect on whether significant conclusions can be drawn. In some cases, the data sample might be for a specific snapshot. Ideally, the sample should cover a wider timeframe to result in a more robust outcome. Such an approach also allows for fluctuations in point samples and allows trends over time to be assessed and considered.

If the study uses more than one data sample (e.g. for different regions) of different timeframes, apply best judgement to reflect the timeframe of the core data sample used). Example: The vast majority of data used is from a large country for the years 2004-2005 (2

years) with an additional small sample from a small country covering 2003- 2005 (3 years), assign the lower score of 1.

Table 3: Timeframe of sample: assessment criteria

Description	Score
5 or more years of data used	3
3-5 years of data used	2
1-2 years of data used	1
Less than 1 year of data used	0
Not applicable (for example for driving simulator studies or individual case studies)	n/a

6.2.1.2 Age of the data

The age of the data used also influences quality. This should include the most recent data that availability allows such that the outcome is the best representation of the state of design and technology development. In some cases, there may be instances where key research is based on older data but still remains the main source in the field: this should be acknowledged accordingly by ratings in other aspects. Note: The time spans for benefit data are longer than for cost data, because the nature of accident research (i.e. the time spans required for collecting evidence, analysis and publication) does generally not allow publication of studies based on data from the previous year.

If the data sample spans more than 1 year, this assessment should be based on the most recent end of the core body of data used. For example, if 7 years' worth of data are used, from the years 2008-2014, assign a score of 3 based on the year 2014.

Table 4: Age of benefit data: Assessment criteria

Description	Score
Most recent data (within 2 years of current year)	3
Within 3–5 years of current year	2
Within 6–10 years of current year	1
More than 10 years old	0
Not applicable (for example for driving simulator studies)	n/a

6.2.1.3 Geographical scope of data used

The input data used for the study should be as representative of the geographic area to which the measure is being applied. For Europe, this is a common issue because of the differences in underlying road safety (vehicles and infrastructure) in different European regions and the differences in data recording process and quality. Studies relevant to the European context should include (or consider appropriate sources) that apply to multiple countries, and ideally include data representative of different European regions with respect to their level of safety.

Note that the reported geographical scope of the *output* of a study by itself is not sufficient to assess this aspect. For example, a study could report to have calculated a cost-benefit ratio for 'the European Union', but should still score low on this if the important pieces of *input* data (e.g. in-depth accident data) was in fact only from a single country.

Table 5: Geographical scope: assessment criteria

Description	Score
Multiple European samples (3+ countries) including consideration of counties with different levels of safety (i.e. Northern and Southern Europe)	3
Multiple European country samples (2)	2
Single European country sample	1
Single sample representative of a region (within a European country), or single sample of a non-EU country	0
Not applicable (for example for driving simulator studies or individual case reports)	n/a

6.2.1.4 Size of the data sample

The robustness of the analysis is affected by the size of the data sample (input data), where larger samples result in more robust study results. An appropriate sample size depends on the study type and the exact issue under investigation.

Table 6: Size of data sample: assessment criteria

Description	Score
Sample size was appropriate to achieve statistically significant results (to an accepted confidence level in the field; often 0.05 = 5%)	3
Sample size appears sufficient to draw firm conclusions but statistical significance not reported (Guidance: thousands of collisions for target population studies; hundreds of collisions for statistical analyses; tens of subjects/ participants/ cases for experimental studies and case-by-case analyses) (note sample size in comments)	2
Sample size appears insufficient to draw firm conclusions (Guidance: Everything below the levels suggested above, including individual case reports) (note sample size in comments) or unknown.	0
Not applicable	n/a

6.2.2 Cost (primary cost of measure)

6.2.2.1 Age of the data

Costs for systems change rapidly with developments in technology. This should include the most recent data available.

Table 7: Age of cost data: Assessment criteria

Description	Score
Most recent data (within 1 year of current year)	3
1-3 years of current year	2
3-5 years of current year	1
More than 5 years old or unknown	0
Not applicable	n/a

6.2.2.2 Quality of cost estimate

The cost to the manufacturer of fitting a certain system to a vehicle or implementing a certain measure is generally confidential information and has to be based on estimates. The quality of these estimates can vary widely based on the source.

Table 8: Quality of cost estimate: Assessment criteria

Description	Score
Cost information provided by OEM, supplier, trade body, industry expert or stakeholder questionnaire	3
Cost information derived from detailed engineering assessment	2
Cost information derived from retail price to consumers (e.g. for optional extras, by applying a fixed factor of 1/3 to estimate the cost to OEM)	1
Cost information estimated without further rationale or unknown	0
Not applicable	n/a

6.3 Quality of the method

This step is an assessment of how the data presented by the source has been used. This is important because sources may not follow the formal cost-benefit format; this assessment will identify how compatible the data is compared to the EC Better Regulation guidelines for cost-benefit assessments. If the source is not a formal cost-benefit assessment, it will make an assessment of how the data has been used in terms of the context for use in a benefit assessment.

Note that for this step only *one* of the parts of the spreadsheet needs to be filled in (either CBA, research study, individual case report, or cost information depending on the source reviewed). Follow instructions in the spreadsheet.

6.3.1 Cost-benefit assessments

Cost-benefit assessments are those studies that aim to quantify the potential future impacts of introducing a measure. These studies are usually performed to inform regulators on whether the benefits of a legislative change (casualties prevented, emissions saved, etc.) will outweigh its costs (system fitment costs, costs for developing test procedures, etc.) taking into account society as a whole. The outcome of these studies is usually a benefit-cost ratio (values larger than 1 indicate a cost-effective measure) or a break even cost (providing an indication of what cost level is just about acceptable for a system to make its introduction cost-beneficial; this is usually applied if the system cost is unknown).

6.3.1.1 Comparison with baseline

If the study is a cost-benefit format, comparison of the intervention(s) to a baseline is important so that the situation for the 'no action' situation over time is accounted for in the time period of assessment.

Table 9: Comparison with baseline: assessment criteria

Description	Score
CBA study compares costs and benefits to a baseline (the 'no action' scenario)	3
CBA study does not compare costs and benefits to a baseline (the 'no action' scenario)	0
Not applicable	n/a

6.3.1.2 Time period of CBA

The quality of the cost-benefit assessment is dependent on the time period over which the assessment of costs and benefits has been made, i.e. how many years into the future is the study projecting ahead. This period should be at least [10 years] and/or encompass the situation where the benefits and costs have been fully realised. For example, the period of the assessment should be such that the annual costs and annual benefits have been realised; otherwise the assessment may be biased towards initialisation costs and not take account of benefits realised later in time.

Note that this is the time period looking forward (output) and not the time frame of the input data used.

Table 10: Time period of CBA: assessment criteria

Description	Score
Appropriate time period; long enough to make reasonable estimate of costs and benefits	3
Inappropriate time period; not long enough to make reasonable estimate of costs and benefits	0
Not applicable	n/a

6.3.1.3 Discounting and inflation

The quality of the cost-benefit assessment is dependent on the assumptions that have been made about the future costs and benefits since these should be valued in a different manner to the costs and benefits that are immediately incurred or attainable. The cost-benefit study should be checked that it has used inflation at a recognised level [1–3%] to reflect the future increases in value for costs and benefits and that these have then been discounted by a recognised value [4–6%] to reflect the fact that these are valued lower than costs and benefits today.

Note that discounting and inflation are monetary effects that are independent of natural fluctuations of prices over time (e.g. changes in oil prices) or price reductions of technology due to mass production. If a CBA has applied discounting and inflation factors these words will usually appear explicitly somewhere in the text and the rates applied will be mentioned.

Table 11: Discounting and inflation: assessment criteria

Description	Score
Appropriate inflation and discounting levels implemented	**3**
Unusual/no inflation or unusual/no discounting implemented	**2**
No inflation and no discounting considered (or unknown/not mentioned in text)	**0**
Not applicable	**n/a**

6.3.1.4 Assumptions used

The assumptions used in a study influence the quality of the outcome. The assumptions should be reviewed to check if there is a convincing rationale or evidence that supports them. If judgement or pure estimates have been used, the results could be affected significantly. If assumptions are not discussed explicitly in the text or if the source for the assumptions is not stated then this should be assumed to be an unsupported estimate.

Example of an assumption that is stated but not supported with rationale: "*For this option a CBA has been carried out, assuming that the legal action would in future be 50 to 80% effective in reducing alcohol related road deaths.*"

Table 12: Assumptions used: assessment criteria

Description	Score
The major assumptions are explicitly stated and supported by evidence or clear rationale	3
The major assumptions are stated but not supported with clear rationale	2
Assumptions are not stated in the report	0
Not applicable	n/a

6.3.1.5 Peer-review

Most scientific journals and some conferences perform a peer-review of submitted material to select studies of appropriate quality and to ensure appropriate study design and interpretation of results. Having passed this review by other scientists in the same field is usually an indication of a high quality study applying widely accepted methods in the field. Note that some conferences publish papers *without* peer-review (e.g. most papers at the ESV conference).

Project reports are usually also not peer-reviewed but recognised research institutes, such as TRL, BASt, TNO or NHTSA, or consortia of big collaborative research projects do commonly perform internal reviews before reports are being published (e.g. TRL's TR process).

Table 13: Peer-review

Description	Score
Peer-reviewed	3
Internally reviewed	2
Not reviewed	0
Not applicable	n/a

6.3.2 Research studies

Research studies aim to identify aspects such as how effective a system is at preventing collisions, how big the fuel savings associated with a system are, how much the driver reaction time can be reduced by a system, etc. This information can be used to feed into cost-benefit studies, but the research studies themselves do not perform cost-benefit calculations.

6.3.2.1 Appropriate analytical design

Analytical design, particularly the control of confounding factors (e.g. systematic biases such as age of driver etc.) can strongly affect the quality of the study. The reviewer should examine the methodology used by the study and assess this in terms of:

- Is the analysis appropriate and logical to answer the research question the study is trying to address?

- Is the sample biased to an extent that calls into question the universal applicability of the results (e.g. predominantly young drivers, who might be more inclined to be involved in collisions; or predominantly large segment vehicles, which might be inherently safer when involved in a collision)? If so, has this bias been adequately controlled for?

Table 14: Analytical design: assessment criteria

Description	Score
Logical and appropriate method to answer the research question of the study and no obvious bias in sample that affects results (or adequate control of such bias)	3
Logical and appropriate method to answer the research question of the study but with obvious bias in sample that likely affects results	2
Inappropriate method to answer the research question	0
Not applicable	n/a

6.3.2.2 Assumptions used

The assumptions used in a study influence the quality of the outcome. The assumptions should be reviewed to check if there is a convincing rationale or evidence that supports them. If judgement or pure estimates have been used, the results could be affected significantly. If assumptions are not discussed explicitly in the text or if the source for the assumptions is not stated then this should be assumed to be an unsupported estimate.

Example of an assumption that is stated but not supported with rationale: "*For this option a CBA has been carried out, assuming that the legal action would in future be 50 to 80% effective in reducing alcohol related road deaths.*"

Table 15: Assumptions used: assessment criteria

Description	Score
The major assumptions are explicitly stated and supported by evidence or clear rationale	3
The major assumptions are stated but not supported with clear rationale	2
Assumptions are not stated in the report	0
Not applicable	n/a

6.3.2.3 Peer-review

Most scientific journals and some conferences perform a peer-review of submitted material to select studies of appropriate quality and to ensure appropriate study design and interpretation of results. Having passed this review by other scientists in the same field is usually an indication of a high quality study applying widely accepted methods in the field. Note that some conferences publish papers without peer-review (e.g. most papers at the ESV conference).

Project reports are usually also not peer-reviewed but recognised research institutes, such as TRL, BASt, TNO or NHTSA, or consortia of big collaborative research projects do commonly perform internal reviews before reports are being published (e.g. TRL's TR process)..

Table 16: Peer-review

Description	Score
Peer-reviewed	3
Internally reviewed	2
Not reviewed	0
Not applicable	n/a

6.3.3 Individual case report

6.3.3.1 Incident causation

Table 17. Incident causation: Assessment criteria

Description	Score
The source provides technical detail about the causation factors of the incident (from relevant experts, e.g. fire rescue services)	3
The source provides technical detail about the causation factors of the incident (from non-experts, e.g. journalists)	2
The source discusses the general circumstances of how the incident occurred, but does not discuss technical aspects	1
The source does not discuss causation of the incident	0
Not applicable	n/a

6.3.3.2 Mitigation potential

Table 18. Mitigation potential: Assessment criteria

Description	Score
The source mentions the proposed measure as a suitable mitigation (from relevant experts, e.g. fire rescue services)	3
The proposed measure would likely mitigate or prevent the incident discussed (researcher's or journalist's opinion)	1
The proposed measure would likely *not* mitigate or prevent the incident discussed (researcher's opinion) or unknown	0
Not applicable	n/a

Annex 2 STAKEHOLDER CONSULTATION MEETING

Annex 2.1 List of attendees

#	Company Name	Attendee	Day 1	Day 2
1	**ACEA**	Mr. Ulrich Veh Safety Director	Yes	
2	**AGU Zürich**	PD Dr. Kai-Uwe Schmitt Research, Development & Consulting / Seminars & Education	Yes	Yes
3	**Aspöck Systems**	Mr. Adam Mitchell	Yes	Yes
4	**AUDI AG**	Mr. Thomas Roscher Development TPMS, Testing Chassis Characteristics		Yes
5	**Autoliv**	Dr. Nils Lubbe Research Specialist	Yes	Yes
6	**BASt - Federal Highway Research Institute**	Mr. Claus Pastor Passive Vehicle Safety & Biomechanics		Yes
7	**BASt - Federal Highway Research Institute**	Mr. Patrick Seiniger Section F1 – Active Vehicle Safety and Driver Assistance Systems		Yes
8	**BMW Group**	Mr. Abayomi Otubushin Corporate and Governmental Affairs	Yes	Yes
9	**Bundesministerium für Verkehr und digitale Infrastruktur / Federal Ministry of Transport and Digital Infrastructure**	Mr. Thomas Fuhrmann Division LA 20 - Automotive Engineering Vehicle Safety and Innovative Technologies	Yes	Yes
10	**Charge**	Mr. Nick Clay Head of Homologation and Quality	Yes	
11	**CLEPA**	Mr. Paolo Alburno Director Technical Regulation	Yes	Yes
12	**DAF Trucks Ltd**	Mr. Philip Moon Marketing Manager	Yes	
13	**DAF Trucks N.V.**	Mr. Johan Broeders Vehicle Definition Vehicle Safety and Braking	Yes	Yes
14	**Daimler AG**	Mr. Dieter Schoch External Affairs, Emissions & Safety Commercial Vehicles	Yes	Yes
15	**Dennis Eagle**	Mr. Douglas Gardner Technical Manager - Homologation		Yes
16	**DENSO INTERNATIONAL EUROPE**	Mr. Dimitris Vartholomaios Regulatory Affairs Executive	Yes	
17	**DENSO INTERNATIONAL EUROPE**	Mr. Jean-Michel Henchoz European Affairs & Business Development Manager		Yes
18	**DfT**	Mr. Mike Lowe Senior Engineer, Safety and Type Approval		Yes

19	**DfT**	Mr. Roy Addo Senior Engineer, International Vehicle Standards Division		Yes
20	**DUNLOP TECH GmbH**	Mr. Bernd Schuchhardt Managing Director		Yes
21	**DUNLOP TECH GmbH**	Mr. Tobias Stohrer Manager Research and Development TPMS		Yes
22	**ETSC**	Ms. Ellen Townsend Policy Director	Yes	Yes
23	**ETSC**	Ms. Graziella Jost Project Director	Yes	Yes
24	**Euro NCAP**	Dr. Michiel van Ratingen Secretary General	Yes	Yes
25	**European Commission**	Mr. Peter Broertjes Vehicle Safety Policy	Yes	Yes
26	**European Cyclists Federation**	Mr. Ceri Woolsgrove Policy Officer	Yes	Yes
27	**Fédération Inter-Environnement Wallonie**	Mr. Pierre Courbe Mobility Policy Officer	Yes	
28	**FIA Region I**	Mr. Victor Brangeon Policy Manager	Yes	
29	**Fiat Chrysler Automotive**	Mr. Gianfranco Burzio Homologation & Regulation	Yes	Yes
30	**Ford**	Mr. James Abraham Safety Regulation Europe	Yes	
31	**Fujitsu Ten (Europe) GmbH**	Mr. Yoshikuni Miki Engineering Coordinator	Yes	
32	**German Insurers Accident Research at GDV**	Dr. Matthias Kuehn Head of Vehicle Safety	Yes	
33	**Honda Motor Europe**	Mr. Louis Ballaux Government Relations & Regulations		Yes
34	**Hyundai Motor Europe Technical Center GmbH**	Mr. Jens Schenkenberger Manager / Regulation, Vehicle Safety & Environment Regulation Chassis & Brakes	Yes	Yes
35	**JASIC - Japan Automobile Standards Internationalisation Centre**	Mr. Takashi Naono Director	Yes	Yes
36	**Jeanne Breen Consulting**	Ms. Jeanne Breen	Yes	Yes
37	**JLR**	Mr. Paul Jones Product Compliance (Regulations)	Yes	Yes
38	**JLR**	Mr. Richard Ashmore Veh. Safety Technical Specialist	Yes	Yes
39	**MAN Truck & Bus AG**	Mr. Hans Hesse Expert in Technical Regulation	Yes	Yes
40	**NIRA Dynamics**	Mr. Jörg Sturmhoebel Marketing and Sales		Yes
41	**NIRA Dynamics**	Mr. Predrag Pucar Managing Director	Yes	Yes

42	**Nissan Technical Centre Europe**	Mr. Alan Kennedy Safety Strategy and Performance Development	Yes	Yes
43	**Parliamentary Advisory Council for Transport Safety (PACTS)**	Mr. Paul Fay Member of PACTS' Vehicle Design Working Party	Yes	Yes
44	**Parents d'Enfants Victimes de la Route - SAVE asbl**	Mr. Koen Van Wonterghem Administrateur délégué	Yes	
45	**Parliamentary Advisory Council for Transport Safety (PACTS)**	Mr. David Davies Executive Director	Yes	Yes
46	**PSA Peugeot Citroen**	Mr. Philippe Hamadouche Head Of Homologation & External Technical Relations RHN UK	Yes	Yes
47	**PSA Peugeot Citroen**	Mr. Kai Frederik Zastrow Head of Unit Safety Regulation & Systems Homologation	Yes	Yes
48	**RDW**	Mr. Hans Ammerlaan Senior Engineer Crash Safety	Yes	Yes
49	**Renault**	Ms. Irina Dausse Passive Safety Regulation	Yes	Yes
50	**RoadPeace**	Ms. Amy Aeron-Thomas Advocacy and Justice Manager		Yes
51	**SBD Automotive**	Dr. Alain Dunoyer Head of Autonomous Car Research and Consulting Division	Yes	
52	**SBD Automotive**	Mr. Luigi Bisbiglia Business Development Manager	Yes	
53	**Scania**	Mr. Magnus Jalkesten Head of Regulations and Certification Road Safety	Yes	Yes
54	**Schrader / Sensata Technologies**	Mr. Frederic Arbousse-Bastide Marketing Manager		Yes
55	**SMMT - Society of Motor Manufacturers and Traders Limited**	Mr. Barnaby Simkin Technical Manager Public Policy and Vehicle Legislation Department		Yes
56	**SMMT - Society of Motor Manufacturers and Traders Limited**	Mr. Paul Fitchett Public Policy and Vehicle Legislation Department	Yes	
57	**Suzuki Motor Corporation**	Mr. Tim Meisner Industry Relations	Yes	Yes
58	**TfL**	Ms. Hannah White Programme Manager		Yes
59	**TfL**	Ms. Kerri Cheek Principal Delivery Planner	Yes	
60	**TfL**	Mr. Peter Sadler Principal Technical Specialist (Road Safety)		Yes

61	**TfL**	Mr. Simon Bradbury Senior Strategy and Planning Manager – Road Safety		Yes
62	**Towards Zero Foundation**	Mr. Alex Ward Administrator and Policy Officer	Yes	
63	**Toyota Motor Europe NV/SA**	Mr. Tjark Kreuzinger Senior Manager of Safety Research & Technical Affairs	Yes	Yes
64	**Toyota Motor Europe NV/SA**	Mr. Rene Nulens Senior Manager regulation, Technical Affairs Planning	Yes	Yes
65	**Transport & Environment**	Mr. Stef Cornelis Safer and Cleaner Trucks Officer		Yes
66	**Transport & Environment**	Mr. William Todts Director		Yes
67	**University of Leeds, Institute for Transport Studies**	Mr. Oliver Carsten Professor of Transport Safety	Yes	Yes
68	**UTAC CERAM**	Mr. Antoine Pamart Department manager Safety Type Approval	Yes	Yes
69	**Vlaamse Stichting Verkeerskunde**	Mr. Eddy Klynen Coordinator	Yes	
70	**Volkswagen AG**	Mr. Rolf Bergmann Head of Global Safety Affairs	Yes	Yes
71	**Volvo Group Trucks Technology**	Mr. Claes Avedal Safety Manager	Yes	Yes
72	**VOLVO Group Trucks Technology (Renaut Trucks)**	Mr. Jean Louis Chazalette GPPL Regulations	Yes	Yes

Annex 2.2 Meeting minutes

28th and 29th November 2016 – United Kingdom, London, Europe House

Day 1

TRL: David Hynd (DH), Richard Cuerden (RC), Matthias Seidl (MS), Anna George and Rob Hunt

European Commission: Peter Broertjes (PB)

Stakeholders: See attendance list

Stakeholders were invited by TRL, to Europe House in London, by the commission to attend a two day meeting in London to discuss their views and recommendations for each of the proposed measures selected to go through to the second review. The schedule for the meeting is displayed in the table below. Due to the large number of measures to be discussed, parallel sessions were held on the second day as shown in the table below.

Day	Session 1	Session 2
1 **Monday 28th November 2016 (10:00 - 16:00)**	Cars and HGVs (Heavy Goods Vehicles) REV, EDR, ISA, DDR, ALC, SBR and ESS	N/A

2 **Tuesday 29th November 2016 (09:15 – 16:15)**	Room 1 – Cars FFW, FSO, F94, PSI, SFS, S95, RFT, HED, TPM, LKA, AEB and AEB-PCD	Room 2 – Heavy vehicles VIS, TPM, REV, BFS-AFE, BFS CNG, RUR and LAT

For each measure, the TRL topic lead gave a brief presentation to:

- Define the measure
- Indicate its feasibility and the proposed clustering for benefits and technologies
- Summarise the impacts
- Highlight the recommended input values for a cost-benefit study
- Summarise the input received from stakeholders prior to the workshop Benefit: Cost Ratio (BCR) evidence

The following sections summarise the discussion in the stakeholder meeting for each of the measures.

Introduction

- RC and PB gave an introduction talk describing the layout of the two days and how each measure will be covered.
- 10:10 DH gave a short presentation on the background to GSR1 and 2.
- 10:30 RC gave a brief explanation of the structure of day 1.
- Pierre Courbe (Fédération Inter-Environnement Wallonie): Explained cars are too fast, heavy, powerful and large. Legislators should encourage smaller, lighter, less powerful cars that are less dangerous. We have forgotten how cars are designed. TRL should take into account the power of the vehicle. The point was acknowledged but is out of the project scope.
- Jeanne Breen (JBC): Noted the long term road safety goal to 2050 and asked how the EC and TRL are going to give weighting for vehicle measures that can give the largest contribution to death or injury? What will you do if it is cheap to implement but has a minor affect and vice versa?
    - RC: Replied that we will document the evidence for the costs and benefits for the EC impact assessment team. Some measures will have more confidence than others. The driving force is how can we affect the most causalities and how can we do it as quickly as possible.
    - PB: Commented that before proposing any new measure, the EC must do an impact assessment. The first draft of the impact assessment will be completed in Q1 2017. There will be further opportunity for stakeholder contributions, but the timing for that is not confirmed as yet.
- Kai Frederik Zastrow (PSA): Explained that introducing a new measure takes a certain amount of time: in the best case, a measure could be sent to parliament at the end of 2017, be adopted in 2018 and published by the end of 2018. However, some potential measures have a large impact on vehicle design and manufacturers need sufficient lead time to integrate the required changes into the vehicle design. Could some measures be phased in based on integration with vehicles?
    - PB: Replied that the Commission is aware of the issue of time and that the dates are not final. Dates will be determined in the final phase of preparation of proposals.

Reversing Detection or Camera Systems (REV)

M1/N1 Only

Presentation from MS:

- Paul Fitchett (SMMT): Clarified that the SMMT agrees with the ACEA position (unless otherwise declared) and has also provided specific statements on small and ultra-small manufacturers.
- Michiel Van Ratingen (Euro NCAP): Asked whether auto-brake linked to reversing detection was in scope for the measure?
    - MS: Replied that this is not in scope.
- Gianfranco Burzio (ACEA): Noted that large vehicles must have a banksman so may have less justification for camera systems.
    - MS: Asked GB to raise this in the M2/3 and N2/3 session.
- Paul Fay (PACTS): Asked whether the research has quantified the target population?
    - MS: Noted that the target population is not defined explicitly yet, because of the layer system – we need to know the effect of the layer above first – but that we have defined where to get the information from.
- Abayomi Otubushin (BMW): Noted that based on types of vehicles and driveways we are unlikely to see this casualty group in the EU; it is a US specific problem.
    - PB (EC): Noted that we have a proliferation of SUVs and Crossovers in the EU, which may be moving us closer towards the situation in the US and we should take account of this.
- *Name missed*: Surprised that only one source was identified (NHTSA)
    - MS: We have a methodology of finding high quality and appropriate sources. This doesn't mean it's the only one but it is the most appropriate study at a sufficient level of quality

Additional Evidence:

- Michiel van Ratingen (Euro NCAP): Commented that there should be lots of info from Japan, because this has been on the agenda for JNCAP for a long time.
- Hans Ammerlaan (RDW): Noted that there is a TNO report on this for delivery vans (2012 study) and offered to distribute the report.
- Kai Frederik Zastrow (PSA): Currently only US benefit to be applied to EU situation?
    - MS: That is the available information identified to date.
- Naono Takashi (JASIC): Commented that the Japanese position is that this measure is very important to avoid VRU casualties, especially children. Japan has already drafted requirements on this measure and started discussion at WP.29; two weeks ago WP.29 agreed to proceed with the discussion. JASIC can provide data to the EU activity.
    - PB (EC): Thanked Japan for the offer to contribute data and noted that the EC will co-operate closely with Japan to develop specifications for this topic in Geneva.

Other Comments

- David Davies (PACTS): Asked whether many of the casualties occur off the public highway, which would mean that they are not captured by casualty statistics?
    - RC: Replied that this is certainly the case for the UK, but not sure about other EU countries.

Event Data Recorder (EDR)

Presentation from DH:

- Tjark Kreuzinger (ACEA): Clarification of ACEA's position; ACEA would support the mandatory implementation. It should follow US content specification, recording rates.
- Kai Frederik Zastrow (PSA): Stated recording of personal data is regulated on a national level. It is not harmonised across the EU (in France for example speed must not be recorded). He asked if TRL/the commission are in contact with the appropriate national organisations for each country that look after data protection and how can we be ensured that the EDR legislation is not in conflict with national legislations.
    - PB (EC): Explained we are developing an EU regulation that will prevail over these. He expressed concern that fundamental vehicle information is not allowed to be registered in a black box. He highlighted the need for sensible collection and use of the data.
- Oliver Carsten (Leeds University): Asked to what extent have TRL considered the changes necessary when moving to automated vehicles? He carried on saying you can't interview a driverless car, knowing the status of the system will be vital. How much are you considering the growing need of automation?
    - DH: The primary measure is to work on immediate requirements such as Part 563 maybe with a few enhancements to standardise additional items people are typically recording. We have noted the increasing discussions at Geneva regarding recording of automated vehicle systems. It might not be EDR; it might a second box that measures these other systems.
    - Olivier Lenz (FIA): R*esponse missed*
- Victor Brangeon (FIA): Clarified their position on EDR: They reinforced what TRL summarised; however, the FIA does not see EDR as a major measure for road safety. The position of the FIA is still under development. FIA was asked for a revised position statement.
- Graziella Jost (ETSC): Believes EDR is a very important measure to learn from to improve the next generation of vehicles; they believe there will minor or no additional costs to fitting it. She asked why does this not apply to all vehicle categories. Driver monitoring could reduce insurance premiums. Harmonisation of data on EU level would be favourable for use of the data in research. Support the date of 2022.
    - DH: Heavy vehicles were in scope of TRL's DG MOVE CBA and there was agreement with heavy vehicle manufacturers that if there was a defined specification it would be possible. There was a willingness to do this if a standard were created.
    - Hans Hesse (MAN Truck & Bus AG): Stated legal experts see this in conflict with the constitution in Germany (with regard to data privacy).
    - Kerri Cheek (TfL): Emphasised that 80% of people Killed or Seriously Injuries (KSI) in London are Vulnerable Road Users (VRU) and therefore supports additional triggering considerations relating to these casualties.
    - PB: Trucks and buses could be considered, for example by defining a voluntary standard.
- Abayomi Otubushin (BMW): The main purpose of this is to learn how accidents happen. This can be done already by simulating accidents that did happen by varying input parameters.
- Hans Ammerlan (RDW): Asked if there was any evidence of the behavioural influence of EDRs?

    - RC: Replied for fleets we have seen reductions in collision rates; however this might not be directly transferrable.
- RC: Summarised this measure; all were in agreement of having data recorded but more clarity in how the data is recorded is needed. The data needs to be more widely available so we can learn more about the mechanisms that learns to incidents. There were no oppositions to this measure.

Intelligent Speed Assistance (ISA)

Presentation from MS:

- Ellen Townsend (ETSC): Supports the comments from Professor Carsten (OC is one of their advisors); ISA is one of the top priorities for ETSC. They are looking for a voluntary (not advisory) policy with no on/off button and that their position is it should be over-ridable but always on. ET also suggested changing the terminology from Intelligent Speed Adaptation to Assistance as it would be better for public acceptance. ETSC support mandatory for trucks and buses as they do speed on roads with lower limits. ISA will add to the speed limiter.
- Ulrich Veh (ACEA): Explained OEMs see it as a topic of sequence: need accurate speed information in maps, or adequate signs (including ITS), then can use it within the cars.
    - RC: Replied by asking UV if we have any knowledge of the proportion of roads that is not adequately mapped. UV replied no.
- Kerri Cheek (TfL): Said TfL are about to publish a trial (by TRL), and found that the low limit areas were those with the highest effectiveness. They also have a digital map of London (updated every month), and will ask colleagues for the cost of developing and maintaining this.
- Oliver Carsten (OC): Believes Euro NCAP already rewards this and the mapping systems are pretty good. There is an EU consortium on this. For most studies there is no consideration of the greater mass of the heavy vehicles, they assume the same effect as for cars, which will lead to an underestimate of effectiveness.
- Claes Avedal (Volvo Group Trucks Technology): Explained we don't get anything like the quoted effectiveness (figures too high); may be able to provide further information.
- Stef Cornelis (T&E): Believes that most of the potential for heavy vehicles is on non-motorway roads. He has reports on this that can be shared.
- Hans Ammerlaan (RDW): Commented the costs per vehicle are less than the cost of a speeding ticket, which may help convince people of the benefit!
- Jeanne Breen (JBC): Believes this is one of the most important safety measures that the EC could introduce at this time. She recommends a voluntary over-ridable system rather than an advisory one as the benefits would be too small. There are examples of these systems on the market and doing well.
- Ceri Woolsgrove (ECF): Explained we need to contribute to the safety of cyclists and pedestrians as a reduction in the perceived risk will encourage more people to use these modes.
- Stef Cornelis (T&E): Thinks we don't necessarily need a one-size-fits-all policy (could be e.g. mandatory for heavy vehicles and voluntary for cars) this is because different vehicle types have different associated risks.
- David Davies (PACTS): Thinks it would be good to get input from the police on this.
- Kerri Cheek (TfL): Said TfL will be rolling-out mandatory ISA on all 9000 London buses in the next few years. There should be no reason this can't be done elsewhere.

- RC: Summarised the discussion; the use of assistance rather than adaptation, exceptions and effectiveness for trucks and whether it should be voluntary or mandatory.
- PB (EC): Explained the idea of an integrated approach and how the infrastructure and the car industry need to address this. Making this mandatory for the vehicle would provide a clear encouragement to member states and enable them to sort out the infrastructure. The EC should make the first move. PB has also been in communications with the European Union Agency for Law Enforcement Training (CEPOL). They have a large amount of interest in General Safety and will ensure that they are part of the discussion going forward.

Drowsiness and Distraction Recognition (DDR)

Presentation from MS:

- Hans Ammerlaan (RDW): Have any of naturalistic driving studies reported at the Enhanced Safety of Vehicles (ESV) conference by the National Highway Traffic Safety Administration (NHTSA) been included?
    - MS: Replied we will check, but do they look at countermeasures or just target population.
    - Oliver Carsten (University of Leeds): The NHTSA studies look at the risk of a collision given a certain level of distraction (duration of gaze away from the road). Fatigue much less clear from Naturalistic Driving Studies. Action TRL: to check the ESV papers.
- Hans Ammerlaan (RDW): Commented on taking care that the DDR won't be irritating for drivers. It took several phases of development to get this right for seat-belt reminders.
- Paul Fay (PACTS): Questioned a comment from the introduction, about phase-in and being technology neutral, and asked whether there is a clash. If using an existing forward-looking camera you would have one warning threshold, if using a steering angle sensor you would need a different warning threshold. How will this be handled?
    - PB (EC): Explains the EC will not specify a certain technology but may have a requirement that you track the eyes. In practice cameras may be the best option but this won't be noted so any technology that works could be used. Distraction is currently a major political issue and in the media. Ideally it would be preferred to go for full distraction recognition immediately. However, it is important to be neutral and if the time is not right to make a case we could consider a phased approach. It is a difficult balance and we need to understand your priorities as stakeholders. Similar to EDR, there is a privacy issue to do with pointing a camera at people. How will people react to having cameras in front of their face?
    - RC: Highlights the difference between fatigue and drowsiness. Distraction is a much shorter and less predictable event.
- Paul Fay (PACTS): Airline pilots accept having their voice recorded continuously.
- RC: Asked the floor how do they feel about the differentiation between the simpler drowsiness recognition compared with the likely more complex distraction recognition?
    - Oliver Carsten (University of Leeds): Replied this could be passed back to the OEMs, who are acknowledging that they need to detect driver availability for Level 3 and 4 automation systems.
    - Abayomi Otubushin (BMW): Answered yes, they are addressing this with these systems. The company started with a coffee cup symbol and are now developing systems that ensure that the driver can come back into the

loop when needed. The timing needs to be locked into the timing of higher levels of automation.

- Yoshikuni Miki (Fujitsu-TEN): Commented location information is uploaded for eCall, so there is a precedent for some level of privacy for a safety benefit. However, they believe that DDR can be done without privacy issues.
    - Abayomi Otubushin AO (BMW): Replied if you have a contract with a customer there is no issue. In other situations it is different. There was a lot of discussion about this in defining the eCall for minimum invasion of privacy, e.g. only storing the data for a very short period of time.
- RC: How do we measure the effectiveness of the warning that is provided? How do we make it both effective and acceptable? The car can see the driver on his phone, how do you lessen the driver's experience? E.g. turn the radio off.
    - Oliver Carsten (University of Leeds): The teen driving studies in the US have targeted groups with parental feedback. But has a very limited target population.
    - *Name missed*: Suggested comparing this measure with forward collision warning, which is not very effective because it either warns the driver far too early of far too late and people switch it off; if it is linked with distraction monitoring it could provide an appropriate warning.
- Matthias Kuehn (GDV): IIHS have also noted that this is particularly helpful for older drivers having e.g. medical difficulties.
- RC: Summarised this measure by saying it clearly affects a large number of casualties each year because of collisions due to being tired or distracted, there is a range of devices currently available, driver distraction is a complex matter and we have large knowledge gaps in this area.
- PB (EC): Asked the floor what are the preferred options. Should we focus on Just drowsiness from monitoring swerving or distraction as well?
    - Tjark Kreuzinger (ACEA): Commented that technically we know about the drowsiness systems; however, distraction technology is not mature enough. They will be better used in the future as support for automated driving features.
    - Ellen Townsend (ETSC): ETSC is concerned with driver distraction. A position paper will be ready for the 7 December deadline.
    - Kerri Cheek (TfL): Distraction is one of TfL's highest priorities; however, better systems need to be available.
- MS: Any further comments from heavy vehicle industry?
    - RC: There are a lot of aftermarket systems.
    - Claes Avedal (Volvo Trucks Technology): There is no other information for HGV's but they have the same technical challenges.

Alcohol Interlock Installation Document (ALC)

Presentation from MS:

- Hans Ammerlaan (RDW): The alcohol interlock programme in NL has stopped because there were too few participants to make it workable. MS asked if there was follow up study into why it didn't work and if it was linked to costs. HA was unsure but can see if there is more information available.
    - Ellen Townsend (ETSC): SWOV presented at an ETSC conference on this recently. There was a court case in the NL, with a hearing in the NL Parliament and there was overwhelming support for reinstating it in the NL.

- Ellen Townsend (ETSC): ETSC would certainly welcome this as a first step. ETSC has been calling for new vehicles to be fitted with AIDs. They definitely support the measure to allow people the option to enter a programme instead of losing their license and support certain member states' local requirements that vehicles transporting children professionally have to be fitted with an AID.
- PB (EC): Explained that the EC are not talking about mandating AIDs, just facilitating the fitment. These are two entirely different things. Thank you to ACEA, in particular Gianfranco Burzio, for working hard on the EN standard which will take the form of a basic guide on how to install an AID to type of vehicle. This is important as the AID industry is struggling to fit their devices to ever more complex vehicles due to the lack of information available. The car industry have said they want to help and through interacting with the European Committee for Standardization (CEN)/European Committee for Electrical Standardization (CENELEC) groups the EN standard was created. The plan is to make this part of type approval. This is a relatively low-level measure, but it is also a very important one.
    - Gaziella Jost (ETSC): Replied there is a need also to implement the other parts of the EN standard that defines the AID such as an interface.
    - Gianfranco Burzio (ACEA): Replied the EN standard does not define a standard interface, but defines how to interface an AID. It may be that a standard interface is defined in the future, but it is very dependent on the vehicle architecture. The data communication is part of the current standard that we are talking about. *Option one and two missed*. The third option is provide better communication and is the most realistic choice.
    - RC: Clarifies GB's comment, the architecture of modern cars is at such a high level that you have to make sure that the system is secure it is more than just the information being supplied.
    - Gaziella Jost (ETSC): Replied it should not be up to manufacturers to choose the third option.
    - PB (EC): Explained this would effectively require regulating the vehicle systems, which is not desirable and may impede new technology development. A suggestion is if such a system is fitted, AID must be supported – an 'if-fitted' requirement. Another suggestion may be able to have a dynamic reference to the EN standard, updating as new car networks are introduced. This is an option for discussion.
    - Gianfranco Burzio (ACEA): Replied by saying the third option is actually less expensive for the end user; the installer needs to go to the OEM and get information for the first two options but not with the third option.
    - RC: Summarised this measure as cost-beneficial and about making vehicles capable of being fitted with interlocks.

Seat-Belt Reminders (SBR)

Presentation from MS:

- Paul Fay (PACTS): Commented that there is reasonable cost-benefit for rear seat without occupancy detection, but not with occupancy detection.
    - PB (EC): Confirmed that we have taken on board that these are not occupant detection systems for the rear.
- Jeanne Breen (JBC): Does UN regulation 16 require this?
    - PB (EC): The Commission worked with Japan and Korea to develop requirements. It will include occupant detection for front seats but may be the non-detection types for rear seats.

    - Jeanne Breen (JBC): Wanted to highlight the large casualty problem of low seat-belt use rates in rear seats in many countries, which wastes the efforts manufactures go to improve their vehicles. The alternative methods to increase seat belt use are limited and SBR scores high for cost effectiveness, so it is very important.
    - PB (EC): Euro NCAP is very active in encouraging this. The EC would like Euro NCAP to pick up where they leave off in terms of non-detection systems in the rear.
    - Michiel van Ratingen (Euro NCAP): Believes just because the current occupant detection technologies are not cost-effective for the rear seats, it doesn't mean that new technologies won't fill that gap – suppliers are working on this.
- Graziella Jost (ETSC): Commented that the system will detect that a rear seat occupant has unbuckled mid trip easily; however, the problem is people not buckling-up at all. NCAP doesn't require detection, but does encourage it. Can also be introduced earlier than indicated. There is also something wrong in the text. It says Euro NCAP will require occupant seat detection. It just gives incentives and the incentive is too low. We are challenging for more so the market will pick it up. Also the UN Regulation states 2019 for new types and 2021 for new vehicles. Which year are we aiming for?
    - PB (EC): The aim is 2019 to align with UN.
- Hans Ammerlaan (RDW): Comments we need enforcement and education, to work with the technology for maximum benefit.
    - PB: Explained a point raised by Korean research which says seat belt reminders for rear passengers in the car will have educational effect on drivers.
- RC: No comments for trucks and buses.

Emergency Stop Signal (ESS)

Presentation from MS:

- Tjark Kreuzinger (ACEA): Comments every change for existing types and new vehicles would require some lead time.
    - PB: Clarified that the date for new vehicles would be 2020 and 2022
    - ACEA: Indicated agreement; ESS would be made mandatory at EU level, not through Regulation 48 because other contracting parties might not approve.
- Oliver Carsten (University of Leeds): Asked what is the justification for allowing both types of indication? Is one better than the other?
    - DH: Replied there was evidence that flash the indicators were more effective.
    - RC: Replied it's harder to detect.
    - Oliver Carsten (University of Leeds): Explained how there was a study in the US about why us red turn signal had a problem. Drivers had to wait for a cycle to see if the vehicle in front was turning or braking. This meant there was a longer reaction time to the flashing red indicators.
    - *Comment missed*
    - DH: Answered for directional indicator not for emergency brake lights
- *Name missed*: The US allows red direction indicators, what about ESS?
    - PB: ESS is not allowed in the US.

- Name missed: Asked if the amendment will be at UN level? How can an optional system be made mandatory at EU level?
    - PB: Explains there is a level of discretion; a good example is TPMS; i.e. if it complies to Regulation 48 the approval will be accepted but will not lead to a full European Type approval.
- Hans Ammerlaan (RDW): Commented the rise time of the filament lamps (compared to LED) should be considered.
    - DH: replied this has been accounted for in the allowance
    - Hans Ammerlaan (RDW): using LED lights makes a difference.
- Hans Hesse (MAN Truck & Bus AG): Asked if the 1968 Convention allows flashing brake lights?
    - PB: The EU is not a signatory to the 1968 Convention.
    - Hans Hesse (MAN Truck & Bus AG): But all member states apart from UK are.
- Adam Mitchell (Aspöck UK Ltd): It is clear to find the activation point of the system but we haven't actually defined when it deactivates. Is it the drivers velocity that provokes acceleration rate
    - PB: responded by saying we adhere to the UN regulation. The specifications will be laid out in this.
- Adam Mitchell (Aspöck UK Ltd): Asked whether O Category vehicles will be affected by this? It should be clearly defined whether or not a trailer would also need to flash the lamps, which will require forwarding the signal. Aftermarket tow-bar hitches might have an influence; trailers are towed by M Category vehicles as well. Should be clarified how O Category will be treated.
- Adam Mitchell (Aspöck UK Ltd): Added to this by mentioning the current designs of progressive indicators (e.g. by Audi) sliding to the side) should also be taken into account.
- Hans Ammerlaan (RDW): When using the side marker lamps as well it should be considered whether this leads to voltage drop (which would make the lights darker?)
- PB: believes the rapid flashing of the indicators will only occur on the rear indicators.
- *Name missed:* current legislations say the side markers have the same function as the rear indicators. The signal will be from ISO socket to the trailer.
- DH: Is there an objection to standardise the signal on one signal (indicators or brake lights?) or the other
    - *There were mixed views in the room*.
    - PB: Could have standardisation only on the trailer. This would mean you have amber lights on tractor and reds lights on trailer.
    - *Name missed*: commented standardisation might mean the existing design might need to be adopted and it could also lead to difficulties at UNECE levels.
    - PB: preference is if there is an issue the GRE will address it at Geneva. We will have no necessary input or request of modifications at UN level with regards to this measure.
- Adam Mitchell (Aspöck UK Ltd): The suggestion currently very difficult achieve with the ISO socket would require permanent changes. We need to keep in mind this does not just affect o class vehicles but those also pulled by M class vehicles.

- RC: Summarised this measure; single system would introduce more cost; PB is happy allowing the UN to make the judgement on the performance specification. The cost will be nil or low if this route is taken.

Close

RC closed Day 1 of the meeting at 16:00.

Day 2

TRL: David Hynd (DH), Richard Cuerden (RC), Matthias Seidl (MS), Phil Martin (PM), Anna George and Rob Hunt

EC: Peter Broertjes (PB)

Stakeholders: See attendance sheet

Session 1 – Heavy vehicles

Direct Vision and VRU detection (VIS)

Presentation from MS:

- RC: Explained to the stakeholders they should send their information to TRL by 7 December if they want the information to be included in the report. The formal Impact Assessment will be conducted in early 2017. The Commission will run the formal Impact Assessment for all measures. The EU stakeholder meeting will take place in spring time.
    - PB: Emphasised that the Commission will engage in another stakeholder consultation, but please do not wait until then to provide more information. That period will be used to fine tune everything. We need the big picture now. If we find out its not feasible, we will have to drop the measure from the proposal. The date and time is to be confirmed.
- Richard Damm (Federal Ministry of Transport and Digital Infrastructure): Commented cameras might not have such a high influence when bicycles are moving parallel with the HGV. The camera lag time can have a major effect on cyclist safety due to them cycling so close to the HGV and adjusting their course so quickly. Do you see this as different measures or do you see the EC merging cameras and rear view into one measure?
    - PB: replied it depends if the cost effectiveness brings one of them down, then separation could be wise. Ideally one package is preferred.
- Hannah White (TfL): Asked why are construction and distribution figures separated? How developed is the idea of separating HGV roles?
- Mike Lowe (DfT): Asked what happened to longer cabs, front and rear flaps? Has this stalled?
    - PB: Replied there will be two separate tracks, PB is currently working on both and a more refined answer will come soon (by end of year). The technical requirements for rear, front flaps, etc. are coming soon.

o PB: Explained the direct vision will be separated from the elongated cab. You will be able to have elongated cabs without meeting the direct vision requirements thereby unlinking the two matters. We need more fuel efficient vehicles on to the market. We can do this without the direct vision requirements.

- Claes Avedal (Volvo Group Trucks Technology): Asked what do you mean by camera and detection systems? Should the cameras be fitted instead of mirrors or complement them?

- Adam Mitchell (Aspöck UK Ltd): Added cameras improve aerodynamics.
- PB: Responded eventually mirrors will be replaced by cameras. For the time being the camera systems can be enhanced to recognise cyclists. Definitely scope for that (eventually replacing).
- Claes Avedal (Volvo Group Trucks Technology): Currently cameras are more of a warning system.
- MS: Clarifies that both was required, detection and warning, of VRUs.

- Hannah White (TfL): If you're looking at different types of vehicles and different accident types. How is the thinking developing on separating vehicle types?
  - RC: Explained we are looking at rigids as TRL believe these trucks have more exposure to these scenarios. Work is continuing. If you have evidence to disprove this, please can you provide help?
- Stef Cornelis (T&E): Mentioned that Dennis has published accident investigation work.
- Takashi Naono (JASIC): Added we announced yesterday the start of discussions for HGV visual requirements. They have established an informal working group, proximity of visual requirements including heavy duty vehicles. We could incorporate ideas. Japan accident survey for VRU passing in front of HGV. JASIC is happy to share data with the EC.
- Simon Bradbury (TfL): Added he has two unpublished reports on the effectiveness of VRU detection on buses in London. They are unpublished due to legal challenges from the manufactures. To what extent do you need information? TfL will need to know how to sanitise the report if TRL wants to use them.
  - RC: Replied it all needs to be published as it increases transparency. We ideally need to reference published material.
  - PB: Added it is still scope to include, as he has experience in working with anonymised data about real driving emission testing. He used the data but did not declare any vehicle models. We should be able to use that.
- Richard Damm (Federal Ministry of Transport and Digital Infrastructure): Commented they will provide a report; however, their test procedure disregards aftermarket systems.
- Hans Hesse (MAN Truck & Bus AG): Explained he is not happy about political regulations. There are so many different types of scenarios and possibilities. The technology is not yet robust enough for this system. MAN spent 6 months developing a system, tried in all conditions, but it couldn't go on to market as it was not robust. It couldn't predict what the cyclist was going to do due to the close running of the cyclist. He added it is only a political regulation. It's too easy to say do X and Y. Have we got the man power to make this a reality? Is it possible to make this possible? We haven't.
  - RC: Replied the aim of this is to determine what measures can we implement that positively affect vehicles? We get all the CBA information from the literature and pass the information on to the EC. I think the comments you make about what systems do and do not work. We have evidence that trucks have the equipment. How many lives can we save?
- Ellen Townsend (ETSC): Asked where is the front underrun protection? She expected this to be linked with direct vision.
  - PB: Responded Front Underrun Protection (FUP) is a moving target. It exists for the moment. We are not sure on its effectiveness. If we go for more elongated cab with cone shape we will need to update the FUP regulation and include a new type of assessment protocol. It is still in its early stage of conceptualisation. FUP will be on the weight and dimension

directive not in the GSR process as it has a more imminent need. It could come into effect faster under weights and dimensions than under GSR.

- Ellen Townsend (ETSC): Asked are you fundamentally going to change how FUP works?
- PB: Responded it is currently open for debate. Work is starting on it in Geneva. The shape of the underrun will change. At the moment it is straight. Adding curvature to the design will make testing more difficult. PB suggested it could be dynamically tested with a Mobile Deformable Barrier.
- Magnus Jalkesten (Scania): Added FUP is different scope.
- Ellen Townsend (ETSC): Responded revision of front underrun should be on GSR 2.
- Hannah White (TfL): Responded by saying front underruns may reduce injury, it is relevant. It is not fair to say it doesn't effect VRU protection.
- Magnus Jalkesten (Scania): Replied we are mixing different topics.
- PB: Added we can do it at UN level. It is already mandatory at EU level.
- Ellen Townsend (ETSC): Note to say they are disappointed that it is not included.

- Ellen Townsend (ETSC): Commented on direct vision vs camera detection, we support direct vision over cameras and AEB for pedestrians and cyclists. Overall direct vision. Also support differentiated approach, phasing in, suggested by T&E.
- Claes Avedal (Volvo Group Trucks Technology): Added current aftermarket camera system performance levels are not very good.
- MS: Commented it is a chicken and egg situation. Could we achieve goals through less radical design changes?
- Jean Louis Chazalette (Volvo Trucks Technology): Explained that low-entry cabs (LEC) are very effective for urban operations but sub optimum for long haul routes.
  - MS: Do you have a path? What data is available to help?
  - *Name missed*: Trucks are very different. One standard will not fit all types of HGV. We need to distinguish between each type or at least the major types.
  - *Name missed*: LECs up to 26 tonnes cover must urban roles.
  - *Name missed:* Which vehicles cause which injuries in Stats 19? The Information is out there. Rigid vehicles in urban areas are the main issue.
  - Claes Avedal (Volvo Group Trucks Technology): The 2 billion cost estimate figure maybe correct in the case of an over haul but it is not the same as the regulatory cost. It's an investment. How expensive is low entry to normal cab? Do you need a new powertrain? Probably not. What additional costs are linked to low volume manufacturing? Heavier vehicles are mostly on the same level of direct vision. One or two slightly worse as their cab design hasn't been updated. Best in class system would be good.
  - *Name missed*: Responded are you requiring complete redesign or not. Defining direct vision could be more effective.
  - Magnus Jalkesten (Scania): It is important to check loading capacity. LEC's won't have the same capacity (payload) .
  - Claes Avedal (Volvo Group Trucks Technology): Responded we need to look at all aspects; we could create a scenario when all city trucks were LEC.

    - Magnus Jalkesten (Scania): Added there is more load on LEC front axles, there are many aspects which need to be researched further.

- Hannah White (TfL): Commented this is a really good opportunity to dramatically improve safety. There needs to be more focus on having the right vehicle for the right job. We've done some simulated experiments. Reaction times are faster by improving direct vision compared to relying on indirect vision/detection. It made a significant difference in reaction time. TfL have scientific evidence.
    - *Name missed*: Suggested increased collaborative work with manufacturers in the room.
    - *Name missed*: Asked if we can take existing cabs and turn them in to a LEC?
    - *Name missed*: Asked do we need off road cabs in cities?
    - *Name missed*: Can you have a 26 tonne LEC?
- Hans Hesse (MAN Truck & Bus AG): *Missed comment*
- Johan Broeders (DAF): Asked why are we talking about LEC? High visibility is the goal.
- *Name missed*: Added drivers have to look in several directions all of the time. Detection is more effective than direct vision.
- RC: Asked how is DV vs what systems can do to help integrated? If we are going to have detection systems on vehicles, what will the roadmap look like? What is the likely fitment of the systems? Standard equipment?
- Ceri Woolsgrove (EFC): Likes the idea of splitting roles. Construction lorries are the main issue and should be looked into further.
- PB: Commented we are now at a cross roads, we have to think about a differentiated approach. Long haul HGVs are involved in fewer accidents. Where are we with the data? Is it robust enough? If so, we can take a decision today (soon) on what approach we can take.
    - Stef Cornelis (T&E): Asked considering that LEC HGV's already exist; can we be more ambitious with the implementation dates?
    - PB: Responded that is a fair comment however OEMs may disagree. It is most likely easier said than done.
- Dieter Schoch (Daimler): Commented that a cyclist riding alongside a vehicle (just behind the cab) is the worst-case scenario. In this case direct vision will not help. Cameras are needed to supplement direct vision.
    - RC: Responded given we understand where these accidents happen and the mechanisms. Can we start to separate the vehicles? We need the data to do this.
    - Simon Bradbury (TfL): Replied there are different vehicles involved in this category. Camera and detection could be an interim measure in advance of improved DV. The assumed effectiveness of the detection needs to be equated to.
    - *Name missed*: Buses can see pedestrians; there is a greater role for AEB predicting the collision path of the pedestrian. Define presence or collision detection warning.
    - Magnus Jalkesten (Scania): Commented Scania does not have the data; we need to evaluate camera detection and how effective it is before we move on to direct vision.
    - Hannah White (TfL): Added drivers cannot see out the windows, need six mirrors, which then takes a five second sweep to look at them all. Arup and University of Leeds report supports this. It's a fundamental design

flaw. Referring to Arup study, in terms of effectiveness of detection cognitive load increases incidents because of the additional information to consider. Be careful with effectiveness assumptions.

- RC: Added Mercedes truck will brake for driver, technology moving faster than legislation.
    - Simon Bradbury (TfL): Responded by saying the driver could become so reliant on the system he won't bother to check mirrors.
- Hans Hesse (MAN Truck & Bus AG): Added we must have a regulated point, however we do not have it. The national Regulation for direct vision in Germany is not mandatory. It is a guideline more than a regulation. It is very complicated to improve direct vision if complying with Regulation 29. What is really necessary for the type approval process?
- Dieter Schoch (Daimler): *Comment missed*
- Adam Mitchell (Aspöck UK Ltd): Unless there is an incentive to purchase LEC's, the fleet penetration will be low. Most major fleet composition decisions are done by CBA so will not care about it unless there is a reason to do so.
- Ceri Woolsgrove (EFC): Commented we don't have vision standards, now is a revolution in truck safety. We need to combine direct vision and AEB.
- Mike Lowe (DfT): Stated he prefers direct vision over detection. As technology improves, the level of standard equipment can be added to over time. He recommended setting out a trajectory rather than big bang solve.
- Ellen Townsend (ETSC): ETSC works with employers and believes there is a strong business case for vehicle safety. Employers do not want their trucks involved in accidents because of the social and reputational costs of hitting someone.
- Hannah White (TfL): TRL is working on a direct vision standard. More collaboration with the manufactures needed to make it happen. Operators need to choose the correct vehicle for the right role.
- William Todts (T&E): Disagrees with the idea of a big bang solution. Instead introduce X, Y, and Z to your portfolio by 20XX.
- Johan Broeders (DAF trucks): Is working with TfL to determine what affect location has on manufactures. Location specific (e.g. London) standards will enable quicker implementation however if we are not careful we could end up with different requirements for each city/region. Setting a clear direction with a common set of standards is vital.
    - RC: Agreed we all need to get behind a clear direction.
- PB: Explains we can take the cost of development however it is the additional costs figures which is lacking. PB urges the manufactures to provide any available information otherwise assumptions will have to be made.
- Claes Avedal (Volvo Group Trucks Technology): Volvo has the information but will not discuss in detail in front of other companies
    - *Name missed* (ACEA): Explained the Commission can't ask ACEA for cost figures, they will have to ask individual manufacturers.
    - RC: Responded we don't want to the point accuracy rough estimates will be sufficient.
    - PB: Relied by reiterating this is not about you making it easy to get our way. Transparency is vital. It will not be possible to make all the measures happen. The EC will definitely consider a differentiated approach.
    - Claes Avedal (Volvo Group Trucks Technology): Volvo will have a meeting to decide how to provide TRL with the information.

- Dieter Schoch (Daimler): Commented that the cost of a new vehicle is very different to modifying it.

- RC: Summarised this measure; the industry is at a cross road, the two main ideas are one size fits all or a segmented approach, we could direct costs to types with higher exposure to VRU's and we need further evidence and figures.

Tyre Pressure Monitoring System (TPM)

Presentation from MS:

- Claes Avedal (Volvo Group Trucks Technology): Asked why does this come under GSR2?
  - MS: TNO studies looked at various aspects of this technology. Safety was one of these but it may not have been a dominant factor.
  - Claes Avedal (Volvo Group Trucks Technology): Asked what are the target accidents? Volvo have tried to identify the accidents and identified tyre explosions as very rare.
  - MS: Replied that properly inflated tyres increase control and welcomed further comments.
  - Dieter Schoch (Daimler): The easiest method to improve tyre friction is to eliminate the worst tyres on market.
  - MS: out of scope. There is a lot of research on light vehicles but not on HGV's. How relevant are tyre related issues?
- Hans Hesse (MAN Truck & Bus AG): Explained he had the lead for TPMS while in German equivalent to DfT. It made no sense to regulate because out of 3700 truck related deaths only three were killed as a result of heavy vehicle tyres. There is also very minimal data on injuries and the CBA was negative.
- Hans Hesse (MAN Truck & Bus AG): Continued there are 400-500 different types of tyres and you would have to test all the types to full fill the tests. Furthermore 50-60% uses re-treaded tyres which add to the complexity. We don't see any provision to make mandatory.
  - MS: Asked what is the current situation for cars? Is it only the OEM recommended tyres?
  - Hans Hesse (MAN Truck & Bus AG): Cars have fewer tyre combinations compared to heavy goods vehicles.
  - MS: Can you put explanation in writing please, Hans agrees. We need specific arguments and figures to state if disregarding measure.
- Frediceric Arbousse-Bastide (Sensata Technologies): Commented that their position is that the TNO survey makes sense and that there is no more precise information. As a road user, he would much prefer a system that prompts the driver that a tyre is de flatting or deflated than not.
- *Name missed*: Having a tyre problem on a truck is largely due to rust.
- *Name missed*: Asked if Regulation 64 could be expanded to larger vehicles or even wider.
- *Name missed*: TPMS for trucks is very complex. But we have systems on the road working.
- MS: Replied we know tyre-related accidents are hard to determine. Often it is not possible to take inflation level after an accident due to damage.
- Frediceric Arbousse-Bastide (Sensata Technologies): Commented that the weight and size of the vehicle has an impact in incidents. You may have more damage; it could be harder to escape and could create extra accidents.

- PM: Asked the floor if there are any comments for buses. No comments.
- *Name missed*: Commented it could be the optimum solution for some vehicles. Tractor have a maximum of six tyres, some combinations have more than 30 tyres.
- *Name missed*: When we have a mandated regulation we will have to test all the possible combinations
- Stef Cornelis (T&E): Stated Indirect Tyre Monitoring Systems (TMS) are not performing in real world conditions. We shouldn't be mandating systems that don't work in reality.
    - Dieter Schoch (Daimler): Responded by saying indirect system wouldn't work on trucks.
- Hans Hesse (MAN Truck & Bus AG): Commented most of heavy vehicles have no connection for trailer tyres in the tractor unit.
- Jean Louis Chazalette (Volvo Trucks): Replied that the system must be able to be connected to multiple manufacturers. E.g. trailer manufacturers.
- PM: Summarised there is a diverging opinion on whether it will be implemented on HGV and buses and is looking forward to receiving the data.

Reversing Detection or Camera Systems (REV)

Presentation from MS:

- Adam Mitchell (Aspöck UK Ltd): Questioned the scope of O2 and O3 class vehicles. O2 would be more beneficial than 03 and O4 because O3 and O4 class vehicles do relatively little reversing on to open road as they tend to operate on major roads.
- William Todts (T&E): Commented that UK Stats19 could be helpful and questioned if this camera technology already exists? Group answer Yes.
- Claes Avedal (Volvo Group Trucks Technology): The 5% figure on the slide comes from the Volvo research team. Claes needs to confirm if this is for rigid vehicles only . It does not include trailers.
- Dieter Schoch (Daimler): Believes heavy vans and light trucks are another complex area. He also added multistage vehicles are different to rigid vehicles.
    - MS: Determine if rigid or artic is a better method of separating vehicles than N1 and N2
    - *Name missed*: Asked Hesse why is it different?
    - Adam Mitchell (Aspöck UK Ltd): Commented the sensor technology exists and works with ABS but does not interact (or have an interface inside) with the cab. It is a standalone system.
    - Dieter Schoch (Daimler): Believes a standardised interface should be developed.
    - Adam Mitchell (Aspöck UK Ltd): Added systems that do interact are not standardised.
    - William Todts (T&E): Asked what about under reporting accidents on private land?
- Ellen Townsend (ETSC): ETSC would support this recommendation. We will try and get more information.
- MS: Asked what are the effectiveness values? Are they similar to light vehicles?
- *Name missed*: Commented In some member states a bank man is required.
- Magnus Jalkesten (Scania): Commented we also have a reverse warning.

    - MS: Replied by asking if that is the external warning? Is it mandatory?
    - Adam Mitchell (Aspöck UK Ltd): Responded not on O class
    - Claes Avedal (Volvo Group Trucks Technology): Responded on a national basis.
- Toshiharu Matsuoka (JASIC): Added there is a proposal for reversing alarms. He was not sure if it will be made mandatory. At the next UNECE meeting Germany will propose this.
    - MS: Asked the floor if anyone knew more on this and for any views from the suppliers? No comments.
- Hans Hesse (MAN Truck & Bus AG): Commented he has spoken to a selection of people about this, what is the minimum quality of the camera? Price and quality are key factors.
    - MS: The NHTSA report looks into this and fulfils quality standards.
    - Adam Mitchell (Aspöck UK Ltd): It is worth considering various different options for delivering info to screen. Wi-Fi is good but has lag time and the connection may be difficult to fit.
    - PM: Asked if anyone knows of any cost figures.
        - Adam Mitchell (Aspöck UK Ltd): Responded by saying that the estimated proposed for proximity based systems for O class figures are significantly out.
        - *Name missed*: Assumption is too low needs to be 250 Euros
    - *Name missed*: Will sensors work due to noise of air systems?
        - Adam Mitchell (Aspöck UK Ltd): Replied we use ultrasonic sensors. They are in use but are not sure if the system meets necessary requirements.
        - MS: Suggested RADAR and asked what would be the cost?
        - Adam Mitchell (Aspöck UK Ltd): Responded by saying you would need more units.
        - MS asked How much more expensive is RADAR compared to ultrasonic? Adam had no answer but will look in to.
- Hans Hesse (MAN Truck & Bus AG): Missed comment
- MS: We haven't carried out the CBA because the Commission will do this. If we want a regulation for cameras on back side of vehicles, type approval for overall vehicle and a standardised interface. At the moment we do not have this.
    - MS: Asked the floor what is the dominant factor in costs?
    - Hans Hesse (MAN Truck & Bus AG): Replied with clear regulated provisions. The whole system needs to be looked into not just the cost of the camera.
- *Name missed*: Believes it would be beneficial to look at Stats19 for target population

Bus Fire Safety-Automatic Fire Extinguishers (BFS-AFE)

Presentation from MS:

- Dieter Schoch (Daimler): Commented that the requirements are close to being fixed now. And asked why do we expect additional bus fires compared to the situation now? There are a very low number of bus fires which occur mainly in older vehicles. A number of new buses have caught alight because of changes in the updated noise requirements.

- General agreement that the definition of the target population is ok.
- Adam Mitchell (Aspöck UK Ltd) and *name missed* (BAST): Were surprised by the high figures for bus fires.
    - Adam Mitchell (Aspöck UK Ltd): Commented that if those figures are correct, there should be time and effort on the cause rather than putting them out.
    - MS: The investigation is limited by scope.
- MS: Asked the floor if anyone has more data on bus fires.
- MS: We were also astonished by high figures. But clarified that only 60% are caused by engine compartment.
- MS: Asked for any further comments? Potential effectiveness? Limited research, asked the floor if they agree with TRL's assumptions (Close to 100%)? No comments.
- MS: Asked if there are any discussions in Geneva about the test procedure? Reply from stakeholders that there is a defined test procedure available in Geneva; close to finalisation.
- MS: Asked if there was any information on the cost of system. No Comment.
- MS: Asked if there was any opposition to measure. No opposition.

Bus Fire Safety-CNG Pressure relief (BFS-CNG)

Presentation from MS:

- Dieter Schoch (Daimler): Explained that this measure is also close to finalisation in Geneva.
- Magnus Jalkesten (Scania): Commented he was not sure about costs for this measure and that he would look in to it.

Rear Underrun Protection (RUR)

Presentation from MS:

- *Name missed*: commented that foldable Rear Underrun Protection Systems (RUPS) have not been mentioned in Geneva.
    - MS: Asked what precisely is included in the 03 amendments 58?
    - Magnus Jalkesten (Scania): Responded by saying that only applies to height.
    - *Name missed*: Added this series of amendments does not include exemptions.
    - Claus Pastor (BAST): To supply a source to TRL.
    - Magnus Jalkesten (Scania): Is that with the additional loading (strength requirements)? Yes.
    - Claes Avedal (Volvo Group Trucks Technology): Commented that 03 amendments to R58 reviews different wording for exemptions.
    - MS: Asked if the modification will reduce the number of exempt vehicles?
    - Claes Avedal (Volvo Group Trucks Technology): Commented the regulations add general wording.
    - Dieter Schoch (Daimler): It was mainly directed to off road vehicles.
    - Claus Pastor (BAST): The change in Geneva would not have an impact on these vehicles.

- *Name missed*: What was the outcome of the CBA?

- Erwin Kirschner (Daimler): The discussion in Geneva is close to finalisation
- MS: Asked the floor if the 100 kN across three points was included in the proposals discussed in Geneva?
    - Jean Louis Chazalette (Volvo Group Trucks Technology): Commented the strength for the test is increasing. New designs are needed to meet these standards. Loads were to increase significantly in 03 series.
    - *Name missed*: Commented there is no connection to the three points.
    - *Name missed*: Commented increased loading was taken in to consideration in CBA.
    - *Name missed*: Commented it might be included in 04 but we are still working on 03 series.
    - *Name missed*: Commented that there is a good CBA study available for 03 Series of Amendments.
    - *Name missed*: Commented what's on the slide (100 kN loading across three points) is possibly more appropriate for 04.
    - Dieter Schoch (Daimler): Commented that the forces applied to certain points were significantly higher than 100 kN.

Lateral Side-Guards (LAT)

Presentation from MS:

- MS: We have an update for ground clearance happening in Geneva. MS clarifies is it just the exemptions? Scania and Volvo agree.
- *Name missed*: No new technical requirements.
- Dieter Schoch (Daimler): Added not to talk about technical requirement but remove exemptions at DG MOVE.
- Magnus Jalkesten (Scania): What do you mean by current fleet?
    - MS: Clarified across all affected categories e.g. rigid, artic.
    - *Name missed*: Added there are no requirements for tractor units.
    - *Name missed*: Commented that it was a major issue for rigid vehicles
    - *Name missed*: Replied it was not so common with articulated combinations
- MS: Asked if there were any opinions on the potential to reduce ground clearance of side guards? He added it may reduce performance in certain situations
    - Adam Mitchell (Aspöck UK Ltd): Side guards are not filled in at the moment (a series of bars rather than a solid sheet).
    - Magnus Jalkesten (Scania): Explained that the problem is how the vehicle is used. Why should an off road vehicle have side protection? There is a reason why you have the classification for off road vehicles.
- MS: The TfL investigation addresses these problems. Are there any potential benefits from sliding or detachable side guards?
    - Magnus Jalkesten (Scania): Added off road vehicles costs less due to not having side guards.
    - Ellen Townsend: (ETSC): Added some vehicles have triple bars and ground clearance.
    - *Name missed*: Suggested looking in to shock absorbing side guards instead of rigid. Will send more information.

- Adam Mitchell (Aspöck UK Ltd): Asked if TRL want information on where pedestrians get hit, how they are hit and where they go under the wheels?
    - MS: Replies this would be very helpful.
    - Adam Mitchell (Aspöck UK Ltd): Replied we have data on causation and mechanics of accidents
- Claes Avedal (Volvo Group Trucks Technology): Commented the Geneva decision has not happened yet.

Claes Avedal (Volvo Group Trucks Technology): Added installing a side guard when you have special body work is complex.

- *Name missed*: Commented the discussion in Geneva is not as developed as other measures
- Dieter Schoch (Daimler): Commented the discussion in Geneva about exemptions should be limited to transport applications not on road.
- MS: Asked the floor for any opinions on ground clearance, effectiveness, limited effectiveness due to high ground clearance, could improve this by lowering. Any objections? No comments. From accident research? No objections.
    - Claes Avedal (Volvo Group Trucks Technology): Commented it is very difficult to quantify the effectiveness.
    - MS: Replied unfortunately we cannot change the scope of what's been given to us.
    - Claes Avedal (Volvo Group Trucks Technology): Responded by saying we could provide additional considerations such as ground clearance, agree on exemptions
- Ellen Townsend (ETSC): ETSC believe waiting for GSR3 will be too long. People do not want their names, as truck manufacturers, to be linked to cyclist deaths.
- *Name missed*: Commented they have evidence of side underrun not being effective because it is too high.
- MS: Clarified the discussion in Geneva is about exemptions not height.
- Magnus Jalkesten (Scania): Commented that the scope has changed and that we need to take a step back. Reducing the height of the side guard is important but it's a new question for us.
    - MS: Comments we need to confirm this with peter.

MS discussing proposed updates in Geneva which removes exemptions. There must also be consideration to reduce ground clearance of sideguard but this has not been discussed in GSR2.

- PB: Isn't sure where this came from. However it is not out of the question. It should be based on cost effectiveness data. The confusion over LAT sideguard ground clearance could have been linked to RUPS ground clearance is being dropped PB: thought we were discussing only removing the exemptions.
- MS: Clarifies to the floor we are removing it from scope of our report.
    - Ellen Townsend (ETSC): Comment they are in favour of dropping the lateral side guard height.
    - PB: We do not have enough evidence.
- Hans Hesse (MAN Truck & Bus AG): Asked what will happen to off road vehicles? PB explains this is why we need to discuss exemptions.
- Hans Hesse (MAN Truck & Bus AG): *Comment missed.*
- PB: States we will not pursue variable height side guards in Geneva.
- Ellen Townsend (ETSC): *Comment missed*

- PB: Believes the exemptions for side guards need to be tightened and asked If there is a need for the devices to be completely removed (referring to off road HGV's)?
    - Ellen Townsend (ETSC): *Comment missed*
    - MS: Asked the floor if they have any cost figures for fitting side guards or sliding side guards.
    - Magnus Jalkesten (Scania): Asked if they are available now?
    - Jean Louis Chazalette (Volvo Trucks): Clarifies foldable lateral protection.
    - MS: Replies there is research saying foldable/detachable may be possible.
    - Ellen Townsend (ETSC): Thinks Extendable and retractable sideguards could be an issue.
    - Magnus Jalkesten (Scania): Commented he needs to check cost for folding side guards.
- Ceri Woolsgrove (ECF): Asked if they are more expensive than conventional designs/
- Magnus Jalkesten (Scania): *Comment missed*
- PM: The scope was tied down with no objection to assumptions.
- PM: Clarifies ground clearance has not been discussed at Geneva and is shelving the idea for a later date as It would be good to investigate but not now.
- William Todts (T&E): Commented on the weights and dimensions review, if you round front trucks, you could have a nose that has improved crash safety characteristics. Asked if it is included in scope.
    - MS: Replied the extended nose would take up a large proportion of the overall limited vehicle length. This couldn't happen if length wasn't increased
    - MS: Replied not in scope, should it be? Yes.
    - William Todts (T&E): Added it would be unwise not to include
    - Ellen Townsend (ETSC): Replied it would reduce impact force.
    - Dieter Schoch (Daimler): Responded by saying you would deflect into traffic.
    - Ellen Townsend (ETSC): Argued research was done into how they would be deflected.
    - MS: Clarified this is now out of scope.
- PM: Asked the floor if there are any more general comments? No

Close

PM closed Session 1 of Day 2 at 14:47.

Session 2 – Cars

Full-width Frontal Occupant Protection (FFW)

Presentation from DH:

- Hans Amerlaan (RDW): What is meant by "extra small vehicles"?
    - DH: Replied this refers to small volume of vehicles – in terms of production numbers, not the size of the cars.

- Oliver Carsten (University of Leeds): Commented that this may result in a small number of vehicles being unsafe (could go faster as they are not fitted with e.g. ISA, need to be careful), so people should not be encouraged to buy them.
- Kai Frederik Zastrow (PSA): Explained how the assumption that vehicles that are engineered to comply with R94 would also fulfil R137 is not correct. R94 and R137 are two different subjects requirements for frontal impact and should not be treated the same. A vehicle that fulfils one of the regulations does not automatically fulfil the other.
- *Name missed*: Commented some of the small vehicles are produced to conform to FMVSS to be sold in the United States; the European models are aligned with ACEA.
- DH: Asked for any comments on the input values, such as the relevance of van derived passenger vehicles and M1 vehicles? Is there any evidence people can provide on the collision involvement and effectiveness of M1s? No comments.
- DH: Asked if it is harmonised (THOR), will it be cheaper?
    - Tjark Kreuzinger (ACEA): Commented there may be advantages, but it will not be not cheaper;
- Hans Amerlaan (RDW): Commented he expects to see more initiative from the EC to support the THOR implementation in the tests and more supportive behaviour. There is missing commitment from the EC and this should be discussed at *name missed* level.
- Graziella Jost (ETSC): Regrets that there are no female dummies. To send feedback.
    - DH: Noted that Regulation 137 includes a 5th percentile female dummy in the front passenger seat to cover this and there is a development of female THOR.
- Jeanne Breen (JBC): *Comment missed*
    - DH: Replied steps have already been undertaken to improve the Regulation for small and elderly people.
- Claus Pastor (BAST): Asked do you still support second test at lower speed?
    - DH: Replied that studies have shown that the biggest target population in this collision type is older people at lower speed.
- Claus Pastor (BASt): Asked if TRL are going to do CBA.
    - DH: Replied that it will be the EC that perform the impact assessment
- Hans Amerlaan (RDW): Commented that the dummies for average female are based on the ones in 80-ties in the US. 5th female is not representative for 50th female, but it is on the right place in the car.

Small Overlap Frontal Occupant Protection (FSO)

Presentation from DH:

- Hans Amerlaan (RDW): The change and strengthening of the frontal structure of the car may cause a change in course of the car after a small overlap incident and direct the car towards a cycle lane or footpath. If we are satisfied that his is the solution we must look at the distribution of collisions on urban and rural roads (80km +) to see how much of an issue changing the structure of the car will cause to pedestrians and cyclists. The change to the structure may cause further secondary impacts. A small amount of this type of collision happens on urban or 80km roads.

- DH: replied for an IIHS style test, you would want to check the collisions were rural roads, not urban, so that the possibility of a secondary impact is less severe.
- Hans Amerlaan (RDW): more research needs to be carried out to see if the possibility of the car changing course and causing a secondary impact may occur, perhaps there are other solutions such as steering in the other direction or braking. We cannot recommend this solution if there is uncertainties in the consequences.
- Tjark Kreuzinger (ACEA): commented we are talking about secondary impact rather than avoid via steering and are questioning if this is a good idea?
- Hans Amerlaan (RDW): Agrees
- Tjark Kreuzinger (ACEA): Accident study in preparation (DH mentioned) it has been announced that there are some gaps of the information and those will have to be filled later on. Their contractor doing the studies should be informed about the potential side effects on the pedestrians and cyclist.

- Graziella Jost (ETSC): IIHS testing on the driver's side of the car, but now they are going to test with the passenger side. Do we plan to test both sides? As it is not mentioned on the fact sheets.
  - DH: Replied there was one publication in which there was a car that had design changes in response to the IIHS, but only on the driver's side. The same publication also showed a vehicle that appeared to be symmetrical in terms of the design change, but which performed differently when tested with a driver's-side and a FSP's-side impact
- *Name missed*: Not very well defined measure (longer term goal compared to some measures), FSO consumer information testing is needed. We have discussed two options, one is longitudinal impact (very low overlap) where mitigations cause the car to deflect away the other also requires changes to the vehicle restraint systems e.g. airbags and seat belts. We do not have enough information on the costs or benefits. There are concerns about cars deflecting.
  - *Name missed:* Commented that we do not have enough information on the costs or benefits for the EU fleet.
  - *Name missed*: Concerns that when deflecting the car from impact may affect.
  - Tjark Kreuzinger (ACEA): Commented that the focus should be on the mitigation technologies for avoiding these collisions, such as AEB and emergency steering.

Pole Side Impact Occupant Protection (PSI)

Presentation from DH:

- Kai Frederik Zastrow (PSA): Commented in Australia and Japan there is no requirement for old types (only for new vehicles). It is more feasible to include this requirement in to new vehicles than for existing Vehicle types.
  - Oliver Carsten (University of Leeds): Believes it all depends on what types of side impacts you are considering. DH does not recall any discussion of this in GTR 14. OC replies there is an ACEA statement saying that they are not so many run-off road collisions.
- Jeanne Breen (JBC): Believes the target population deserves more attention – not only the car occupants. It seems that in the figures provided there is still a large potential and new information can be dug out. Cannot provide more information about passenger seat belts.

- DH: Is there anyone able to provide better information regarding the fleet penetration.
    - Michiel van Ratingen (Euro NCAP): Believes probably more than 90% passenger vehicles have added protection, including some 2 seaters. It normally takes 8-9 years before a new generation of vans enters the market (so current fleet penetration will be lower). The Euro NCAP requirements for vans are fully aligned with the ones for cars.
- DH: Asked will N1 have a requirement for side impact similar to M1s?
    - Michiel van Ratingen (Euro NCAP): Answered yes.
- Paul Fay (PACTS): *Comment missed*
- Michiel van Ratingen (Euro NCAP): Regarding ejection mitigation, there is one brand in the EU has a side curtain airbag that stays inflated.
- Paul Jones (JLR): Added this test may have a potential for assessing fuel integrity.
- Michiel van Ratingen (Euro NCAP): Asked do you have plans to expand this test for electric cars? For battery integrity.
- DH: Asked the floor if they have any airbag coverage feedback?
    - Graziella Jost (ETSC): To send feedback.
    - Michiel van Ratingen (Euro NCAP): To extend the requirement for the full length of the car to include the passenger doors.
- Hans Amerlaan (RDW): Thinks it is a good idea to take the airbag coverage onwards, but Euro NCAP is done by a small number of assessments. There must be tighter procedures of how it should be achieved.
- Paul Fay (PACTS): Pickups; WG16 discussion.
- DH Summarised this measure; the majority of the N1 sales volume will probably already have appropriate restraints systems. The small numbers that do not have are probably excluded from Regulation 135.
- Jeanne Breen (JBC): Asked why we are only discussing the pole impact, why not impacts with other vehicles for example. Why we are limiting improving head protection to pole impact rather than just car to car protection.
    - DH: Replied that the pole side impact test will encourage improvements to the vehicle and the restraint system that will also be a benefit in vehicle-to-vehicle collisions. PSI has been estimated to be more effective at encouraging these improvements than making changes to Regulation 95.

Side Impact Collision Protection for Far-Side Occupants (SFS)

Presentation from DH:

- *Name missed* (ACEA): Comment the different classes of cars and vans have different occupant levels, e.g. vans may have lower number of passengers than cars.
    - DH: replies there may be a lower proportion of front seat passengers for vans compared to cars.
    - Tjark Kreuzinger (ACEA): The proportion of far side fatalities will be different from severe and slight injuries.
    - DH: Summarised the measure: there is large target population with a good amount of good evidence. It is variable from country to country. There is less evidence on the effectiveness of the countermeasure.
    - Michiel van Ratingen (Euro NCAP): Questioned what future goals for type approval tests for side impact test. There are questions of the suitability of

the dummies as they are developed for near side, not the far side. What is the feasibility to do a test procedure in a representative way?

- *Name missed:* We don't curtain airbags are effective for far side impacts.
- Tjark Kreuzinger (ACEA): Responded by saying Euro NCAP can do things that the regulation cannot do easily.
- DH: The timescales are quite challenging

Regulation 94 Frontal Offset Occupant Protection – Removal of Exemptions (F94)

Presentation from DH:

- Hans Amerlaan (RDW): This group makes up 1.2% of the fleet. There is a certificate of conformity, but I cannot select specific features. Recommends including the ability to select specific features (e.g. what number of cars have ESS) in this functionality in the future. These heavier vehicles will need to have harder tests with rigid barriers because of their higher mass and kinetic energy.
    - Paul Fay (PACTS): Commented WG16 limited the M1s to ones under 3.5t so the "nonstandard" untypical vehicles can be separated from those requirements.
    - DH: Replied echoing the concern raised by ACEA. It has double effect of increasing the stiffness of a vehicle that's already heavier. It has got more kinetic energy to absorb and the barrier is absorbing less. *Name missed* promoted using a moving barrier.
    - RC: Asked if those heavier vehicles are performing?
    - Tjark Kreuzinger (ACEA): If the vehicle is not performing perfect this will only cost you few points from the NCAP.
    - Claus Pastor (BAST): Explained during the time they worked on R94 there were 2% of the cars in Germany.
    - PB: Explained % of the fleet is one thing, but % of newly registered vehicles is another – to account for the trend.
    - PB: Continued by explaining crash testing is not only for occupant protection, but for fuel system integrity and (lately) electric system integrity. Those tests will help to identify whether there are any risks for the rescue workers.
    - RC: Asked the floor about N1 being required to meet R94? No comments in the room.
    - RC: The increase of N1 (e.g. form home deliveries) – the compatibility issue, Is it present? I speculate that a large number of those vehicles are already meeting R94 requirements.
    - Paul Fay (PACTS): Comments the injuries caused by impacts in cars are worse.
    - RC: Suspects there won't be a large change in vehicle design criteria as most as meeting R94 already because they are doing so well in the Euro NCAP tests.
    - Mike Lowe (DfT): Explained there is a big difference between the manufacturers doing something voluntarily or being required to do so. But regulation can be quite costly, should focus on the most beneficial. For N1 under 2.5t – I assume that they already meet the car requirements, so we don't have a big stance when we are talking about N1 under 2.5t.
    - Hans Amerlaan (RDW): Explained the problem is that heavier vehicles are interacting with the other cars (often lighter).

- Claus Pastor (BAST): Explained If something is safe for the N1 under 2.5t unloaded, it doesn't mean it will be still safe if the vehicle is loaded and is above 3.5t

Regulation 95 Side Impact Occupant Protection – Removal of Exemptions (S95)

Presentation from DH:

- RC: Explained the EC is looking for standardisation/harmonisation like in the previous measure
  - Hans Amerlaan (RDW): Asked if this is taking into account electrical safety and fuel system integrity? RC replied yes.
  - Hans Amerlaan (RDW): *Comment missed*
  - Tjark Kreuzinger (ACEA): ACEA made this point with commenting that pole impact is more relevant for structural integrity.
  - Paul Fay (PACTS): Commented it seems like a very blunt tool to use a barrier test with these heavier vehicles
  - RC: This is about harmonising the vehicles with the same size and mass. But we will not know how this will be translate to the CBA, because we do not have information about the size of the issue
  - PB: Asked if there was general consensus over whether pole impact could address the open issues of normal side impact in terms of electrical safety and fuel tank integrity?
  - Abayomi Otubushin (BMW Group): Replied it would be more expensive.
  - RC: Clarified and you will add a dummy in the pole test to measure.
  - Tjark Kreuzinger (ACEA): *comment missed*
  - PB: Asked if you could provide supportive data for that (M1)?
  - RC: For M1 we should consider pole instead of side impact.
- RC: for N1?
  - Tjark Kreuzinger (ACEA): Explained because of the higher seating position and the existing high score on NCAP we will not expect a benefit from regulating it.
  - H Hans Amerlaan (RDW): *Comment missed*
  - RC: Can we say the same for the N1 as we did for M1 that the pole side test will be better.
  - DH: Added except for the ones that are not tested.
  - RC: *Missed comment*
  - Tjark Kreuzinger (ACEA) Asked what kind of monitoring can be implemented, as currently we don't know whether there is a problem?
  - *Name missed:* Side pillars – the inclusion of airbags may increase their width pillars are getting wider and wider which will be a disbenefit as it will increase the risk for motorcycle crashes.
  - PB: Directed to Euro NCAP. Have you got any results from a heavy vehicle conventional side and pole side impact? Have you learnt anything that could be used to support Pole side impact taking over electrical safety and fuel tank integrity instead of just deleting exemptions? Do you have any photos or videos?
  - Michiel van Ratingen (Euro NCAP): Answered we do post-crash electric safety checks

Rear Impact Protection of the Fuel Tank (RFT)

Presentation from DH:

- Paul Fay (PACTS): Commented it will be good to have an estimate of how many vehicles already meet this requirement in order to know whether the regulation will be beneficial.
- Oliver Carsten (University of Leeds): *Comment missed*
    - RC: *Comment missed*
    - Paul Fay (pacts): *Comment missed*
    - PB: Explained it is very rare for manufacturers to apply for R34 rear impact. It is possible to get an approval for R34 with or without rear impact.
    - Louis Ballaux (Honda Motor Europe): Commented It is mandatory for new vehicles in GSR, so we implemented directly to 0.3.
    - PB: Replied not on an EU level.
    - Kai Frederik Zastrow (PSA): *Comment missed*
    - PB: Explained we can't unless we update annex 1 in GS. And if we just go in without appropriate legislative procedure we would get in trouble.
    - RC: From a TRL point of view do we know how many vehicles sold in Europe today are meeting R34?
- Louis Ballaux (Honda Motor Europe):
    - *Name missed*: Same specification for rear test in Europe? Louis Ballaux (Honda Motor Europe): replied yes.
    - *Name Missed:* Asked if you meet the US requirements do you meet R34?
    - *RC:* Asked if there are any concerns about cost? No comments

Adult Head to Windscreen Area Protection (HED)

Presentation from DH:

- Abayomi Otubushin (BMW Group): Asked when talking about cyclist and about the extension, do you take into account the helmets?
    - RC: Replied we are looking the data on the un helmeted heads
    - DH: In particular collisions in the lower end of the speed range.
    - Graciella Jost (ETSC): Commented CBA may be underestimated from cyclist and pedestrians collisions that are not reported.
    - RC: *Comment missed*
    - Jeanne Breen (JBC): To provide feedback.
    - Tjark Kreuzinger (ACEA): Asked do we think that soon AEB will be able to mitigate this?
- Nills Lubbe (EUROCARE): In the Edwards paper, which has higher effectiveness for AEB and passive safety. The figures should be taken into account.
    - Oliver Carsten (University of Leeds): VRU casualties are going up as a proportion. In terms of meeting the long term European targets its really critical that,
    - RC: £170 EUR per car is the only cost we have so far and is from Volvo. Are there any comments? No comments on the costs.
    - Oliver Carsten (University of Leeds): Reminded the people in the room that the number VRU KSI is not going down

- Abayomi Otubushin (BMW Group): Replied isn't the number staying steady even with the increased number of cycling?
- Jeanne Breen (JBC): Explained the correlation between economic growth and the number of KSIs.
- RC: Asked do you think this measure is a sensible way to go forward to reduce the number of KSIs in terms of benefits and costs? VRU are a significant part of our road causalities.
- Jeanne Breen (JBC): As the number of victims is …. It is important the automotive industry to continue contribute to the reduction.
- Abayomi Otubushin (BMW Group): does not think this measure is the right way forward.
- Jeanne Breen (JBC): The EC road safety strategy does cover many areas. May study shows that the vehicle measures lead to a decrease large number of casualties. How has this been evaluated (pedestrians)?
- Peter Saddler (TfL): commented about the expected benefits and how we have to be focused on what has been designed impact speed and how does the technology…
- Kai-Uwe Schmitt (AGU Zürich): Explained that there is an opportunity to improve regulations. So we should grab this opportunity and update this 5-6 years later.
- Graziella Jost (ETSC): Explained the idea is not to use AEB in order to lower the effect but the speed in order to evaluate the effect…
- Jeanne Breen (JBC): Explained there is a large number of severe outcomes related to pedestrians and cars incurred when the driver does not apply the brakes. SO it is very important to have both active and passive safety measures. She believes what is suggested is very good.

- Hans Amerlaan (RDW): *Comment missed.*
  - Paul Fay (PACT): Asked if this is realistic in the timeframe?
  - DH: It is suggested that it will happen. Tjark said that AEB PCD should be taken into account. TK was asked if he had any information how those systems will work and when this will be available?
  - Tjark Kreuzinger (ACEA): Not to focus too much on the current system.
  - Mike Lowe (DfT): Commented the discussion of these measures (as HED) will have far greater impact on saving lives than the exemptions of R94 and R95.
  - RC: Summarised this measure; we have got a good number of papers; many seem to have benefits and varying evidence about the suitability of AEB. RC wrote a paper at UK level saying 50% of cars that hit a pedestrian had the opportunity to brake (could be out of date). One cost measurement is available which isn't ideal. It is a big casualty group.
  - Name missed: TRL has to be more focused to avoid mixing up AEB and extending the passive wrap around distance. X asked if TRL to clarify which method is happening, extending wrap around distance or not? Industry never got back to us saying that's not good enough. Done both by considering the benefits of extending the wrap around distance but bearing in mind that's based on today and AEB is going to improve
  - *Comment missed*
  - PB: Replied it is in the scope of the study but not taken forward.

Tyre Pressure Monitoring System (TPM)

M1/N1 Only

Presentation from DH:

- Jeanne Breen (JBC): Commented the vast majority of benefits are not safety benefits and asked DH to clarify.
    - DH: Separation between safety (injuries and casualties) and economic benefits.
    - *Name missed* (CLEPA): Asked what are the differences between the performance in the regulation environment and field tests?
    - PB: The type approval test can be met with indirect system, but those systems are incapable of functioning in normal road conditions. There has been a feel that those systems are barely covering the requirements, but are not effective on the road. In Geneva there is a current work being done that specifies that the system must work in normal driving conditions. One of the problems we have in the current regulation (mandatory in EU) is that the manufacturer can select the tyre-wheel system with which the test to be performed and when you perform the test with a different combination, the system will fail.
    - RC: Asked are there any thoughts of how should the manufacturers should test to prove the system is working? PB answered no as it is a blanket statement. However if it doesn't work it would be a cause to order a recall.
- Stef Cornelis (T&E): Commented we proved that in real world environment those systems do not work.
- Thomas Rocher (Audi): Explained the TPMS they include in their cars meet the real world requirements, there are no relations with emissions. They work with all the stock and after-sale tyres. They do not see and fear that reset for TPMS will fail, they need an input from the driver to report the correct state of the tyres. The "reset of the TPMS is a safety critical thing". They do not have a feedback from customers saying that this is a problem. We would like to see the research that shows different.
    - Predrag P: Commented the TNO report is non-scientific.
    - Jörg Sturmhoebel (NIRA Dynamics): Commented we are performing a study that takes into account all these factors. The data shows the both TPMS systems have a positive effect. There so far not any evidence that the system isn't working.
    - Thomas Rocher (Audi): Mira data shows that the TPMS increases the tyre pressure with 5% and the average of tire pressure without TPMS is 5% less than the recommended tyre pressure.
    - Predrag Pucar (NIRA Dynamics): Asked why do we not discuss the environmental impact between the two systems?
    - Dunlop tech and Nira will provide raw data from measurements form petrol stations in Sweden and Germany.
    - Thomas Roscher (Audi): Asked if they could see this data, because it contradicts their results.
    - DH: The gap between 55 and 100 is done to the driver choosing to use the system.
    - RC: The costing information has come from the TNO report. Please, can Audi share their data with us?
    - PB: Asked how are the results going to be shared and help shape the remainder of the conversation?

Lane Keeping Assist (LKA)

Presentation from DH:

- Oliver Carsten (University of Leeds: *Comment missed*
    - Tjark Kreuzinger (ACEA): Explained there is very clear distinction between direct steering system that can steer you through the corner and LKA. LKA is does not allow you to perform hands-free driving
    - Patrick Seiniger (BASt - Federal Highway Research Institute): Explained emergency lane keeping which will activate departure prevention and will turn on after ignition. It will activate automatically when there is road departure.
    - Mike Lowe (DfT): *Comment missed*
    - DH: Would anyone object LKA being turned on automatically after ignition?
    - Tjark Kreuzinger (ACEA): Replied yes as the customers would find it annoying.
    - Kai Frederik Zastrow (PSA Peugeot Citroen): It is too annoying and the would customers complain, especially if the system is not perfect
    - Mike Lowe (DfT): based on R79. It should be able to be switched off. The Driver has to be in control and must be able to switch the system off in certain driving conditions. It should be treated as an add on rather than a system that is always on.
    - RC: *Comment missed*
    - Hans Ammerlaan (RDW): How would the system work in different EU countries with different road markings?
    - RC: There is an EU project, called....
    - Patrick Seiniger (BASt): Thinks that may be the assumption that using a camera for LKA only may not be appropriate.
    - *Name missed* (ACEA): *Comment missed*
    - PB: Commented on the hydraulic assist systems. As far as I know we need electronic actuator but the hydraulic systems do not have that. Would it be an option for you to consider for those vehicles we will downgrade the requirements for LKA by only requiring LDW. He is happy with the effectiveness numbers. He would like to consider this.
    - *Name missed*: Can the automotive industry provide input?
    - Kai Frederik Zastrow (PSA Peugeot Citroen): From vehicle architecture point of view the vehicles with hydraulic system are nearer in the heavier vehicles.
    - RC: TRL will now look into Lane departure warning and LKA depending on the type of steering.
    - Oliver Carsten (University of Leeds): Comment missed the study mentioned by Volvo cars was a retrospective study in LDW.
    - RC: The insurance data from the states show LDW is neutral.
    - PB: Added and it will be European.
    - Mike Lowe (DfT): Explained the manufacturers have to make a decision regarding the steering system based on the lighter requirements for the LKA for hydraulic system.

Autonomous Emergency Braking (AEB)

Presentation from DH:

- Oliver Carsten (University of Leeds): Asked why have only front-to-rear collisions been considered?
    - DH: Replied because the test procedures relate only to these configurations.
    - Tjark Kreuzinger (ACEA): Responded to this by saying there is an effect as well for side-impacts.
    - DH: Added TRL could not identify how big the positive effect is and if it existed for implementation that just meet regulation.
- *Name missed* (ACEA): ACEA Supportive of this measure and asked where is the effectiveness highest (motorway etc.).
- RC: Asked the floor if the effectiveness estimates are agreeable?
- *Name missed*: Commented that we should include braking for all speeds and asked whether city buses could be included?
    - *Name missed* (DfT): Commented the current truck and coach requirements are designed for speeds of larger roads, so inner city vehicles were exempt.
- DH: Replied the speed ranges TRL assumed were ca up to 80 kmph (based on Euro NCAP).
- DH: Asked if there were any comments on Cost. No comments from room; no disagreement.
- PB: Commented that we should think about including buses and low speed situations (Is the range of speeds already included in UN Regulation?). He was not sure if it is timely to already amend this regulation, considering that requirements were only recently taken into account; but we should reflect on the potential for city buses.
- DH: Asked the floor if we can assume that N1 is very similar to cars (effectiveness)? There were no concerns from the room.

Autonomous Emergency Braking for Pedestrians and Cyclists (AEB-PCD)

Presentation from MS:

- Tjark Kreuzinger (ACEA): There is a missing bullet from ACEA comment – pedestrian movement is more chaotic than vehicles, so consideration of avoiding false positives is important.
- Ceri Woolsgrove (ECF): Asked if it is already in Euro NCAP for pedestrians and going to be in 2018 for cyclists, can the timescale be brought forward to match?
    - Abayomi Otubushin (BMW Group): Current systems do not have cyclist detection; it is difficult to do this mid-product cycle, so it will be a vehicle model cycle (six years) before they do. It is the same for all manufacturers.
- Paul Fay (PACTS): Listed potential for increased service costs. Please clarify.
    - MS: Replied e.g. calibration of the system when the windscreen is replaced.
- Oliver Carsten (University of Leeds): Did not understand the desire for exemption for small volume manufacturers as you can buy a system off the shelf.
    - Barnaby Simkin (SMMT): Commented it would take significant development costs to integrate a system from a Tier 1, which is spread across a very small number of vehicles.

- Ceri Woolsgrove (ECF): Added we should mention that there are already cyclist detection systems in the field: JLR and others.
- Jeanne Breen (JBC): Asked if TRL could clarify how this links with the HED measure?
    - MS: Replied if both measures are implemented, we would certainly need to look at the combined benefits. This presentation is looking at one of the three data required; David's presentation before looked at the other two. All are covered between the two measures.
- William Todts (T&E): Asked if the PCD can be specified for heavy vehicles as well? PB: For the moment as it is not in the scope of the work we are doing for the time being because the AEB for heavy vehicles has only just come into force.
    - William Todts (T&E): Talking about 2026/8 – there should be technical progress in that time frame. PB: agreed.
- Ceri Woolsgrove (ECF): Commented given the huge potential benefits of this and the need to focus on VRU's, we need much more ambition on the dates of implementation.

Close

RC closed Session 2 of Day 2 at 16:15

- *Name missed*: Asked when will the report be available?
    - PB: responded by saying he is not certain yet as it is linked to the impact assessment process. But he will let everybody know. Further input may be required later next year.

Annex 3 WRITTEN STAKEHOLDER INPUT

The full written stakeholder input is not included in this report due to file size limitations. Copies are available on application to TRL Ltd.

Annex 4 PRELIMINARY COST-BENEFIT INDICATORS

Annex 4.1 Background

As discussed in Section 4.1 there will be overlaps in the casualty groups addressed and there will be potential to share technology components between measures. These interactions will depend on the specific subset of the 24 measures that will be considered for implementation. This clustering of measures into specific 'policy options' has not been decided at the time of this report, which prevents a full cost-benefit assessment being carried out.

Nevertheless, in order to aid the selection of measures for the policy options, preliminary cost-benefit indicators for individual measures are calculated and presented in this annex using the input values defined in Section 5. Take note of all applicable limitations when interpreting these preliminary indicators (see Annex 4.2.2).

Annex 4.2 Method

Annex 4.2.1 Calculations

For each measure where enough data is available, three preliminary cost-benefit indicators are calculated:

- Indicative benefit-to-cost ratio (BCR)
- Indicative break-even cost (BEC)
- Indicative break-even benefit (BEB)

Indicative benefit-to-cost ratio (BCR)

BCR describes the ratio of expected benefits to society (arising from prevented casualties) to expected costs (arising from fitment to new vehicles; costs at the point of the vehicle manufacture). A BCR greater than one indicates that the benefits would exceed the costs and the measure might be cost-effective. A higher BCR value indicates higher cost-effectiveness.

The indicative BCR, per measure per vehicle category, is calculated as:

$$BCR = \frac{B}{C} = \frac{p_F \cdot e_F \cdot m_F + p_E \cdot e_E \cdot m_E + p_L \cdot e_L \cdot m_L}{f \cdot v}$$

with:

B: Monetary benefit to society per annum across EU-28

C: Fitment cost to all new vehicles of respective category per annum across EU-28

$p_{F,E,L}$: Number of fatal/serious/slight casualties per annum across EU-28 within target population

$e_{F,E,L}$: Effectiveness in preventing fatal/serious/slight casualties within target population

$m_{F,E,L}$: Monetary value for prevention of one fatal/serious/slight road casualty

f: Fitment cost per vehicle

v: Number of new vehicle registrations of respective category per annum across EU-28

Note that the equations are simplified for illustrative purposes; the target population will not be a homogenous group but sometimes made up of several sub-groups to which different effectiveness values apply. The values are extracted from the sources as suggested in Section 5 for each measure and vehicle category ('Input values for cost-benefit model') and from the tables in Annex 4.3.

Indicative break-even cost (BEC)

BEC describes the highest tolerable fitment cost per vehicle for a measure to be still cost-effective for society, based on the expected magnitude of benefits. This value can be a useful indicator when there is no cost estimate available. A higher BEC value indicates a higher potential for cost-effectiveness.

The indicative BEC, per measure per vehicle category, is calculated as:

$$BEC = \frac{B}{v} = \frac{p_F \cdot e_F \cdot m_F + p_E \cdot e_E \cdot m_E + p_L \cdot e_L \cdot m_L}{v}$$

with variables as defined above.

Indicative break-even benefit (BEB)

BEB describes the minimum number of road fatalities that need to be prevented by a measure per annum across EU-28 for it to be potentially cost-effective. This value can be a useful indicator when there are no effectiveness or target population estimates available. A higher BEB value indicates a lower potential for cost-effectiveness.

The indicative BEB, per measure per vehicle category, is calculated as:

$$BEB = \frac{C}{m_F} = \frac{f \cdot v}{m_F}$$

with variables as defined above.

Annex 4.2.2 Limitations

The following key limitations should be considered when interpreting the results:

- This method does not consider dispersion into the fleet over time; it suggests that all new vehicles entering the fleet will have to be equipped with a certain measure (assumption for costs), in a hypothetical situation where the entire fleet is fitted (assumption for benefits).
- Future general casualty trends over time are not modelled.
- Inflation and discounting of future benefits and costs are not modelled.
- Benefits and costs of measures are analysed individually because the clustering of measures into specific 'policy options' has not been decided at the time of this report. This means that (a) overlaps in targeted casualty groups are not accounted for, which can result in overestimates of the cumulative benefit; and (b) existing potential for technology sharing is not reflected, which can result in overestimates of the costs.
- Where a range of values was recommended for effectiveness and cost parameters in this report, the average value was used as an approximation.
- Vehicle categories M2 & M3 and N2 & N3 are treated combined because the new vehicle registration and casualty numbers are not available separately (the weight limit in regulation between N2 and N3 vehicles is 12 tonnes, whereas for all the other data 16 tonnes is used; buses and coaches are treated together and a breakdown by the category criteria for M2 and M3 in regulation is not available).
- The target population estimates are based on high level EU-28 casualty data (CARE database) and therefore contain a high level of uncertainty. These should be substantiated with a more detailed accident analysis of data from at least national statistics (ideally from in-depth studies) for a final cost-benefit assessment.

Annex 4.3 EU-28 statistics

The calculations use input data on the effectiveness and cost of each measure from Section 5 ('Input values for cost-benefit model') and data on EU-28 casualty numbers as per Table 30, average casualty savings monetisation as per Table 31, and EU-28 new vehicle registrations as per Table 32.

Table 30: EU-28 casualties per annum by vehicle category occupied (average numbers from years 2013–2015); Sources: CARE database[199], *values not recorded separately

Vehicle category	Breakdown	Fatally injured	Seriously injured	Slightly injured
M1		11,265	91,770	676,054
M2 & M3*		126	1,854	20,281
N1		720	4,307	29,724
N2 & N3* (incl. towed O3 & O4)		488	2,740	11,244
Pedestrian	total	5,373	35,682	112,530
	of which:			
	in impact with M1	(3,389)	(26,475)	(81,901)
	in impact with M2 & M3	(161)	(925)	(2,840)
	in impact with N1	(414)	(1,806)	(5,716)
	in impact with N2 & N3	(529)	(891)	(1,625)
	other/unknown	(880)	(5,585)	(20,448)
Pedal cycle	total	2,019	31,451	131,793
	of which:			
	in impact with M1	(958)	(16,584)	(84,681)
	in impact with M2 & M3	(50)	(283)	(1,112)
	in impact with N1	(135)	(1,122)	(4,771)
	in impact with N2 & N3	(259)	(902)	(2,333)
	no other vehicle	(343)	(8,213)	(21,552)
	other/unknown	(274)	(4,347)	(17,344)
Motorcycles & mopeds		4,542	55,117	167,821
Agricultural tractor, other & unknown		1,497	8,562	30,078
Total		**26,030**	**231,483**	**1,179,525**

[199] http://www.careproject.eu/database/

Table 31: EU-28 average monetary value for prevention of road accident casualties by severity; Source: (Hynd *et al.*, 2015)[200]

Casualty severity	Monetised value per prevented casualty
Fatally injured	€1,564,503
Seriously injured	€231,278
Slightly injured	€17,753

Table 32: EU-28 new vehicle registrations per annum by vehicle category (average numbers from years 2013–2015); *values not recorded separately

Vehicle category	New vehicle registrations	Source
M1	12,720,900	EC Statistical Pocketbook 2016[201]
M2 & M3*	41,058	EC Statistical Pocketbook 2016
N1	1,549,676	EC Statistical Pocketbook 2016
N2 & N3*	305,125	ACEA consolidated registrations by country[202]
O3 & O4*	unknown	N/A

Annex 4.4 Results

Annex 4.4.1 Guide to interpreting the results

- **Benefit** is the expected monetary benefit from prevented casualties each year.
- **Cost** is the expected fitment cost to equip all new vehicles of the respective category entering the fleet each year.
- **BCR** is the ratio of expected benefits to expected costs. A BCR larger than one indicates that the benefits would exceed the costs and the measure might be cost-effective. A higher BCR value indicates higher cost-effectiveness.
- **BEC** is the highest tolerable fitment cost per vehicle for a measure to be still cost-effective. A higher BEC value indicates a higher potential for cost-effectiveness.
- **BEB** is the minimum number of road fatalities that need to be prevented by a measure each year for it to be potentially cost-effective. A higher BEB value indicates a lower potential for cost-effectiveness.
- Consider all limitations as per Annex 4.2.2.

[200] https://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/

[201] https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2016_en

[202] http://www.acea.be/statistics/tag/category/by-country-registrations

Annex 4.4.2 M1 vehicles

Table 33: Preliminary individual cost-benefit indicators for measures applicable to vehicle category M1

Code	System description or comment	Benefit	Cost	BCR	BEC	BEB
AEB*	–	€4.49 bn	€2.77 bn	≈ 1.6	≈ €353	≈ 1,768 fatalities
AEB-PCD*	–	€5.86 bn	€2.77 bn	≈ 2.1	≈ €461	≈ 1,768 fatalities
ALC	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
DDR	For attention monitoring without advanced distraction recognition; uncertainty regarding effectiveness	€0.38 bn	€0.11 bn	≈ 3.3	≈ €30	≈ 73 fatalities
EDR	For Part 563-type EDR. Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
ESS	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
F94	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
FFW	For R137 with Hybrid III: Negligible benefits (expected that new cars already meet requirements) but compliance costs	Negligible	Existent but not quantified	≤ 1.0	≈ €0	Unknown
FSO	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
HED	Conservative estimate	€1.58 bn	€2.16 bn	≥ 0.7	≥ €124	≤ 1,382 fatalities
ISA*	For voluntary ISA	€13.53 bn	€2.77 bn	≈ 4.9	≈ €1,063	≈ 1,768 fatalities
LKA*	Uncertainty regarding target population	€5.88 bn	€2.77 bn	≈ 2.1	≈ €462	≈ 1,768 fatalities
PSI	Uncertainty regarding existing fleet penetration	€0.13 bn	€0.10 bn	≈ 1.3	≈ €103	≈ 64 fatalities
REV	Uncertainty regarding target population	€0.50 bn	€1.60 bn	≈ 0.3	≈ €39	≈ 1,020 fatalities
RFT	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
S95	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
SBR	From previous study (McCarthy & Seidl, 2014)	€0.02 bn	Unknown	Unknown	≈ €9	Unknown
SFS	Uncertainties regarding effectiveness	€1.95 bn	€1.27 bn	≈ 1.5	≈ €154	≈ 813 fatalities

**: The existing potential for technology cost sharing between these measures is not reflected in the numbers. If these measures were implemented together, the cost-effectiveness could be considerably better.*

Annex 4.4.3 M2 & M3 vehicles

Table 34: Preliminary individual cost-benefit indicators for measures applicable to vehicle categories M2 & M3 (combined)

Code	Comment	Benefit	Cost	BCR	BEC	BEB
ALC	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
BFS-AFE	Target population and benefits from prevented property damage need more complex consideration	Unknown	Unknown	Unknown	Unknown	Unknown
BFS-CNG	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
DDR	For attention monitoring without advanced distraction recognition; cost unknown; uncertainty regarding effectiveness	€3.09 mn	Unknown	Unknown	≈ €75	Unknown
ESS	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
ISA	For voluntary ISA; high uncertainties regarding target population and effectiveness	€306.60 mn	€8.93 mn	≈ 34.3	≈ €7,468	≈ 6 fatalities
REV	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
SBR	For front seat SBR. From previous study (McCarthy & Seidl, 2014)	€0.36 mn	Unknown	Unknown	≈ €31	Unknown
TPM	Based on external cost-benefit study (Van Zyl et al., 2013)	Unknown	Unknown	> 1.0	Unknown	Unknown
VIS	Target population, effectiveness and cost need more complex consideration	Unknown	Unknown	Unknown	Unknown	Unknown

Annex 4.4.4 N1 vehicles

Table 35: Preliminary individual cost-benefit indicators for measures applicable to vehicle category N1

Code	Comment	Benefit	Cost	BCR	BEC	BEB
AEB*	Uncertainties regarding target population and effectiveness	€232.68 mn	€337.05 mn	≈ 0.7	≈ €150	≈ 215 fatalities
AEB-PCD*	–	€570.95 mn	€337.05 mn	≈ 1.7	≈ €368	≈ 215 fatalities
ALC	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
DDR	For attention monitoring without advanced distraction recognition; uncertainty regarding effectiveness	€34.92 mn	€13.95 mn	≈ 2.5	≈ €23	≈ 9 fatalities
EDR	For Part 563-type EDR. Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
ESS	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
F94	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
FFW	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
HED	No data for N1; consider implementation for car-derived N1	Unknown	Unknown	Unknown	Unknown	Unknown
ISA*	For voluntary ISA	€885.65 mn	€337.05 mn	≈ 2.6	≈ €572	≈ 215 fatalities
LKA*	Uncertainties regarding target population and effectiveness	€306.21 mn	€337.05 mn	≈ 0.9	≈ €198	≈ 215 fatalities
PSI	Target population and cost need more complex consideration	Unknown	Unknown	Unknown	Unknown	Unknown
REV	Uncertainties regarding target population and effectiveness	€42.56 mn	€194.48 mn	≈ 0.2	≈ €27	≈ 124 fatalities
RFT	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
S95	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
SBR	From previous study (McCarthy & Seidl, 2014)	€8.10 mn	Unknown	Unknown	≈ €43	Unknown
SFS	Target population and effectiveness not known	Unknown	€154.97 mn	Unknown	Unknown	≈ 99 fatalities
TPM	Based on external cost-benefit study (Van Zyl et al., 2013)	Unknown	Unknown	> 1.0	Unknown	Unknown

**: The existing potential for technology cost sharing between these measures is not reflected in the numbers. If these measures were implemented together, the cost-effectiveness could be considerably better.*

Annex 4.4.5 N2, N3, O3 & O4 vehicles

Table 36: Preliminary individual cost-benefit indicators for measures applicable to vehicle categories N2, N3, O3 & O4 (combined)

Code	Comment	Benefit	Cost	BCR	BEC	BEB
ALC	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
DDR	For attention monitoring without advanced distraction recognition; cost unknown; uncertainty regarding effectiveness	€37.86 mn	Unknown	Unknown	≈ €124	Unknown
ESS	Assumed to be cost-effective due to existent benefits and negligible cost	Existent but not quantified	Negligible	> 1.0	Unknown	≈ 0 fatalities
ISA	For voluntary ISA; high uncertainties regarding target population and effectiveness	€717.47 mn	€66.36 mn	≈ 10.8	≈ €2,351	≈ 42 fatalities
LAT	Target population needs more complex consideration	Unknown	Unknown	Unknown	Unknown	Unknown
REV	Effectiveness and cost not known	Unknown	Unknown	Unknown	Unknown	Unknown
RUR	BCR for EU derived from external source (GRSG/Germany, 2013)	Unknown	Unknown	≈ 3.1 to 12.3	Unknown	Unknown
SBR	From previous study (McCarthy & Seidl, 2014)	€11.00 mn	Unknown	Unknown	≈ €27	Unknown
TPM	No clear picture of costs and safety benefits	Unknown	Unknown	Unknown	Unknown	Unknown
VIS	Target population, effectiveness and cost need more complex consideration	Unknown	Unknown	Unknown	Unknown	Unknown

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