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IMPACT ASSESSMENT

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users, amending Regulation (EU) 2018/... and repealing Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009

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LIST OF ABBREVIATIONS AND GLOSSARY OF TERMS

<i>Term/abbreviation</i>	<i>Explanation</i>
ACEA	European Automobile Manufacturers' Association
AEB	Autonomous Emergency Braking
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead
ALC	Alcohol interlock installation facilitation
BCR	Benefit-to-Cost Ratio
CARE database	Community Road Accident Database
CARS 21	The Competitive Automotive Regulatory System for the 21st century High Level Group on the competitiveness and sustainable growth of the automotive industry in the EU with representatives of the EU Member States, EU institutions, automotive industry, Trade Unions, NGO, users and the Commission.
C-ITS	Cooperative Intelligent Transport Systems
CLEPA	European Association of Automotive Suppliers
C-ROADS Platform	The C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability.
DDR-ADR	Distraction recognition
DDR-DAD	Drowsiness and attention detection
DG	Directorate-General
EDR	Event (accident) Data Recorder
ESC	Electronic Stability Control
ESS	Emergency Stop Signal
EU	European Union
Euro NCAP	European New Car Assessment Programme is a voluntary European car safety performance assessment program backed by the European Commission and several European governments, as well as by motoring and consumer organisations. Euro NCAP publishes safety reports on new cars, awarding 'star ratings' based on the performance of the vehicles in a variety of crash tests, including front, side and pole impacts, and impacts with pedestrians. The top rating is five stars.
FFW-137	Full-width frontal occupant protection crash test
FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints
GSR	General Safety Regulation
HDV	Heavy Duty Vehicles
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)
ISA	Intelligent Speed Assistance
ISA-VOL	Intelligent Speed Assistance (through non-intrusive haptic feedback)
ISO	International Organisation for Standardisation
LDV	Light Duty Vehicles
LDW	Lane Departure Warning
LKA-ELK	Lane Keeping Assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving

	the lane with oncoming traffic)
MPV	Multi Purpose Vehicle
NGO	Non-Governmental Organisation
PO	Policy Option
PSI	Pole Side Impact Occupant Protection
PSR	Pedestrian Safety Regulation
REV	Reversing Camera or Detection System
R&D	Research and Development
SAE	Society of Automotive Engineers
SMEs	Small and Medium-Sized Enterprises
SUV	Sport Utility Vehicle
T&E	European Federation for Transport and Environment
TFEU	Treaty on the Functioning of the European Union
TNO	Netherlands Organisation for Applied Scientific Research
TPM / TPMS	Tyre pressure monitoring (system)
TRL	Formerly the UK Government's Transport Research Laboratory subsequently transformed into a private company in 1996
UNECE	United Nations Economic Commission for Europe
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle
VIS-DIV	Vulnerable road user improved direct vision from driver's position

1. INTRODUCTION: POLITICAL AND LEGAL CONTEXT

1.1. Political context

Road safety is a pan-European issue that is addressed through an integrated approach on EU, national, regional and local level. Policies are traditionally structured around three pillars: road users (drivers, pedestrians and cyclists), vehicles and infrastructure. The coordination of actions and measures adopted by the different authorities in the various domains (e.g. traffic rules enforcement, health care, education, improvement of infrastructure, vehicle type-approval and roadworthiness inspections) calls for strategic planning. Road safety policy is best defined and implemented under an overarching strategy that addresses all these aspects. Moreover, road safety stakeholders: road user associations, vehicle manufacturers and suppliers, infrastructure managers, fleet operators and other organisations should play an active role in ensuring road safety.

The remarkable progress achieved in the past decades is the result of measures taken in these three areas. Today however, as the reduction of road casualties is stagnating, it is even more evident that further progress can only be achieved by continued improvement across the various domains, including that of vehicle safety. For that reason, the present initiative to significantly improve vehicle safety performance has to be viewed in close relation with several other initiatives. Reflections on whether and how the relevant policy areas should be amended should be seen as part of the preparation of an EU road safety policy framework for the period 2020 – 2030 (to be proposed as part of the Third Mobility Package in May 2018). Progress in the reduction of road fatalities and serious injuries on EU roads has stalled in recent years, and a revised framework better adapted to this challenge and to the changes in mobility resulting from societal trends (e.g. more cyclists and pedestrians, an aging society) and technological developments is necessary. The complex situation calls for a dynamic policy adjustment that addresses the major challenges in a consistent and effective way across the entire spectrum of road safety policies.

The framework should follow the Safe System approach. This approach is based on the principles that human beings can and will continue to make mistakes and that it is a shared responsibility for actors at all levels to ensure that road crashes do not lead to serious or fatal injuries. In a safe system approach, the safety of all parts of the system must be improved; roads and roadsides, speeds, vehicles and road use so that if one part of the system fails, other parts will still protect the people involved.

In addition to enhancing vehicle safety features, the foreseen amendment of two directives on road infrastructure safety management¹ and on minimum safety requirements for tunnels² also aim at contributing to the reduction of the number of fatalities and injuries on EU roads. Thus, the named initiatives do not only share a common horizon (in form of the baseline), but they also interlink as the vehicle technology needs to rely on infrastructure in order to be operational (e.g. visible road markings to support lane keeping assistance technologies). On the other hand, the overall vehicle and infrastructure safety framework needs to take into account developments in connected and automated driving, which are advancing at high speed. Therefore, the present exercise is closely linked to Commission's Strategy on

¹ Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network, OJ L 167, 30.4.2004, p. 39–91

² Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management, OJ L 319, 29.11.2008, p. 59–67

Cooperative Intelligent Transport Systems (C-ITS)³ and in particular to the upcoming proposal for a strategy for Cooperative, Connected and Automated Mobility. In order to become future-proof, vehicles not only have to be ready for the new technological developments in the infrastructure, but they will also have to take the lead and pave the way towards fully automated driving. For this reason, mandating advanced safety features for vehicles is seen as the right step in this direction.

Then there is a third ongoing initiative to update legislation on qualification and periodic training of drivers⁴ by raising the standards for new professional drivers and continuously updating their skills, including their awareness of road safety risks and the ways to reduce them. Proper training and education of drivers is particularly valid and important in the light of new vehicle safety features becoming available in motor-vehicles.

Thus, the present initiative is fully in line with the Council conclusions based on the Valletta Declaration, in which transport ministers reconfirmed their commitment to improving road safety⁵ and notably called upon the Commission to enhance the protection of road users, and in particular vulnerable road users, by ensuring the deployment of new safety features for vehicles.

Lastly, the proposal corresponds to the call made by the EP Committee on Transport and Tourism in its own initiative report⁶ for resolute and determined action to be taken by the Commission in the field of vehicle safety. It is observed that approximately 95% of all accidents are due to human error, nearly half of road fatalities involve vulnerable road users and fatalities among this group are decreasing much slower than those of other road users. Therefore, EP calls on the Commission to mandate cost-effective driver assistance systems significantly promoting safety, which have attained market maturity, and to consider additional passive safety measures to mitigate severe injurious effects of accidents. This standpoint has also been voiced throughout numerous Parliamentary questions⁷ during the past years.

1.2. Legal context

Directive 2007/46/EC⁸ sets out harmonised safety and environmental requirements that motor vehicles have to comply with before being placed on the internal market, thus facilitating the free movement of vehicles and ensuring equal health and safety standards across the EU. It

³ Communication from the Commission “A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility” (COM/2016/0766 final)

⁴ Directive 2003/59/EC of the European Parliament and of the Council of 15 July 2003 on the initial qualification and periodic training of drivers of certain road vehicles for the carriage of goods or passengers, amending Council Regulation (EEC) No 3820/85 and Council Directive 91/439/EEC and repealing Council Directive 76/914/EEC (OJ L 226, 10.9.2003, p. 4)

⁵ http://ec.europa.eu/transport/road_safety/sites/roadsafety/files/valletta_declaration_on_improving_road_safety.pdf

⁶ Report on Saving Lives: Boosting Car Safety in the EU – Rapporteur Dieter-Lebrecht Koch (2017/2085(INI))

⁷ E-009286/2015, E-014211/2015, E-014761/2015, E-015519/2015, E-015953/2015, E-000388/2016, E-001145/2016, E-005715/2016, P-006385/2016, E-007920/2016, E-009592/2016, E-001462/2017, E-003189/2017, E-004478/2017, E-005145/2017.

⁸ Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (Framework Directive) (Text with EEA relevance), OJ L 263, 9.10.2007, p. 1

provides a framework under which a multitude of separate regulatory acts with specific technical requirements for the different types of vehicles are operating.

The type-approval framework is in the process of being revised. In December 2017, the European Parliament and the Council reached an agreement on the proposal for a Regulation on the approval and market surveillance of motor vehicles adopted by the Commission in January 2016⁹.

1.1.1. Vehicle safety legislation under the type-approval framework

In the context of the type-approval framework, the vehicle safety legislation consists of the two following regulations:

The General Safety Regulation (GSR):

General vehicle safety is regulated through a single act, namely Regulation (EC) No 661/2009¹⁰ as adopted by the co-legislator, covering a large number of safety measures. The main objectives of the GSR were adding new technologies and safety features to vehicles as standard equipment and simplification.

The Pedestrian Safety Regulation (PSR):

Regulation (EC) No 78/2009¹¹ aims to protect pedestrians and other vulnerable road users involved in a collision with a vehicle. It requires cars, vans and other light commercial vehicles to be fitted with energy absorbing bonnets and front bumpers, to cushion the head and legs of a pedestrian. It further requires manufacturers to fit so-called ‘brake assist systems’ into their vehicles, for more efficient panic stops, shaving-off valuable fractions of the speed of impact as well as centimetres of stopping distance.

1.3. Adapting the legislation to vehicle safety developments

Both¹² under the GSR and PSR the Commission has to report to the European Parliament and Council on the monitoring of technical developments in the field of enhanced passive safety requirements, and the consideration and possible inclusion within the Regulations, of new and enhanced safety features as well as enhanced active safety technologies. To fulfil the obligations, the Commission Report “Saving Lives: Boosting Car Safety in the EU”^{13, 14} was adopted on 12 December 2016, outlining the possible ways forward to improve vehicle safety in the EU. These are captured in this initiative.

⁹ COM (2016) 31 final.

¹⁰ Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor (Text with EEA relevance), OJ L 200, 31.7.2009, p. 1

¹¹ Regulation (EC) No 78/2009 of the European Parliament and of the Council of 14 January 2009 on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users, amending Directive 2007/46/EC and repealing Directives 2003/102/EC and 2005/66/EC (Text with EEA relevance), OJ L 35, 4.2.2009, p. 1

¹² Article 17 of the GSR and Article 12 of the PSR

¹³ Reporting on the monitoring and assessment of advanced vehicle safety features, their cost effectiveness and feasibility for the review of the regulations on general vehicle safety and on the protection of pedestrians and other vulnerable road users (COM(2016) 787 final)

¹⁴ <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2016:431:FIN>

1.4. Contribution of vehicle safety legislation to road safety in general

Road safety in the EU has improved significantly over the past decades, thanks to strong and effective action taken at the EU, national and local levels to address vehicle safety, user behaviour, and infrastructure, as part of the EU policy on road safety¹⁵.

In 2003, the Commission adopted its third European action programme for road safety, which aimed to halve the number of road deaths by saving 25 000 lives until 2010. While the initial target was not quite met by the end of 2010, it was decided to continue with a target of halving the overall number of road deaths in the EU by 2020, starting from a new baseline in 2010¹⁶ from approximately 31 000 to 15 000 in 2020.

Measures have been taken as part of an integrated approach. The measures taken in the framework of passive vehicle safety overall, e.g. introduction of frontal and side crash legislation, presented a medium advancement, considering that their implementation depended on the vehicles renewal rate where the total fleet was expected to be completely renewed after about a 14-year-cycle¹⁷. The *ex post* analysis further concluded that between 2001 and 2007, vehicle occupants' safety had been increasing remarkably. In general, both the effectiveness and the efficiency of passive vehicle safety improvements had proven to be positive, where generally the technologies themselves were not considered as hugely expensive, but were observed to be having a great impact on injury and fatality reduction. Clear examples of such effective safety regulations are the provisions for passenger car frontal and side crash safety that were phased in between 1998 and 2003¹⁸ which, in the meantime, were integrated within the GSR for simplification and legislative harmonisation purposes.

Also, for protecting pedestrians and other vulnerable road users such as cyclists, a set of comprehensive vehicle safety requirements had been introduced and phased in for normal passenger cars from 2005 to 2013¹⁹, eventually as part of the current PSR. When comparing the EU situation in 2014 to that of 2005 as regards the total number of fatalities, analysis shows a 33% reduction of pedestrian and 30% reduction of cyclist fatalities respectively over the entire period²⁰.

Road collisions are often multifactorial, with various driver, infrastructure and vehicle factors contributing to their causation. Addressing any of the causation factors of a specific collision bears a certain chance to prevent it or mitigate the resulting consequences. It should therefore be acknowledged that the effects of additional in-vehicle safety systems and infrastructure improvements will, to a certain extent, affect the same population of road traffic collisions. In how far the cases where the two sets of measures are effective overlap, i.e. being successful at

¹⁵ *Ex post* evaluation of the European Road Safety Action Programme (2001-2010) – http://ec.europa.eu/transport/facts-fundings/evaluations/doc/2010_road_safety.pdf, Interim evaluation of the Policy orientations on road safety 2011-2020 – <http://ec.europa.eu/transport/facts-fundings/evaluations/doc/interim-road-safety-evaluation-report-final8june15.pdf>

¹⁶ Towards a European road safety area: policy orientations on road safety 2011-2020 (COM(2010) 389 final)

¹⁷ https://ec.europa.eu/transport/facts-fundings/evaluations/doc/2010_road_safety.pdf

¹⁸ Directive 96/27/EC of the European Parliament and of the Council of 20 May 1996 on the protection of occupants of motor vehicles in the event of a side impact and amending Directive 70/156/EEC (OJ L 169, 8.7.1996, p. 1.) and Directive 96/79/EC of the European Parliament and of the Council of 16 December 1996 on the protection of occupants of motor vehicles in the event of a frontal impact and amending Directive 70/156/EEC (OJ L 18, 21.1.1997, p. 7.)

¹⁹ Directive 2003/102/EC of the European Parliament and of the Council of 17 November 2003 relating to the protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle (OJ L 321, 6.12.2003, p. 15.)

²⁰ CARE historical percentage change in number of fatalities by mode of transport 2016 – https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/asr2016.pdf

preventing a targeted collision, is very complex to quantify in detail. Namely, scope and effectiveness vehicle safety measures are relatively closely defined, designed to avoid collisions by compensating for mistakes or non-compliant behaviours of human drivers. However, the resulting collision types are likely involve interaction with the road infrastructure, for instance run-off road or head-on collisions following unintentional lane departures due to inattention or excessive speed. A proportion of these accidents could also be addressed by rumble strips or roadside barriers if they were laid down and placed on the full road network. There are however also collisions with an assumed low level of infrastructure interaction, such as rear collisions or vehicle to pedestrian or cyclist collision due to a distracted driver. The effectiveness values for in-vehicle safety measures are typically in the order of 20% to 40% of the targeted collisions. The effectiveness for the passive safety measures will be lower and predominantly act through mitigation of consequences rather than collision prevention.

The scope of the road infrastructure and tunnel safety initiative is defined at a higher level, focusing on audits (of new roads), inspections, black spot identification (of existing roads) and minimum safety standards for tunnels, which leaves the decision on suitable technical countermeasures open for the specific roads covered. While radical changes of the road infrastructure design could have the potential to ‘undermine’ vehicle safety cost-effectiveness evaluation, the measures expected from the road infrastructure and tunnel safety initiative are not believed to fall in this category, because, for instance, separation of carriageways using central barriers could physically prevent front-to-front collisions resulting from lane departures, but is unlikely to be viable for most of the single lane road network. The initiatives are aimed rather to lift a greater part of the road infrastructure to an appropriate safety level that is achieved on better performing roads already. Therefore, the vehicle safety effectiveness studies as conducted remain valid.

Furthermore, certain in-vehicle systems rely on a well-maintained road-infrastructure: Lane keeping systems require well-maintained lane markings, and speed assistance systems rely on speed limit signs in a good state of repair for camera detection. The road infrastructure and vehicle safety initiatives will therefore also complement each other in certain areas and enable in-vehicle systems to realise their full safety potential.

Figure 1: Pace of traffic accidents, injuries and fatalities in the EU

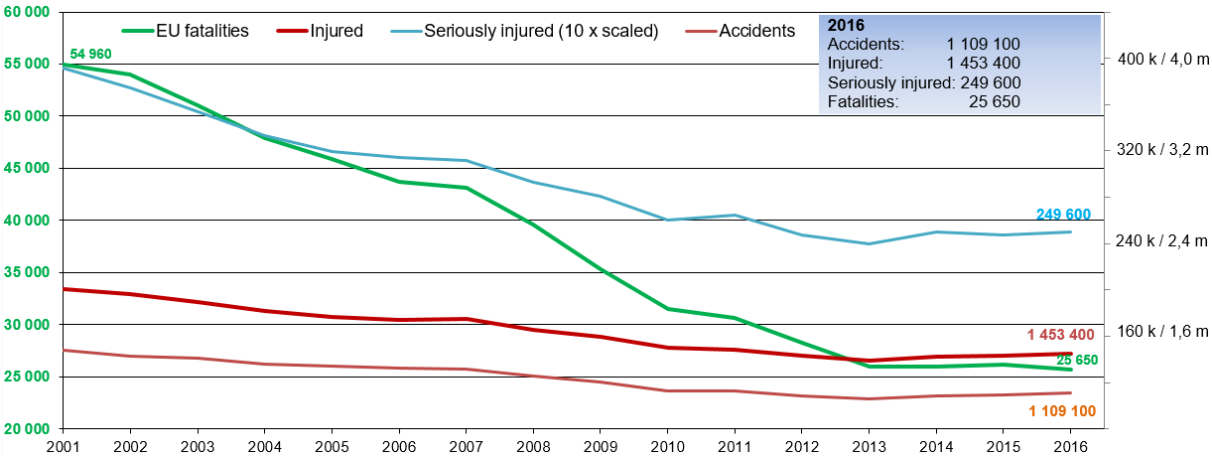


Figure 1 demonstrates the respective number of fatalities, injuries, serious injuries and accidents, over time. It is easy to note that the reduction rate of accidents is running in parallel with the reduction rate for slight and severe injuries, but that that the one for road fatalities is

more pronounced and performing better. This may be linked to current vehicle safety evolution, but given the nature of the combined road safety actions and the insufficient availability of EU wide in depth accident data²¹, it has so far been proven impossible to attribute a clear quantified reduction rate to mandatory vehicle safety legislation.

In context of the above, it should also be noted that apart from demanding EU vehicle safety legislation, vehicle manufacturers have been further encouraged to make vehicles even more safe and to fit state-of-the-art advanced safety technologies through consumer new car assessment and rating programmes, notably that carried out by the European New Car Assessment Programme (Euro NCAP) that launched its activities in December 1996. The resulting positive effects are also taken into account as part of the baseline scenario based on the EU Reference scenario 2016 covering the entire transport system, within this Impact Assessment.

With increasing levels of vehicle automation being a priority for car manufacturers, accurate, robust, durable and affordable sensor technologies are becoming widely available. These are necessary to detect the environment around the vehicle fully and also to facilitate the determination of a safe passage through traffic scenarios. Fitting such sensors and data processing technology to vehicles will continue contributing to safety improvements, especially regarding vulnerable road users, and even to the reduction of congestion and the ensuing pollution, given that 15% of all congestion in Europe is due to accidents²². The beneficial effect of connectivity is achieved by various ways like messages transmitted via smart phones, navigator devices as well as Internet of Things applications. The concept of Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) communication is however not yet mature enough for widespread incorporation in vehicles. Despite this, it may be considered to ask the co-legislator for a mandate to ensure standardisation, as requested by the industry²³, to better facilitate e.g. multi-brand platooning.

The *ex post* evaluation of the road safety action programme, published in December 2009, already concluded that the development of measures related to the active safety of vehicles (primarily those having accident avoidance capability) presented a good state of advancement, but that they would play a considerable role for safety in the medium or long term rather than the short term. Accident avoidance measures can help in further reducing the number of road accidents by assisting the driver and providing a remedy for human errors, which is by far the main cause of road traffic accidents²⁴.

2. WHAT IS THE PROBLEM AND WHY IS IT A PROBLEM?

1.5. Traffic accidents in the EU and their effects

Until 2009, transport accidents were the leading cause of death in the EU, but this is no longer the case²⁵. The number of road fatalities has come down considerably during the last 15 years, namely with an approximate 54% reduction from 54 900 in 2001 to 25 300 in 2017 according to the statistical *EU accident data*²⁶. However, traffic accidents still affect hundreds of thousands of families and lead to huge economic costs each year, not only due to the loss of

²¹ http://www.dacota-project.eu/Deliverables/DaCoTA_D2.5_finalreportv2.pdf

²² http://ec.europa.eu/transport/themes/its/road/application_areas/vehicle_safety_systems_en.htm

²³ http://www.acea.be/uploads/publications/Platooning_roadmap.pdf

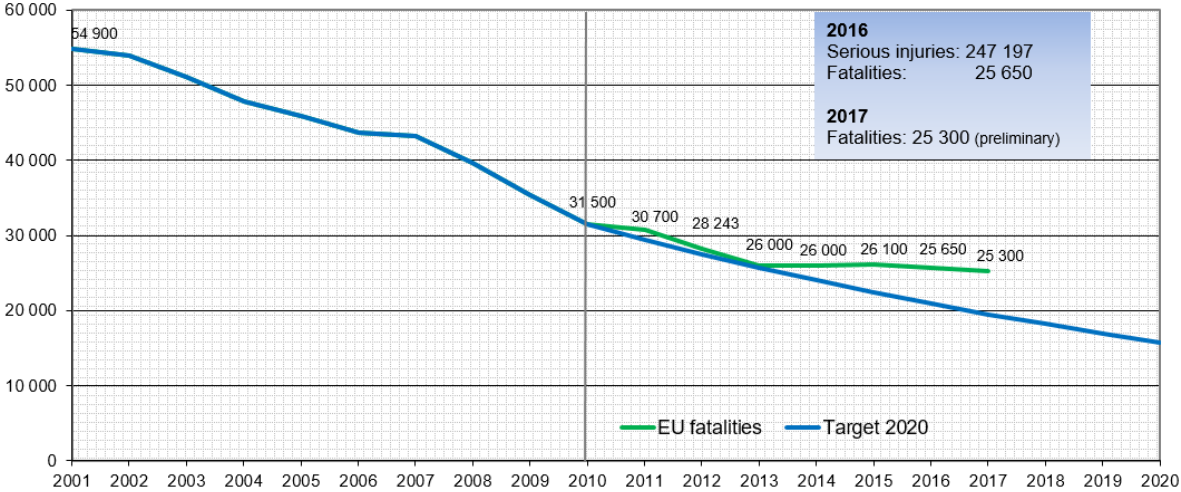
²⁴ eSafety Final Report of the Working Group on Road Safety, DG INFSO, November 2002

²⁵ http://ec.europa.eu/eurostat/statistics-explained/index.php/Causes_of_death_statistics

²⁶ Data are extracted from CARE (Community Road Accident Database) – https://ec.europa.eu/transport/road_safety/specialist/statistics_en

lives, but also due to persons sustaining serious injuries in road accidents. The social cost due to road casualties (i.e. rehabilitation, healthcare, death, material damages, among others) is estimated to be at least in the order of € 100 billion per year²⁷ and as such, the problem of road safety remains an urgent one.

Figure 2: Road traffic fatalities and serious injuries in the EU (CARE database)



Strong annual reductions of road fatalities were observed, for example considering the total reduction in each of the Member States from 2005 to 2014, with the highest rate reduction per million inhabitants occurring in Spain (65%) and Lithuania (65%) followed by Czech (61%) and lowest rate reduction in Romania (26%), followed by Bulgaria (29%) and Germany (35%). However, the overall reduction appears to have stagnated since 2013. This is clearly visible in the plateau that has developed from 2013 to 2017 (last available annual data).

The main problem to tackle at this instance is the persistent high number of accidents that in turn leads to a high number of fatalities and a high number of severe injuries. The solutions to address the main problem should either **avoid and lower the number of accidents** or **lower the severity of un-avoided accidents** to lower the number of fatalities and severe injuries.

Whereas some Member States are still making considerable progress every year, some others are even recording increases in fatalities. The causes are diverse, including structural factors (e.g. urbanisation, a growing number of cyclists and pedestrians, an ageing population, fewer resources for enforcement, road maintenance and vehicles following the economic crisis) and behavioural factors (e.g. distraction by electronic devices, speeding; alcohol). The lack of detailed data makes a precise analysis difficult. It is however clear that much of the low hanging fruits for policy making at national and EU level have been picked and that it is unlikely that the EU objective of a 50% reduction in road fatalities between 2010 and 2020 will be reached. A paradigm shift is needed towards a framework based on results that addresses the major challenges in an effective and flexible way across the entire spectrum of road safety policies. Such a framework will be proposed for the period 2020 – 2030 as part of the third Mobility Package and will follow the Safe System approach.

New and safe vehicles, meeting the latest EU requirements adopted by the Council and the European Parliament in 2009 and becoming mandatory for almost all vehicles since 2014, are sold on the EU market today and dispersing into the fleet, replacing older and unsafer

²⁷ Press release statement – http://europa.eu/rapid/press-release_IP-16-863_en.htm

vehicles. However, we also know that increasing traffic volumes will lead to a mounting number of road incidents potentially leading to more collisions and casualties. We now also become aware that an increasing safety level in the vehicle fleet, resulting from the vehicle safety measures introduced in the previous years, is required simply to achieve the status quo. Without the previous measures, the fatality and severe injury rates could even be expected to rise. Those effective vehicle safety measures however as introduced in the past and that are still dispersing into the fleet, e.g. stability control, are integrated into the baseline scenario for future years and indeed seen to avoid casualties, but not to the extent necessary to considerably overcompensate the increase in traffic volumes. Hence, further action is now needed.

According to the Safe System approach²⁸, death and serious injury in road collisions are not an inevitable price to be paid for mobility. While collisions will continue to occur, death and serious injury are largely preventable. The Safe System seeks to better accommodate human errors, which are often simple errors of perception or judgment by otherwise compliant users, whilst also dealing with misbehaviour. It is a shared responsibility of actors at all levels and from all relevant sectors to ensure that road crashes do not lead to serious or fatal injuries. Better vehicle construction, improved road infrastructure, lower speeds for example all have the capacity to reduce the impact of accidents, and addressing one factor alone will not be enough. The aim is to create several layers of protection so that when one element fails, others will compensate for it. For example, if a drowsy driver veers from his lane, vehicle technology can alert him or gently correct the vehicle's trajectory. Rumble strips provide another warning. Should the vehicle nevertheless leave the road, a "forgiving roadside" without dangerous obstacles or with energy absorbing roadside barriers can prevent serious consequences. Finally, crash absorbing vehicle design, along with seatbelts and airbags, protect vehicle occupants. The Safe System approach is being adopted increasingly in EU Member States, regions and cities. It is recommended globally by the World Health Organisation²⁹.

Working towards the EU's strategic objectives to halve the number of road deaths by 2020 compared to 2010 and to move close to zero deaths by 2050 ("Vision Zero" approach) requires a wide range of measures. Experts agree³⁰ that contributions towards these targets will have to come from all areas of road safety policy. Measures addressing speed, drink-driving and vehicle safety, and – to a slightly lesser extent – measures addressing road infrastructure, protective equipment (seatbelts, child restraints) and post-crash care, are generally regarded as having the highest potential impact. Vehicle and infrastructure safety are being addressed in the present proposals. Further complementary actions will be assessed in the future, subject to separate impact assessments.

According to the main statistical findings provided and analysed by Eurostat³¹, the number of road traffic fatalities in the various countries and regions depends on both structural differences (size of the country/region; composition, density and quality of the road network, characteristics of the population) and socio-economic differences (characteristics of the vehicle stock, transit and tourist traffic, behavioural aspects, etc.).

²⁸ OECD/International Transport Forum (2016): "Zero Road Deaths and Serious Injuries: Leading a paradigm shift to a Safe System", OECD Publishing, Paris; and <http://www.visionzeroinitiative.com>

²⁹ http://www.who.int/roadsafety/decade_of_action/plan/plan_en.pdf

³⁰ The SafetyCube (Safety CaUsation, Benefits and Efficiency) review project, financed under Horizon2020, synthesises relevant research: <https://www.safetycube-project.eu>

³¹ http://ec.europa.eu/eurostat/statistics-explained/index.php/Road_safety_statistics_at_regional_level

The trends in fatality rates vary significantly throughout the entire EU. For the period 2014-2015, 16 Member States reported rising casualty figures³² (e.g. Belgium (4%), France (2%), Germany (3%), Czech Republic (7%), Austria (10%) and Cyprus (27%). A decrease was observed in 10 Member States (e.g. Poland (-8%), Ireland (-15%), Estonia (-15%) and Luxembourg (-9%).

Causes and **sources of traffic accidents** have been subject to extensive investigation during many years. There are several in-depth international studies on traffic crashes that have identified significant causes and severity factors. Infrastructure, e.g. road layout such as hills, bends or narrow lanes and road environment such as slippery roads due to the weather conditions, contribute to the causes factors. On the other hand, **road user factors**, such as inadequate restraint systems or improper use play a dominant role in severity factors. In contrast, vehicle factors (e.g. due to malfunction, worn parts, non-compliance) contribute only a relatively small portion to accident severity factors (road user factors 63%, road factors 33% and vehicle factors 4%)³³.

The traditional vehicle safety performance, not to be confused with vehicle factors, has been consistently addressed through previous measures introduced in EU legislation. Of these, the passive safety measures consist of improving car designs and construction to protect the occupants in a crash. This is done by physically strengthening the vehicle chassis, structure and bodywork as well as the designs of e.g. seats, steering column and energy absorbing elements. More recently, the active safety measures that have been introduced are those that deploy once an accident is already occurring, e.g. airbags and safety belt tensioners. An area however that so far has not really been fully addressed is that of accident avoidance measures (with the noted exception of new stability control systems that are mandatory for all new vehicles since November 2014 and is identified as a major influence on the baseline scenario). Avoidance systems have the capability of indeed preventing an accident from happening altogether and the initiative covered by this Impact Assessment has a particular focus on deploying such measures alongside other conventional passive and active safety measures.

Some of the **sources of accidents with great impact on accident severity** factors are thus **ideal candidates to address** by means of **new and advanced safety measures**. For this purpose this was assessed in the context of the Commission's reporting to European Parliament and the Council as referred to in section 1.3 above. One has to think along the lines of forward looking detection systems that can spot safety issues before the human driver can see them, in a way addressing infrastructure shortcomings. It should be noted that these sources differ across EU countries, thus avoidance measures enhance the overall safety effect throughout the EU.

Another area that can be addressed concerns **population diversity** throughout a regional population. This is done by improving (e.g. softening and optimising) in-vehicle restraint systems for better protecting physically sensitive elderly drivers with reduced bone density and frailty due to their age, as well as protecting small female occupants, as the smaller the person, the fewer crash forces the body can tolerate. This **addresses the road user factors** and in particular the inadequate restraint systems mentioned above.

It has further been suggested by stakeholders that the increasing number of older persons lead to an increase of reversing accidents in which an older pedestrian is hit, as the elderly have

³² Country by country road deaths per million inhabitants – http://europa.eu/rapid/press-release_IP-16-863_en.htm

³³ Final report – Support study for an impact assessment of the revision of Directive 2008/96/EC on road infrastructure safety management and Directive 2004/54/EC on minimum safety requirements for road tunnels in the trans-European network (to be published)

less agility to get out of the way of impending danger. It could also be argued that drivers of age may have longer reaction times and that they would benefit from autonomous safety systems. However concerning the latter there is insufficient data available that would help to precisely quantify both problem and benefit.

Another possible problem driver that is often mentioned³⁴ by stakeholders and Member States, but for which only limited EU wide evidence exists³⁵, is that of driver inattention because of distraction through the **use of smartphones while driving**. Distraction can be addressed by new technologies in motor-vehicles. In a recent publication on a targeted questionnaire in the Netherlands³⁶, up to 39% of car drivers indicated using a mobile phone behind the wheel for a task other than hand-held or hands-free calling. The overall average mobile phone use while driving was admitted by 42% of respondents, where the age group 25 to 34 topped the range at 79%. Of the respondents, 37% conceded doing this on a frequent basis. Along the same lines on driver inattention, driver fatigue and drowsiness should be mentioned, as it is estimated that this is a major factor in a large proportion of road crashes, in the 10% to 20% range³⁷.

Therefore, in order to reach the current EU strategic target of halving the number of road deaths from approximately 31 000 in 2010 to 15 000 in 2020, as stated in the Policy Orientations on Road Safety 2011 – 2020³⁸, or rather the updated targets that are to be set beyond this date, additional efforts are needed. Despite the big improvement made in the past, road fatalities are still persistent in European countries. As explained above, a large part of those are driven by human error factors. Therefore, **in order to complement our past initiatives** and contribute to a further reduction of fatalities, our **focus should be on** introducing new safety measures, especially those ones **tackling human error factors**, something that has not been the centre of attention before, to help boost road safety.

1.6. Transformation of main safety problem into vehicle level problems

In this section the description of specific road safety problem is ultimately provided from the perspective of persons that are injured or killed in traffic accidents involving vehicles. However, with reference to Annex 5, no less than 96 accident scenarios have been reviewed and subsequently rated in terms of feasibility and occurrence rate while taking into account EU accident data analysis. Account was taken of vehicle to vehicle accident as well as vehicle to person accident scenarios. A further rating was then applied based on assessment of risk, specifically concerning the persons in and around the vehicle involved in the accident, in order to identify the target priorities.

Given the scope of the legislative framework that has been considered, the vehicle classes could be crudely grouped into two main distinctions: Light Duty Vehicles (LDV) and Heavy Duty Vehicles (HDV) as illustrated in Figure 3.

³⁴ <http://etsc.eu/several-countries-looking-to-crack-down-on-mobile-phone-use-at-the-wheel/>

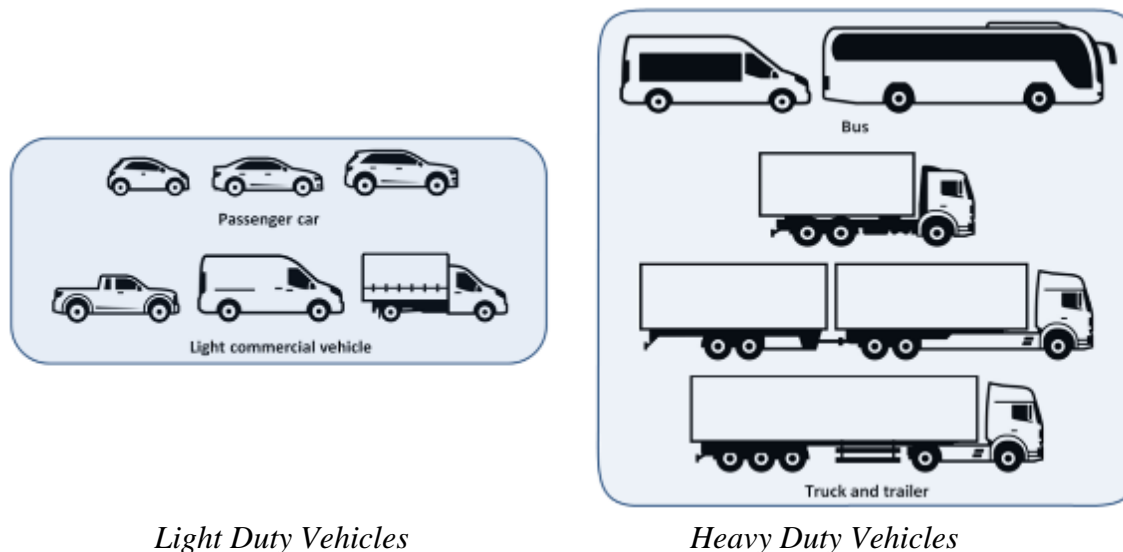
³⁵ https://www.who.int/violence_injury_prevention/publications/road_traffic/distracted_driving_en.pdf

³⁶ <https://www.swov.nl/publicatie/interpolis-barometer-2017>

³⁷ https://ec.europa.eu/transport/road_safety/specialist/knowledge/fatigue/fatigue_and_road_crashes/conclusions_en

³⁸ COM(2010) 389 final

Figure 3: Vehicle categories and grouping for problem description



Light Duty Vehicles

Heavy Duty Vehicles

A further distinction was made in relation to the category of vulnerable road users, namely pedestrians and cyclists.

Although moped and motorcycle riders are also often referred to as vulnerable road users, and e.g. the users of self-balancing machines, they are not explicitly included as such for the purpose of this Impact Assessment, although improved protection will to a certain extent also benefit them. This is however not quantified, because there is a considerable variation in the Member States in the distribution of e.g. moped and motorcycle fatalities by area and road type, diverging practises of helmet use, and the most frequently recorded specific critical event for riders is surplus speed that is described as speed that is too high for the conditions or manoeuvre being carried out, very much in contrast to pedestrians and cyclists³⁹. Also, motorcycle riders tend to be disconnected from the vehicle in case of an accident. Although this group should clearly be taken into account wherever practicable, specific measures to address their safety⁴⁰ were deemed more appropriate outside of the regulatory framework impacted by this specific initiative. Other possible improvements could for instance be achieved through road infrastructure risk management, by encouraging the application of roadside barriers that are especially designed to better protect riders sliding over the ground and impacting them.

The *EU accident* data, as well as by the additional preparatory analysis⁴¹ carried out specifically in support of this Impact Assessment, finally supported that the accident scenarios as mentioned below, most commonly involving LDV and HDV with the identified primary and secondary risks to be addressed by the initiative:

³⁹ https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/bfs2016_motomoped.pdf

⁴⁰ Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles (OJ L 60, 2.3.2013, p. 52) and Commission Delegated Regulation (EU) No 3/2014 of 24 October 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of two- or three-wheel vehicles and quadricycles (OJ L 7, 10.1.2014, p. 1)

⁴¹ Based on CARE 2015 data and TRL, Seidl *et al.*, May 2017 including the additional Technical Annex to the report, concerning “Cost-effectiveness analysis of Policy Options for the mandatory implementation of different sets of vehicle safety measures – Review of the General Safety and Pedestrian Safety Regulations”, not yet published

- **Frontal impacts and the protection of occupants** resulting in about **63% (8650/yr)** of all occupant fatalities in LDV and HDV, as well as a need for fire and electric shock prevention after a crash occurrence;
- **Side impacts and protection of occupants** resulting in about **17% (2325/yr)** of all occupant fatalities in LDV and HDV, as well as a need for fire and electric shock prevention after a crash occurrence;
- **Rear impacts and protection of occupants** resulting in about **5% (725/yr)** of all occupant fatalities in LDV and HDV, as well as a need for fire and electric shock prevention after a crash occurrence.

and

- **Pedestrian and cyclist** protection hit by the **front-side** of a vehicle, resulting in about **78% (5250/yr)** of all pedestrian and cyclist fatalities hit by LDV and HDV;
- **Pedestrian and cyclist** protection hit by the **side** of a vehicle, resulting in about **8% (575/yr)** of all pedestrian and cyclist fatalities hit by LDV and HDV;
- **Pedestrian and cyclist** protection hit by the **rear-side** of a vehicle, resulting in about **11% (750/yr)** of all pedestrian and cyclist fatalities hit by LDV and HDV.

As the protection of persons is central to the reduction of road casualties, this aspect should be the focus of attention in the context of actions that are analysed within this Impact Assessment.

1.7. Slow market uptake of new safety features in the vehicle fleet

The rapid development of accident avoidance technologies in the past years has resulted in the availability of a panoply of driver assistance features (e.g. autonomous emergency braking, lane keeping assist, reversing camera) that have a great potential to improve road safety, by either avoiding collisions altogether or reducing impact speed and thus the victims' injury levels. In parallel, improved active safety features (e.g. window airbags, deployable bonnet, safety belt pre-tensioners and load limiters) as well as passive safety features (e.g. energy absorbing windscreens, larger windows on trucks) also play an important role to further reducing the number of fatalities or injuries in collisions that will inevitably still occur. The voluntary market uptake of new vehicle safety features however has shown to be rather slow, as typically, mainly larger luxury cars did benefit from these new features. Passive safety measures beyond those that are imposed and that are not primarily directed at protecting the occupants (i.e. pedestrian safety) are rarely incorporated in motor-vehicles on a voluntary basis.

1.8. Competitiveness and innovation

It is envisioned that the current road safety problems can help to stimulate innovation for safer cars and technologies. As mentioned above, innovation on safety features has been limited to certain market segments so benefits are not optimal across the board. However, any introduction of new legislative measures shall not harm competitiveness of car manufacturers and suppliers nor penalise their capacity to innovate..

1.9. Efficiency of measures introduced so far

Given the very recent timeframe in which the latest safety measures have become mandatory, or in some cases still have to, the dispersion of fully compliant vehicles within the EU fleet is not yet achieved and will take up to 2025. This issue is the direct consequence of the choice of the co-legislators in 2009 to have long transitional arrangements for the implementation of the

measures. Given, these very long transitional arrangements, a comprehensive evaluation of all the measures adopted so far could not be completed.

1.10. Market description

The evolution of fatalities depends on a large number of factors, such as economic development (GDP/capita), mobility level (number of vehicle kilometres driven) or exposure, vehicle safety technologies, driver trainings or behaviour or road infrastructure.

At the same time, the impact of safety measures will depend on the improvements of vehicle technology and gradual penetration of the safety measures into stock of all vehicles. Even though we do not have granular data to approximate the current state of safety measures penetration in the car fleet, we can approximate it by the fleet renewal rates and the age of the car.

When observing an historical evolution of road accidents, we note that most European countries present similar accident trends which differ on the timing, depending mostly on the economic situation of countries⁴² (figure A10.1 Annex 10). After a peak there is a high decrease on the number of accidents, followed by a stabilisation of the trend, with a lower decline rate of accidents. Western European countries experienced a high reduction of road accidents during the 60's and 70's, while Southern European countries did not experience a sharp decrease until some years later. Eastern countries experienced a big decline much more recently, around 2007, with some countries still being in this transition phase.⁴³

During the past decades, the number of vehicles per inhabitant has increased, but we observe different regional tendencies. The number of passenger cars per thousand inhabitants has gradually increased in all Europe since 1990 (figure A10.2 Annex 10). The steep growth in Eastern European countries contrasts with a moderate increase in Western Europe and Central Europe. By 2015, the number cars/thousand inhabitants in South European countries was similar to Central European Member States, while Eastern countries are quickly catching-up and approximating to similar figures to those in Western countries.

On the other side, we observe big differences in vehicle fleet composition between Member States. Even though most of the measures proposed in this Impact Assessment have already attained a certain level of maturity in the market⁴⁴, its integration in different EU countries might remain heterogeneous. From 2007, we observe renewal rates of passenger cars to decrease in all Europe, with especially remarkable falls in South and Western Europe (Figure A10.3 Annex 10). Central European Member States were less affected than other regions, and kept a quite stable renewal rate from 2004 to 2015. From 2013 onwards, most Member States changed the tendency and started experiencing a faster renewal rate on passenger cars. Nowadays, Central Europe and Western Europe are the regions with faster renewal rates, while South Europe and Eastern Europe are slowly recovering.

These differences are confirmed when observing the age of the current car fleet in different countries (Figure A10.4 Annex 10). Member States such as UK, Germany and France have more than half of their fleet composed of relatively new vehicles: 19% of their fleet is not older than 5 years, with less than 15% of cars being older than 10 years. On the other hand, other Member States, such as Poland, Hungary or Spain still present relatively old car fleets,

⁴² Kopits and Cropper 2003

⁴³ COWI report

⁴⁴ TRL, Seidl *et al.*, May 2017 – <https://publications.europa.eu/en/publication-detail/-/publication/77990533-9144-11e7-b92d-01aa75ed71a1>

with more than half of the fleet older than 10 years, and in some cases, even a notorious share of cars older than 20 years (Poland 32 %, and Latvia 22%).

1.11. Outdated safety exemptions for SUVs, MPVs, vans and the like

Currently, heavy passenger cars (e.g. family van, SUV, MPV⁴⁵) and all light commercial vehicles (e.g. cargo delivery van, pick-up) are fully exempted from the frontal crash testing as introduced in 1996. At that time the exemptions were introduced based on either a very low market availability of such vehicles or the notion that utility vehicles would have severe difficulties to comply due to their size and mass. It was further suggested that compliance with the legislation would make larger and heavy cars stiffer at the front, and that this would create a specific problem for small non-compliant older cars in collisions with newer compliant heavy cars (i.e. compatibility mismatch). However, this issue has become increasingly obsolete over time, given that a high percentage of small cars in the fleet⁴⁶ now meet the frontal impact off-set crash requirements.

The absence of frontal crash testing requirements for light commercial vehicles as a whole, based on the notion of size and mass as with SUVs, presents the situation that workers that are required to drive light commercial vehicles to carry out their duties cannot rely on a harmonised minimum level of frontal crash protection. The actual safety level depends fully on the vehicle purchase choice made by their employers and even that safety performance is not subject to a guaranteed level.

In practise, the actual safety level may vary significantly between two vehicles that appear to be completely identical in terms of looks, but that differ on a technical level. Some equipment may be fitted, but their performance can be erratic, given that there is no control mechanism due to the nature of the exemptions in the current legislation.

Vehicles that do not have a seating position under just 70 cm above ground level are in turn fully exempted from the side impact crash test. Also in this case it notably includes those passenger cars that can be characterised as SUVs as well as delivery type vans. The exemption was based on a lower risk of bodily injury of occupants, due to the ‘high’ seating position. In principle this reasoning is still valid, but the regulations contain other safety criteria covering spontaneous door opening in a crash or all doors being jammed shut after a crash, which are then also neglected, putting occupants of these vehicles at a risk.

Rear impact crash testing has been exempted altogether for all vehicle categories although the relevant test specifications and requirements have existed on UNECE level that apply in the EU since its accession in 1997⁴⁷. Its current application in the EU is mandatory, but with a specific exemption concerning the rear crash test.

When motor-vehicles are exempted from these type of crash tests, the post-crash protection against electric shock and fire risks can also not be guaranteed.

⁴⁵ Family van is generally defined as a passenger car version of e.g. a cargo delivery van with windows all around and up to 9 seating positions – SUV means Sport Utility Vehicle generally defined as a large station wagon shaped vehicle with high riding position that is designed to be used on rough off-road surfaces, but that is rather often used on urban roads and motorways – MPV means Multi-Purpose Vehicle generally defined as a family van, but not derived from a cargo delivery van, with high riding position and up to 9 seating positions

⁴⁶ Eurostat, Road transport equipment – Stock of vehicles

⁴⁷ OJ L 346, 17.12.1997, p. 78

In the light of the success of SUVs in the marketplace, up from only 3% in 1996 to 14% market penetration in 2016⁴⁸ and the increasing sales figures⁴⁹ for light commercial vehicles with the market addressing urban mobility solutions the justification for these exemptions has to be reconsidered. In addition, the accelerated shift towards zero-emission mobility with electric vehicles and their heavy and high capacity batteries also plead for re-examination of these exemptions as battery powered vehicles need to offer adequate protection against electric shock and vehicle fire after a crash. It should be recognised that e.g. consumer testing points to certain manufacturers that may very well design and construct vehicles based on due diligence. However, given this very unclear situation, it has also proven to be impossible to quantify this specific problem. Hence the safest way forward would be to scrutinise the old justifications with a view to lift these exemptions, to ascertain that they cannot have an unintended negative effect on the already precarious status quo.

1.12. Contribution to the reduction of the regulatory burden on companies

The initiative has a REFIT dimension, but is not expected to have a significant impact on the regulatory burden for manufacturers or national governments. Vehicle type-approval is already covered by the existing vehicle legislative framework (Framework Directive 2007/46/EC) and the inclusion of any new safety measures is to be integrated within that framework.

Although the relevant vehicle testing and certification procedures can be performed within the existing type-approval infrastructure available in the Member States, additional testing and certification cost will be applicable. These costs are however insignificant⁵⁰ in relation to the overall cost of the development of a new vehicle model (typically ranging from several hundred millions to several billions euros).

The original GSR introduced a range of vehicle safety measures, but also aimed to achieve simplification based on the CARS21 High Level Group recommendations⁵¹ by replacing 38 EC Directives with equivalent and world-wide harmonised UNECE regulations. The proposed new vehicle safety measures covered by this initiative should also adhere to this principle and where detailed technical testing provisions do not yet exist, they should clearly be developed on UNECE level. In the same vein, several EU Regulations that currently implement the GSR will be repealed and replaced by equivalent UNECE regulations that have in the meantime been introduced.

Because of the transparent stakeholder engagement and frequent reporting in EU Working Groups and UNECE Working Parties, there has been significant interest by other Contracting Parties to engage on UNECE level. For instance, work to develop safety standards has already started on Lane Keeping provisions, Autonomous Emergency Breaking for cars and for pedestrians and cyclist detection on the front and to the side of trucks cabs, as well as for a direct vision standard for heavy duty vehicles by countries including Japan, Russia and Canada.

⁴⁸ <http://www.acea.be/statistics/tag/category/4x4-penetration>

⁴⁹ <http://www.acea.be/statistics/tag/category/by-country-registrations>

⁵⁰ Fitness Check of the Legal Framework for the Type-Approval of Motor Vehicles - <http://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=9407681>

⁵¹ COM(2007) 22 final – CARS 21 High Level Group was mandated to make recommendations for the short, medium and the long term public policy and regulatory framework for the European automotive industry that enhances global competitiveness and employment while sustaining further progress in safety and environmental performance at a price affordable to the consumer
<http://ec.europa.eu/DocsRoom/documents/1891/attachments/1/translations/en/renditions/pdf>

The proposed initiative will consolidate in one legal act and repeal the three currently applicable co-decision regulations, namely the General Safety Regulation, the Pedestrian Safety Regulation and the Hydrogen Safety Regulation⁵², as they share specific similarities that will result in simplification of this EU legislation. In particular, a further 15 individual implementing measures of the three main acts will be repealed and replaced, on the one hand with UNECE Regulations that have been adopted in the meantime, and on the other hand with one delegated act and one implementing act.

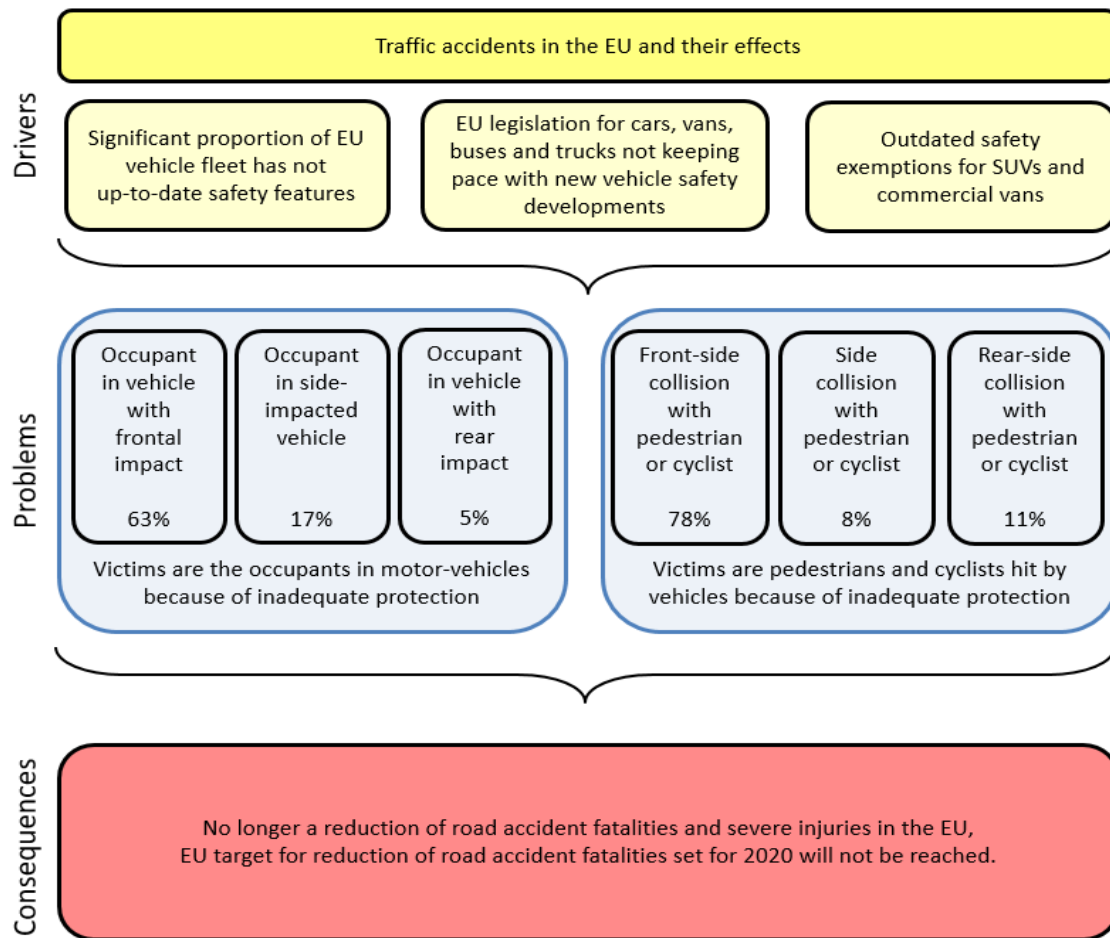
The proposed action is future proof. The envisioned measures are to be put in place on a 'technology neutral' basis. The overall vehicle safety measures covered by this initiative will further adhere to the established and industry welcomed principle of preferred development on UNECE level for reasons of world-wide harmonisation. It is also highly preferential in terms of its potential for efficient adaptation of vehicle safety rules to technical progress. It means that on the one side manufacturers can innovate to meet their own safety performance objectives, without dictating the technical approach, but also that the Commission as regulator can efficiently address technical progress and urgent safety needs through more simple integration within the EU legislative framework.

Finally, thanks to the technology neutral approach, manufacturers will be enabled to exceed the minimum requirements with deployment of new innovations. This is in particular important given the transition to more autonomous functions in vehicles, vehicle to vehicle and vehicle to infrastructure communication. The room that is going to be provided for innovation allows for various options that can benefit the further development of connected and automated transport, e.g. use of advanced sensors and/or cameras for road sensing.

⁵² Regulation (EC) No 79/2009 of the European Parliament and of the Council of 14 January 2009 on the type-approval of hydrogen-powered motor vehicles and amending Directive 2007/46/EC (Text with EEA relevance), OJ L 35, 4.2.2009, p. 32

1.13. Main problem drivers and consequences

Figure 4: Problem tree



Out of scope:

- Road infrastructure (e.g. signs, lane markings, motor-ways, tunnels)
- Driver training
- Level of enforcement
- Mobility mix options (e.g. car-pooling)
- Mobility restrictions (e.g. low emissions zones)
- Cooperative, connected and automated mobility (CCAM)

3. WHY SHOULD THE EU ACT?

The Legislative Framework for type-approval of vehicles in general is based on Article 114 of the TFEU and contributes to the implementation of the internal market for goods. Vehicle safety requirements are already harmonised at the EU level, which not only prevents fragmentation of the internal market, but also ensures equal health and safety standards across the EU as well as offering advantages of economies of scale: products can be made for the whole European market, instead of being customised to obtain national approval for every single Member State.

If actions to address road safety problems were to be taken individually by Member States at national level by imposing additional specific performance requirements, there would be a particular risk of creating obstacles to the free movement of motor vehicles. This risk has

clearly been demonstrated in the discussions about the more strict requirements concerning the positioning or repositioning of the steering-wheel of new or previously registered vehicles designed for left-side traffic in order to be used on public roads of Member States with right-side traffic⁵³.

Another example, demonstrating this risk is linked to local or regional level prohibition of vehicle circulation, for instance inside of certain cities or city sections that would require more stringent safety equipment on vehicles than required by EU legislation. In some cases this is limited to public procurement methods, for instance by the city of Copenhagen with guidelines for procurement of garbage collecting services, requiring that the garbage trucks used should be designed to maximise the safety of surrounding vulnerable road users, e.g. with glass doors for increasing the driver's field of vision⁵⁴. It is however also known that the city of London is working on actually banning EU compliant vehicles from city areas if they do not fulfil specific additional safety criteria⁵⁵. For this purpose, the mayor of London is currently already finalising a set of comprehensive rules on a direct vision standard for trucks⁵⁶, hence there is clear added value to take action at EU level.

Furthermore, given the lack of rapid uptake of new vehicle safety features, as outlined in section 2.2 above, and the fact that the typical fitment rates are still well below what could be considered an effective and appropriate proportion of new vehicles, these matters should rather be considered for EU legislative action.

In addition, making available, on a large scale, motor-vehicles with raised sophistication will also have consequences concerning several aspects related to vehicle drivers as well as the infrastructure. Notably these could include incorporating knowledge and awareness of new technologies in driver training programs as well as optimisation of road markings and traffic signs for the increasing automation functions depending on that type or road infrastructure input. As such, it is again underlined how important the integrated approach remains.

4. WHAT SHOULD BE ACHIEVED?

The **general objective** of the proposed initiative is to **contribute to a further reduction of the number of traffic accident fatalities and severe injuries**.

The problem definition has pointed to **two specific objectives** to address the general objective in terms of physical protection of persons:

- **Occupants of vehicles involved in collisions need to be protected.**
- **Pedestrians and cyclists struck by a vehicle need to be protected.**

A range of underlying problems have also been identified. The slow market uptake of new features and abolishing of outdated vehicle safety exemptions can be addressed when measures indeed focus on upgrading EU vehicle safety with concrete vehicle safety measures and new features. Competitiveness and innovation are general issues that need to be taken on board regardless of the proposed solution. The lack of data on the efficiency of measures that have been adopted in the past cannot be addressed for those measures per se, but to promote a workable solution for new measures that are presently under consideration.

As previously outlined, the legislative framework addressing vehicle safety consists of on the one hand the GSR and on the other the PSR that are thus subject of this Impact Assessment.

⁵³ Judgement of the Court (Fifth Chamber) in Case C61/12

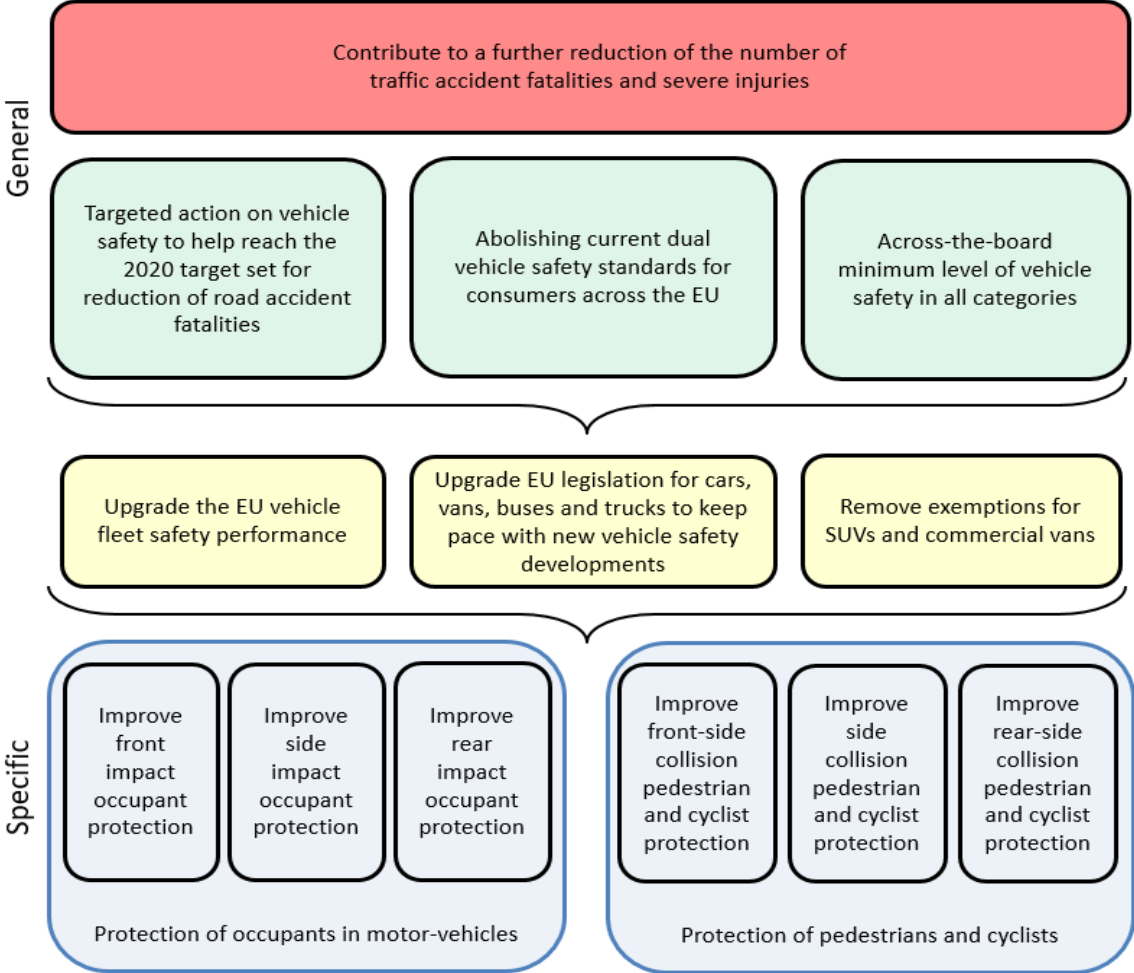
⁵⁴ COM(2013) 913 final -

⁵⁵ <https://tfl.gov.uk/cdn/static/cms/documents/safer-lorries-scheme-traffic-regulation-order-2015.pdf>

⁵⁶ <http://www.tfl.gov.uk/direct-vision-standard>

Reduction of traffic casualties can be achieved through the introduction of new vehicle safety measure implementing legislation, adopting existing implementing legislation available e.g. on UNECE level⁵⁷ to which the EU is a Contracting Party, or by adapting existing mandatory legislation in the context of the specific objective.

Figure 5: Objective tree



5. WHAT ARE THE VARIOUS OPTIONS TO ACHIEVE THE OBJECTIVES?

The main problem to tackle has been identified as the persistent high number of accidents that in turn leads to a high number of fatalities and a high number of severe injuries.

⁵⁷ Council Decision of 27 November 1997 with a view to accession by the European Community to the Agreement of the United Nations Economic Commission for Europe concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted to and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions (‘Revised 1958 Agreement’) (OJ L 346, 17.12.1997, p. 78) as last updated by Council Decision (EU) 2016/1790 of 12 February 2016 on the conclusion of Revision 3 of the Agreement of the United Nations Economic Commission for Europe concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or used on wheeled vehicles and the conditions for the reciprocal recognition of approvals granted on the basis of these prescriptions (‘Revised 1958 Agreement’) (OJ L 274, 11.10.2016, p. 2)

The solutions mentioned below try to address the main problem by either completely avoiding and lower the number of accidents or by lowering the severity of un-avoided accidents to lower the number of fatalities and severe injuries.

The different measures listed below have been selected on the basis of the Commission's study "**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**"⁵⁸, that initially analysed over 50 possible vehicle safety measures. The initial list of potential measures was brought forward by the Commission, but the stakeholders added possible measures for analysis in the course of the frequent consultations that took place. For reasons of transparency this process and the suggestions contributed by the various stakeholders were fully documented in the respective study.

All suggested measures were in a first step assessed on the basis of **feasibility** and **expected cost-effectiveness**. In a second step a reduced list of around 20 measures was based on the results of the initial assessment and it was looked at whether the potential measures were available through existing, robust or otherwise feasible technologies and whether such technologies would be affordable.

For all measures that were assessed positively, the **individual costs and benefits** were assessed. This was also done for the **effectiveness** of measures. These assessments were based on **literature studies** or **input provided by stakeholders** in the course of the consultations.

Subsequently, in the context of a targeted stakeholder workshop event, **all data was explicitly shared with all stakeholders on 'fact sheets' for each individual measure**. Stakeholders were then asked to agree with this data or to provide updated figures and data sources if they did not agree. By this the **stakeholders** eventually **endorsed all input data** that was to be used for the purpose of this Impact Assessment, i.e. the vehicle manufacturers, supplier industry, safety advocacy and environmental groups, as regards the **costs and effectiveness of the range of safety measures**.

In the final stage the **stakeholders** however **insisted** that the assessment of the benefits and costs for multiple **grouped measures** would be assessed in a **combined fashion**, and **not on individual basis**, for each vehicle category. Indeed, some of the proposed measures were targeting the same accident type and thus had a mutual influence/interaction on the level of their effectiveness. E.g. autonomous braking avoiding a collision vis-à-vis improved restraint systems in case of crashing – if the collision is avoided, the improved restraint system is effectively of no use, however, no measure is 100% effective, so there is still a significant merit to improve the restraint systems although its specific effectiveness figure needed to be adjusted downward. Some features also use a common technology (e.g. forward looking camera for autonomous braking, lane keeping and intelligent speed assistance) and their grouping would save cost.

On this basis, the cost and benefit analysis of the measures was adapted accordingly. It should be mentioned as a concrete example, that the safety measure of “small overlap crash test” that was one of the 20 short-listed measures was potentially cost-effective as a standalone measure, but with the simultaneous introduction of “lane keeping” technology and through independent accidentology data provided on behalf of the vehicle industry, the occurrence of

⁵⁸ http://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/?pgid=Iq1Ekni0.1ISR00OK4MycO9B0000BAJ9tQVY;sid=OT_-Ap3uO3P-V8j2wGFgpf_Lm_yCUpo9P-w=

such small overlap accidents would be starkly reduced and the residual effectiveness would no longer weigh up to the cost for structural improvements to the vehicles.

1.14. Measures to completely avoid accidents, to reduce the overall severity of accidents or to mitigate the outcome of injuries in accidents between vehicles or vehicles and obstacles

1.1.2. Frontal impact occurrences

New advanced safety features:

Several of the possible measures addressing frontal impacts revolve around an active intervention by vehicle systems or a general aim to either avoid the frontal impact altogether or to mitigate accident outcome in terms of occupant injury levels. Other measures have the potential to reduce the overall risk of a frontal impact collision or to aid in terms of measurement of the effectiveness of vehicle safety systems.

Autonomous emergency braking for driving and still-standing vehicles ahead is a **new vehicle safety measure** for LDV, but is already mandatory for HDV. It combines sensing of the environment ahead of the vehicle with the automatic activation of the brakes (without driver input) in order to completely **stop the vehicle before the collision occurs or to reduce the impact speed**, the latter also still having great beneficial effect on injury risk⁵⁹.

- **Action to be considered: mandatory application of autonomous emergency braking for driving and still-standing vehicles ahead**

Alcohol interlock installation facilitation is a **new vehicle safety measure** that is expected to lead to more vehicles being equipped with an alcohol interlock device, either on a voluntary basis, due to a national policy for categories of (professional) drivers or as a result of a national (recidivist) fitting program, and that thus **reduces the risk of collision occurrence**.

- **Action to be considered: mandatory application of alcohol interlock installation facilitation**

Drowsiness and attention detection is a **new vehicle safety measure** that detects driver inattention through system analysis over a given timeframe of erratic driving and steering input, either due to fatigue or due to some activity that competes for a driver's visual attention. Upon detection of driver inattention, the driver receives a warning to resume normal attentive driving, or to take a rest, leading to a **reduction of the risk of a collision**.

- **Action to be considered: mandatory application of drowsiness and attention detection**

Distraction recognition is a further **new vehicle safety measure** that also detects driver inattention, but that goes a step further by recognising the situation for which the key shared feature is the actual absence of visual attention on the driving task, again either due to fatigue or due to some activity that competes for a driver's visual attention. Upon more or less instant detection of driver inattention, the driver receives a warning to resume normal attentive driving, leading to a **reduction of the risk of frontal collision**.

- **Action to be considered: mandatory application of drowsiness recognition**

⁵⁹ https://ec.europa.eu/transport/road_safety/specialist/knowledge/speed/speed_is_a_central_issue_in_road_safety/speed_and_injury_severity_en

Emergency stop signal is a **new vehicle safety measure** that consists of a rapid flashing of the brake lamp when full brakes are applied. This system is designed to address front-to-rear accidents. Drivers following a hard-braking vehicle are instantly aware that the vehicle in front is braking with a high retardation so that they can take appropriate action. It helps drivers to avoid late recognition of the hard-braking situation that might **prevent a collision or reduce the resulting impact speed**.

- Action to be considered: **mandatory application of emergency stop signal**

Intelligent speed assistance is a **new vehicle safety measure** that works with the driver to provide non-intrusive haptic feedback, preferably through the accelerator pedal that could be overridden by the driver, to promote the adoption of a (slightly) reduced speed in accordance with the maximum permissible speed limit. Speed limit information would be provided through a combination of optical recognition of maximum speed signs as well as up-to-date detailed map data or real-time over-the-air type data. The link between speed in excess and increased severity and frequency of accidents has long been established. This measure is expected to **reduce the risk of collision occurrence, but also the resulting impact speed** in those collisions that will not be prevented.

- Action to be considered: **mandatory application of intelligent speed assistance**

Lane keeping assist is a **new vehicle safety measure** that either keeps the vehicle in its driving lane by correcting driver steering input where appropriate. In a first step the measure recognises that the vehicle is about to leave or no longer follow the appropriate lane, but then only actively intervenes to keep within the lane in the particular case where also an imminent threat such as leaving the road, or leaving the lane when a collision with other traffic or road obstacles is about to occur. This vehicle safety measure therefore **reduces the risk of frontal collision occurrence through its avoidance potential**.

- Action to be considered: **mandatory application of (emergency) lane keeping assist**

Tyre pressure monitoring system is a **new vehicle safety measure** for all vehicle categories except passenger cars for which it is already mandatory. The system reports situations of a critically underinflated tyre to the driver. Underinflated tyres can lead to poor vehicle handling and increased stopping distances, and can result in catastrophic tyre failure, and subsequent loss of control of the vehicle, due to increased stress and heat build-up in the tyre. This vehicle safety measure therefore **reduces the risk of collisions through its avoidance potential**.

- Action to be considered: **mandatory application of tyre pressure monitoring system**

Event (accident) data recorder is a **new vehicle safety measure** for LDV that stores a range of vehicle status data over a specific timeframe (short duration in conventional vehicles, long duration in vehicles with highly automated functions) before, during and after a crash, usually triggered by airbag deployment. It should facilitate a standardised form of interrogation and should store critical crash-related information such as vehicle speed, state of restraint systems, detection and monitoring systems, light signalling devices and driver direct control input parameters (e.g. steering wheel angle, accelerator pedal, brake force), as well as the level of activation and influence of accident avoidance systems, and further relevant vehicle data at the time of the collision, without linking it to any data facilitating the identification of a

vehicle other than its make, type, variant and version and specific fitted optional equipment. Although studies show a range of **reductions in accidents** when fitted⁶⁰, the addition of **this device would actually make the effectiveness of most of the above vehicle safety systems measurable**, i.e. a key element of setting objectives. The relevant data for the purpose of in depth accident analysis should be made available in a considerably more accurate, consistent and barrier-free way.

- Action to be considered: **mandatory application of event (accident) data recorder**

Extension of existing measures:

Occupants protection in frontal crashes is currently regulated in the EU through a **frontal impact off-set crash** test that was introduced within the EU in 1996⁶¹, subsequently harmonised on UNECE level⁶² and amended several times to account for technical progress. The relevant vehicle safety measure is **UNECE regulation No 94**⁶³.

As described in section 2.4, heavy passenger cars and all light commercial vehicles are fully exempted from the frontal crash testing (as introduced in 1996), based on low market availability, difficulties to comply and potential compatibility mismatch that may have been applicable at the time. Presently, the exemption of these vehicles is no longer justified or desirable.

- Action to be considered: **add heavy passenger vehicles (e.g. SUVs) and all light commercial vehicles to the scope of the mandatory frontal off-set crash tests**

Further benefits are foreseen in the field of occupant protection in frontal crashes when a **new type of crash test** is added to the above that focuses starkly on **improving restraint systems** (i.e. airbag and safety-belt combinations) to encourage adaptive restraints protecting a broader demography of occupants (e.g. small females and elderly) than the current test achieves. The test protocol already exists on UNECE level, but the specific objective would further benefit from a specific revision to enhance that protocol. The relevant vehicle safety measure is **UNECE regulation No 137**⁶⁴

- Action to be considered: **mandatory application of full overlap frontal crash that focusses on restraint system (i.e. safety belt and airbag system) performance.**

Finally, a note for information. **Safety belt reminder system** for the front seats in all motor-vehicles and also on the rear seats in passenger cars and vans have in an early stage of the preparatory work also been identified as a cost-effective safety measure. This was also the case for **improved rear underrun protection device** on trucks, removal of exemptions for **lateral protection devices** on Special Purpose trucks, as well as **fire prevention** measures on

⁶⁰ https://ec.europa.eu/transport/sites/transport/files/docs/study_edr_2014.pdf

⁶¹ Directive 96/79/EC

⁶² Council Decision of 27 November 1997 with a view to accession by the European Community to the Agreement of the United Nations Economic Commission for Europe concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted to and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions ('Revised 1958 Agreement') (OJ L 346, 17.12.1997, p. 78) as last updated by Council Decision (EU) 2016/1790 of 12 February 2016 on the conclusion of Revision 3 of the Agreement of the United Nations Economic Commission for Europe concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or used on wheeled vehicles and the conditions for the reciprocal recognition of approvals granted on the basis of these prescriptions ('Revised 1958 Agreement') (OJ L 274, 11.10.2016, p. 2)

⁶³ OJ L 254, 20.9.2012, p. 77

⁶⁴ Not yet published

buses. These matters have in the meantime all been adequately addressed in the context of technological progress in the respective UNECE regulations and will thus become obligatory in accordance with the transitional provisions in those regulations.

1.1.3. Side impact occurrences

This is currently regulated in the EU through a **side impact crash** test that was introduced in 1996⁶⁵ on EU level, that was subsequently harmonised on UNECE level, and that has been amended several times to account for technical progress. The relevant vehicle safety measure is **UNECE regulation No 95**⁶⁶.

As described in section 2.3, certain vehicles with ‘high’ seating positions are currently exempted from the side crash testing as introduced in 1996, that causes other safety criteria that are normally also checked in this test to be omitted as well. In line with the clarification provided for frontal impact off-set crash, the exemption of these vehicles is no longer justified or desirable.

- Action to be considered: **add vehicles with a high seating position (e.g. SUVs and vans) to the scope of the mandatory side impact crash tests**

Additional benefits are foreseen in the field of occupant protection in side impact crashes when a **new type of side impact crash test** is added to the above that focuses on a vehicle side collision with a rigid narrow pole (i.e. **pole side impact** when skidding off the road) to demand a much better protection in the head strike area of the occupants with interior parts of the vehicle (e.g. side curtain airbag protection). The vehicle safety measure already exists, namely in the form of **UNECE regulation No 135**⁶⁷

- Action to be considered: **mandatory application of pole side impact crash test**

Review of further new vehicle safety measures and opportunities having a significant potential to address side impacts:

- **Autonomous emergency braking for driving and still-standing vehicles ahead**
- **Alcohol interlock installation facilitation**
- **Drowsiness and attention detection**
- **Distraction recognition**
- **Intelligent speed assistance**
- **Tyre pressure monitoring system**
- **Event (accident) data recorder**

1.1.4. Rear impact occurrences

There are no measures currently at our disposal that should be amended to reach this specific sub-objective, nor are there proposed new vehicle safety measures that are specifically and exclusively geared towards it. The only existing legislation that regulates rear impacts revolves around head restraint performance in UNECE regulation No 17⁶⁸ to mitigate the effects on occupants in terms of whiplash protection. However, this regulation is subject to adaptations to technical progress in the context of ongoing regulatory work under UNECE

⁶⁵ Directive 96/27/EC

⁶⁶ OJ L 183, 10.7.2015, p. 91

⁶⁷ Not yet published

⁶⁸ OJ L 230, 31.8.2010, p. 81

and the beneficial effects thereof are therefore incorporated into the baseline scenario in which no specific additional EU regulatory actions are taken.

On the other hand, **UNECE regulation No 34**⁶⁹ on fire risks, fuel tanks and rear impact protection, applies on an obligatory basis in the EU. Again, this legislation suffers from the fact that specific exemptions apply which has the detrimental effect that those vehicles are not tested in terms of post-crash protection against fire risks. It is also explicitly necessary to accelerate the work on including protection against electric shock in the regulation, as has been done for all other vehicle crash legislation on UNECE level, as that is currently not yet the case for this regulation. This is particularly important given that (hybrid) electric vehicle propulsion battery packs are often located in the rear luggage compartment section of conventional vehicles.

- **Action to be considered: add the mandatory application for rear impact testing and also address post-crash electric safety**

Review of further new vehicle safety measures and opportunities having a significant potential to address rear impacts:

- **Autonomous emergency braking for driving and still-standing vehicles ahead**
- **Alcohol interlock installation facilitation**
- **Drowsiness and attention detection**
- **Distraction recognition**
- **Emergency stop signal**
- **Intelligent speed assistance**
- **Tyre pressure monitoring system**
- **Event (accident) data recorder**

1.15. Measures to completely avoid accidents, to reduce the overall severity of accidents or to mitigate the outcome of injuries that result from impacts between vehicles and pedestrians and cyclists

1.1.5. Pedestrian and cyclist protection when hit by front-of-vehicle

This specific aspect is currently regulated for LDV through **Regulation (EC) No 78/2009** of the European Parliament and of the Council on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users, along with its implementing measures. More recently these requirements have been harmonised on UNECE level, with some adaptation to technical progress, under **UNECE regulation No 127**⁷⁰.

The EU legislation, and rather preferably also the UNECE legislation in order to **facilitate future simplification**, should be revised to **enlarge the current head impact zone** as supported by *EU accident data*, to achieve that the **risk of severe head injuries of pedestrians and cyclists is reduced** by means of improved energy absorbing measures integrated in a bigger overall head contact zone, notably including the front windscreen area between the A-pillars.

- **Action to be considered: adding head impact area covering the windscreen area of motor-vehicles**

⁶⁹ OJ L 231, 26.8.2016, p. 41

⁷⁰ Not yet published

This Impact Assessment also reviews possible new vehicle safety measures addressing front-of-vehicle collisions with vulnerable road users. Several of these measures revolve around an active intervention by vehicle systems or a general aim to either avoid collisions with vulnerable road users altogether or to mitigate accident outcome in terms of vulnerable road user injury levels. Other measures have the potential to reduce the overall risk of a collision.

Autonomous emergency braking for pedestrians and cyclists is a **new vehicle safety measure** that combines sensing of vulnerable road users ahead of the vehicle with the automatic activation of the brakes (without driver input) in order to completely **stop the vehicle before the collision occurs or to reduce the impact speed**.

- Action to be considered: **mandatory application of autonomous emergency braking for pedestrians and cyclists**

It is noted that while autonomous emergency braking (for vehicles ahead) is already compulsory on buses and trucks, the relevant implementing legislation should be adapted to technical progress by adding pedestrian and cyclist detection capability as well.

Vulnerable road user detection and warning on front (and side) of vehicle is a **new vehicle safety measure** that uses sensing detection or camera monitor solutions to specifically draw the attention of the driver if necessary and to clearly indicate the presence and the location of a vulnerable road user in or about to be in the vehicle path where a collision is likely to occur if the driver does not take any countermeasures. According to *EU accident* data, the system should in particular indicate the presence of a pedestrian, and to some extent cyclists, either visible or invisible to the driver when crossing the motor-vehicle relatively close to its front edge when the vehicle is about to take-off, **for instance for a truck stopped at a zebra crossing**. This measure is aimed to **avoid collisions with persons**, but without active intervention by the system itself.

- Action to be considered: **mandatory application of vulnerable road user detection and warning on front (and side) of vehicle**

Vulnerable road user improved direct vision from driver's position is a **new vehicle safety measure** geared towards enlarging the field of vision of drivers in bus and truck cabs. Assuming that the driver is aware of the presence of a **vulnerable road user in front of the vehicle**, or his or her attention has been drawn to that fact, the effectiveness relies on the direct visual confirmation by the driver that can take the appropriate counter measures to **avoid a collision with the person**.

- Action to be considered: **mandatory application of vulnerable road user improved direct vision from driver's position**

In line with section 5.1.1. the following are further new vehicle safety measures for review that also has a significant potential to completely avoid front-of-vehicle collisions with a pedestrian or cyclist or to mitigate injury outcome. Other measures have the potential to reduce the overall risk of a front-of-vehicle collision with a vulnerable road user or to help measure advanced safety system effectiveness:

- **Alcohol interlock installation facilitation**
- **Drowsiness and attention detection**
- **Distraction recognition**
- **Intelligent speed assistance**
- **Lane keeping assist**
- **Event (accident) data recorder**

1.1.6. Pedestrian and cyclist protection when hit by side-of-vehicle

There are no measures currently at our disposal that should be amended to reach this specific sub-objective.

Review of possible new vehicle safety measures addressing side-of-vehicle collisions with vulnerable road users:

Vulnerable road user detection and warning on (front and) side of vehicle is a **new vehicle safety measure**, as described in chapter 5.2. *EU accident data* in this case supports that cyclists, and to some extent pedestrians, should be detected at the side of the vehicle when it is making a turn towards the driver's far-side and a collision is about to occur, **for instance a cyclist riding along the side of a truck in the blind spot**. This measure is aimed to **avoid collisions with persons**, but without active intervention by the system itself.

- Action to be considered: **mandatory application of vulnerable road user detection and warning on (front and) side of vehicle**

Vulnerable road user improved direct vision from driver's position is a **new vehicle safety measure**, as described in chapter 5.2. for the presence of a **vulnerable road user on the side of the vehicle**, or his or her attention has been drawn to that fact, the effectiveness relies on the direct visual confirmation by the driver that can take the appropriate counter measures to **avoid a collision with the person**.

- Action to be considered: **mandatory application of vulnerable road user improved direct vision from driver's position**

Review of further new vehicle safety measures and opportunities having a significant potential to address side-of-vehicle collisions with vulnerable road users:

- **Alcohol interlock installation facilitation**
- **Drowsiness and attention detection**
- **Distraction recognition**
- **Intelligent speed assistance**

1.1.7. Pedestrian and cyclist protection when hit by rear-of-vehicle

There are no measures currently at our disposal that should be amended to reach this specific sub-objective.

Review of possible new vehicle safety measures addressing rear-of-vehicle collisions with vulnerable road users:

Reversing camera or detection system is a **new vehicle safety measure** that uses camera monitor or sensing systems that should increase the view of drivers or otherwise warn them of persons behind reversing vehicles. Particularly vulnerable in this context are short, crouching or slow moving people, such as the elderly and children. The system should in particular **indicate presence of a vulnerable road user**, either (indirectly) visible or invisible to the driver **when reversing**, but without active intervention by the system itself.

Review of further new vehicle safety measures and opportunities having a significant potential to address rear-of-vehicle collisions with vulnerable road users:

- **Alcohol interlock installation facilitation**
- **Event (accident) data recorder**

1.16. Policy option “Baseline”

This is the option whereby the **EU would not undertake any new action**.

In line with the standards of the Commission, it is assumed that no actions other than those already initiated would take place, including the adaptation to technical progress of measures currently in force, as is common practise today. The baseline scenario also takes into account the dispersed voluntary uptake of available safety technologies by vehicle manufacturers, for instance with the aim to obtain favourable reviews and ratings in new car assessment programs such as Euro NCAP.

It is understood that the baseline scenario provides for a wide range between pessimistic and optimistic outlooks. In this initiative however, we have adopted a conservative approach by selecting the medium effectiveness in assuming that the other sectors, for different political reasons, will take initiatives to improve road safety at local, national and Union level where this could be applicable.

1.17. Policy options “Regulatory approach” to prevent road accidents or to mitigate the outcome of accidents

Based on the preparatory work carried out to support the Report on “Saving lives: Boosting Car Safety in the EU”, and in particular the consideration of the initial and subsequent in depth cost-benefit indicators, a comprehensive list of proposed vehicle safety measures is considered for implementation (Table 1). The elimination of exemptions that currently exist for front, side and rear impact should be considered as well. Note that trailers and semi-trailers of categories O₃ and O₄ are to be considered as part of the overall motor-vehicle combination according to *EU accident data* and that no further distinction is made.

Table 1: List of all new safety measures considered for mandatory implementation that can be integrated into the indicated vehicle categories

Measure	Description	Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead	M ₁	N ₁		
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	M ₁	N ₁		
ALC	Alcohol interlock installation facilitation	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
DDR-DAD	Drowsiness and attention detection	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
DDR-ADR	Distraction recognition	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
EDR	Event (accident) data recorder	M ₁	N ₁		
ESS	Emergency stop signal	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
FFW-137	Full-width frontal occupant protection crash test	M ₁	N ₁		
FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints	M ₁	N ₁		
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)	M ₁	N ₁		
ISA-VOL	Intelligent speed assistance (through non-intrusive haptic feedback)	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	M ₁	N ₁		
PSI	Pole side impact occupant protection	M ₁	N ₁		
REV	Reversing camera or detection system	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
TPM	Tyre pressure monitoring system		N ₁	M ₂ & M ₃	N ₂ & N ₃
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle			M ₂ & M ₃	N ₂ & N ₃
VIS-DIV	Vulnerable road user improved direct vision from driver’s position			M ₂ & M ₃	N ₂ & N ₃

The cost-effectiveness analysis also specifically takes into account existing mandatory measures and, in particular those that are still dispersing into the fleet. These will continue to contribute to casualty reductions in the real world in the future and, thus, effectively reduce the target populations for some of the proposed measures (see Table 2).

Table 2: List of existing mandatory safety measures still dispersing into the fleet

Measure	Description	Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
AEB-VEH	Autonomous emergency braking for vehicles			M ₂ & M ₃	N ₂ & N ₃
ESC	Electronic stability control	M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
LDW	Lane departure warning			M ₂ & M ₃	N ₂ & N ₃
TPM	Tyre pressure monitoring system	M ₁			

Three policy options to be taken into consideration for the cost-benefit analysis have been defined. These policy options reflect a specific **selection of new safety measures to be implemented for a given vehicle category on a mandatory basis, as established for all vehicle categories**. The options are distinguished primarily by the level of ambition. They are separated on the following basis:

- First, by containing a set of state-of-the art measures that that can already be found on 5% to 90% of all new cars sold today depending on the technology and the vehicle category;
- Second, by, in addition, containing safety measures that are somewhat less frequently fitted to current vehicle models and that may require a longer development lead-time for the other vehicle models to be also enabled; and
- Third, by considering the above plus maximising the overall casualty savings spread over all vehicle categories, while also promoting innovation in terms of vehicle safety solutions designed to address driver behaviour in terms of modern-day distraction sources and lack of effort or inability to continuously check vehicle state or the surroundings.

1.1.8. Design of options and timeframe for implementation

The options distinguish in terms of ambition as well as efforts needed and technological readiness of safety features. The first option can be quickly and easily implemented by manufacturers. The second option requires more R&D effort and engineering solutions for a robust integration. The third option needs considerably more R&D effort and innovation.

In order to calculate the cost-benefits, the envisioned mandatory introduction date of each separate measure has been taken into account. These dates have a significant influence on the short and long term effectiveness. They have however been selected purely taking into account in particular the readiness of potential technical solutions in the marketplace, according to broad stakeholder input. Further such input was provided specifically linked to the anticipated relative burden to the vehicle industry and in particular the effort that is needed to further optimise the technical solutions as indicated by manufacturers and suppliers. For example, some technologies that have been chosen by manufacturers and suppliers to address a given safety issue, as recognised in the stakeholder dialogue, can benefit from a more robust performance for which more field-data and real-world experience is necessary. A longer lead-time will provide manufacturers appropriate additional time to achieve that. This also allows

them to investigate potential alternative solutions if that would be more appropriate. The dates that have finally been selected are fully in line with the agreed CARS21 principles⁷¹ as endorsed and promoted by the Commission. This has in particular also been a clear and firm request by the vehicle manufacturers in the context of the consultations and in their various position papers. Finally, in the context of the UNECE ‘Revised 1958 Agreement’, the dates are set to the 1st of September of a given year aligning with general implementation dates following the agreed principle for UNECE regulations⁷². This avoids the situation for manufacturers to introduce so-called ‘running changes’ in the production process but rather to anticipate on several vehicle changes in one single model year update, as is the industry practise.

The **mandatory introduction dates are grouped into three main timeframes**, where new vehicle types (i.e. entirely new vehicle models introduced on the EU market) will have to comply with the new requirements at a first stage, followed by all vehicles sold on the EU market, in particular those that were introduced on the market before the ‘new vehicle type’ date, at a second stage:

- From **1 September 2021** to 1 September 2023: This timeframe is applicable to the bulk of possible new vehicle safety features (in total **13 features**), which represent ‘add-on’ solutions that are already available on vehicles in the marketplace and will become standard equipment for all vehicles.
- From **1 September 2023** to 1 September 2025: This timeframe concerns **3 features**, for which still a significant effort of further development and evaluation is needed beyond the start date of the first timeframe in order to ensure that technical solutions can deliver the expected effectiveness.
- From **1 September 2025**: This longer timeframe is provided only for **1 feature**, namely the improved direct vision from driver's position for HDVs, which will require significant investment, re-design and changes of the cabins. The mandatory compliance date for new vehicle types remains open to avoid disproportionate and not cost-effective phase-out complications for vehicle manufacturers.

1.1.9. Policy option 1: Generalisation of mature and widely available safety features

State-of-the-art and widely available package of safety measure solutions that are not yet mandatory in the EU and their fitment varies from around 5 to 90% on newly sold vehicles at present (see Table 3) as well as the elimination of the exemptions linked to SUVs and vans.

Table 3: List of mandatory safety measures in PO1

Measure	Description	Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
		M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead	9/2021	9/2021		
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	-	-		
ALC	Alcohol interlock installation facilitation	9/2021	9/2021	9/2021	9/2021
DDR-DAD	Drowsiness and attention detection	-	-	-	-
DDR-ADR	Distraction recognition	-	-	-	-
EDR	Event (accident) data recorder	9/2021	9/2021		

⁷¹ <http://ec.europa.eu/DocsRoom/documents/1891/attachments/1/translations/en/renditions/pdf>

⁷² <https://www.unece.org/fileadmin/DAM/trans/doc/2016/wp29/WP29-169-11.pdf> - Transitional Provisions

ESS	Emergency stop signal	9/2021	9/2021	9/2021	9/2021
FFW-137	Full-width frontal occupant protection crash test	9/2021	-		
FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints	-	-		
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)	-	-		
ISA-VOL	Intelligent speed assistance (through non-intrusive haptic feedback)	-	-	-	-
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	9/2021	9/2021		
PSI	Pole side impact occupant protection	9/2021	-		
REV	Reversing camera or detection system	-	-	-	-
TPM	Tyre pressure monitoring system		-	-	-
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle			-	-
VIS-DIV	Vulnerable road user improved direct vision from driver's position			-	-
Benefit-to-cost ratio		2.95	1.78	4.64	0.56
Total cost per vehicle		€ 201	€ 131	€ 6	€ 6
Fatalities prevented		13 785	852	2	0
Severe injuries prevented		63 493	4 074	33	47
Slight injuries prevented		276 815	11 208	113	157

1.1.10. Policy option 2: Introducing widely available and less commonly available safety features as standard equipment

In addition to PO1, this option includes features that are currently also available and fitted to the vehicle fleet, but which are less common and need more time to fully mature for all vehicle categories and market segments. It also contains measures ensuring driver attention to the driving task and with an overall view on cost effectiveness (see Table 4).

Table 4: List of mandatory safety measures in PO2

Measure	Description	Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
		M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead	9/2021	9/2021		
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	9/2023	9/2023		
ALC	Alcohol interlock installation facilitation	9/2021	9/2021	9/2021	9/2021
DDR-DAD	Drowsiness and attention detection	9/2021	9/2021	9/2021	9/2021
DDR-ADR	Distraction recognition	-	-	-	-
EDR	Event (accident) data recorder	9/2021	9/2021		
ESS	Emergency stop signal	9/2021	9/2021	9/2021	9/2021
FFW-137	Full-width frontal occupant protection crash test	9/2021	-		
FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints	9/2021	-		
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)	9/2023	9/2023		
ISA-VOL	Intelligent speed assistance (through non-intrusive haptic feedback)	9/2021	-	9/2021	9/2021
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	9/2021	9/2021		
PSI	Pole side impact occupant protection	9/2021	-		
REV	Reversing camera or detection system	-	-	-	-
TPM	Tyre pressure monitoring system		-	-	-
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle			9/2021	9/2021

VIS-DIV	Vulnerable road user improved direct vision from driver's position			9/2025	9/2025
	Benefit-to-cost ratio	2.14	1.35	3.11	1.52
	Total cost per vehicle	€ 360	€ 206	€ 607	€ 607
	Fatalities prevented	20 081	1 005	207	1 658
	Severe injuries prevented	107 913	5 068	2 064	3 888
	Slight injuries prevented	389 756	15 536	6 421	9 849

1.1.11. Policy option 3: Introduction of a full set of safety features boosting innovation

As PO2, plus additional safety solutions that are feasible and already exist in the marketplace, but that have a low fitment rate and market uptake. However, they would maximise the overall casualty savings in the EU and have the potential to boost safety solution innovation in the key automotive sector (see Table 5).

Table 5: List of mandatory safety measures in PO3

Measure	Description	Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
		M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead	9/2021	9/2021		
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	9/2023	9/2023		
ALC	Alcohol interlock installation facilitation	9/2021	9/2021	9/2021	9/2021
DDR-DAD	Drowsiness and attention detection	9/2021	9/2021	9/2021	9/2021
DDR-ADR	Distraction recognition	9/2023	9/2023	9/2023	9/2023
EDR	Event (accident) data recorder	9/2021	9/2021		
ESS	Emergency stop signal	9/2021	9/2021	9/2021	9/2021
FFW-137	Full-width frontal occupant protection crash test	9/2021	9/2021		
FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints	9/2021	9/2021		
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)	9/2023	9/2023		
ISA-VOL	Intelligent speed assistance (through non-intrusive haptic feedback)	9/2021	9/2021	9/2021	9/2021
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	9/2021	9/2021		
PSI	Pole side impact occupant protection	9/2021	9/2021		
REV	Reversing camera or detection system	9/2021	9/2021	9/2021	9/2021
TPM	Tyre pressure monitoring system		9/2021	9/2021	9/2021
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle			9/2021	9/2021
VIS-DIV	Vulnerable road user improved direct vision from driver's position			9/2025	9/2025
	Benefit-to-cost ratio	1.39	0.53	2.11	1.03
	Total cost per vehicle	€ 516	€ 521	€ 970	€ 1,013
	Fatalities prevented	21 337	1 283	227	1 947
	Severe injuries prevented	126 390	6 917	2 410	5 023
	Slight injuries prevented	470 747	23 486	8 174	13 274

1.18. Options discarded at an early stage

1.1.12. Policy option “Self-regulation”

This would concern the possibility of using an **industry self-commitment** to increase the vehicle safety in terms of occupant protection as well as protection of pedestrians and cyclists in the event of an accident, and potential other vehicle safety areas.

Self-regulation and commitment by the vehicle industry, agreed by a specific number of manufacturers covering a certain percentage of the EU vehicle market, to increase vehicle safety in terms of occupant protection in front, side and rear impacts. In this case, industry would commit to meeting certain to-be-agreed performance requirements that could be taken from various sources such as SAE⁷³, ISO⁷⁴ or new car assessment programmes, e.g. in the EU or U.S.⁷⁵

This option has been discarded for the following reasons. First this would require, for achieving tangible results, to involve a large number of European and foreign manufacturers with no guarantee to cover all categories of vehicles. Second, there is no political support for this approach from the European Parliament and Member States and it is also clearly not supported by the majority of respondents and stakeholders in the public consultation that requested an opinion on this matter specifically. Third, a previous attempt to self-regulate the inclusion of safety features (energy absorbing bonnets and bumpers) failed in 2001⁷⁶.

6. WHAT ARE THE IMPACTS OF THE DIFFERENT POLICY OPTIONS AND WHO WILL BE AFFECTED?

Given the various three options under consideration pursue the same logic, i.e. addition of advanced safety features, and only differ by their intensity (number of features added), the analysis of impacts does not necessarily discriminate between the three options.

1.19. Social impact

In terms of the various policy options, traffic accidents still affect hundred thousands of citizens and their families. The social cost of, for instance, rehabilitation, healthcare, death, material damages, *etc.*, due to road casualties is estimated to be at least in the order of EUR 100 billion per year as also quantified in section 2. The expected reduction in the number of road fatalities, severe injuries and slight injuries will therefore have a positive impact on social costs.

So far, advanced safety features have mainly been incorporated in the high-end car segment. Thus, mainly people with high incomes could benefit from such measures. The compulsory addition of advanced safety features on cars will contribute to distribute more evenly the benefits from these features among EU citizens, regardless of income considerations.

In this context, there have been repeated requests from the European Parliament for resolute and determined action by the Commission, as well as Member States calling for the Commission to act, adhering to a strict regulatory approach.

⁷³ <http://topics.sae.org/safety/standards/automotive/>

⁷⁴ <https://www.iso.org/search/x/query/vehicle%2520safety>

⁷⁵ <http://www.iihs.org/>

⁷⁶ Commission Communication (COM(2001)389final) concerning the voluntary agreement on safer cars fronts with the European car Industry (ACEA^o)

Some concerns have however been expressed regarding the impact of the introduction of Event Data Recorders on privacy of data. One of the stakeholders (FIA) even suggested carrying out an impact study before taking further steps. The intention is that data contained in the Event Data Recorders should not be linked to the vehicle identification number or chassis number and thus should allow for anonymised treatment of the information.

Some literature suggests that policy intervention such as introduction of compulsory new safety measures could encourage reckless driving behaviour due to additional sense of security, although the views are generally not substantiated. Respondents to the public consultation however have not raised this as a potential issue for this initiative or the specific vehicle safety measures as foreseen.

1.20. Environmental impact

The current initiative is also expected to have positive environmental impacts. Throughout the stakeholder consultations no evidence was brought forward that alluded to any vehicle mass increase because of the addition of proposed vehicle safety measures that would be of such significance that it would have a negative environmental impact. Rather on the contrary, some of the proposed technologies can help contribute to the reduction of CO₂ emissions and therefore to comply with the EU targets on climate action and to the objectives of the Energy Union. For instance, tyre pressure monitoring affects the wear rate of the tyre as well as the stability and braking performance of the vehicle increasing its safety on the road. However, proper tyre pressure also reduces rolling resistance and thus saves fuel and reduces CO₂ emissions, with a relative effect estimated from -0.12% to -0.43% depending on vehicle category⁷⁷. The impact on CO₂ was emphasized also during public consultation: “CLEPA supports further implementation of the tyre pressure monitoring system technical requirements which enable also efficient contribution to the reduction of fuel consumption and CO₂ emissions.”

In addition, fuel savings and CO₂ emissions reduction in the range of 1% to 9% depending on road type resulting from even a slight reduction of average vehicle speed, may be attributable to intelligent speed assistance (ISA) systems⁷⁸. Further benefits were identified in the form of potential reduction of overall journey time or idling time, due to motorway speed management potential and traffic incident reductions.

Finally each accident prevented reduces waste due to scrapping damaged cars/parts and replacing with new ones (e.g. in the NL car damage cost was estimated at between EUR 2,000 and EUR 4,000)⁷⁹.

1.21. Economic impact

Generally, there will be additional cost associated with mandating new vehicle safety features. This is due to the fact that new content, materials and equipment is likely to be added to each vehicle and should be taken into account. Furthermore, engineering, development, validation and type-approval certification costs of the vehicle safety features are also applicable and add to the overall cost as well. In principle this will entail an increasing cost of vehicles for the public.

⁷⁷ https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/tno_2013_final_report_en.pdf

⁷⁸ https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/ldv_speed_control_devices_en.pdf

⁷⁹ The cost of road crashes in the Netherlands. 2016. Page 80.

<https://www.government.nl/documents/reports/2016/11/16/the-cost-of-road-crashes-in-the-netherlands>

It is worth mentioning however that in the public consultation most of the respondents do not expect the introduction of the new safety features to lead to a price increase. Instead it is expected that safety features will become cheaper anyway and that car insurance will decrease as well. This view is largely supported by price change analysis that has been carried out in relation to other new vehicle requirements (see section 6.3.3).

As far as SMEs are concerned, no major impacts are to be expected, also with reference to the analysis in terms of purchase price.

At the level of car manufacturers, most companies are large companies. The number of SMEs is extremely limited. They either produce small-series or are considered ultra-small volume manufacturers. In the course of the stakeholder consultation events and in the public consultation phase, they have clearly expressed their concerns indicating that new measures could bring significant cost due to engineering complexity or lack of access to on-the-shelf technology as is the case for large manufacturers. The cost of in-house development is not likely to be off-set because of limited vehicle production numbers, while the impact on safety of these vehicles is negligible in the overall vehicle fleet. These issues can already be addressed through the existing legislative framework that indeed already contains specific provisions for small series manufacturers⁸⁰.

At the level of suppliers, over 3000 SMEs are in one way or another involved in the supply chain and likely to benefit from additional demand⁸¹. This is also expected to be the case for SMEs involved in e.g. knowledge based engineering services, testing and validation.

In terms of concrete costs associated to specific mandatory vehicle safety features, whether the end-consumer will indeed see a vehicle price increase or not, the policy options are each studied for their cost-effectiveness compared to a baseline scenario, where none of the measures are implemented on a mandatory basis, but voluntary uptake would continue (i.e. Policy option “Baseline”). The reported cost-effectiveness results reflect a comparison between each policy option with the baseline, i.e. capture only the costs and benefits that exceed those estimated for the voluntary fitment scenario.

In terms of the remaining options, the evaluation period was chosen to extend to 2037 in order to capture the effects of dispersion of the new safety measures into the vehicle fleet via fitment to new vehicles. Results are calculated for individual years, converted to present values and summed for the study period extending from 2021 to 2037.

1.1.13. Costs

For each proposed new vehicle safety measure, a ‘per vehicle’ cost was established as provided in detail in section 5.4. This accounts for single one-off costs and ongoing production costs, all of which were estimated to be incurred by the vehicle manufacturer from the time of mandatory introduction. The following costs have been included:

- Substantive compliance costs incurred by the vehicle manufacturers, including fixed and variable costs of manufacturing and assembly, and overheads for research and development; and
- Regulatory charges and administrative costs, when distributed over all new vehicles produced in a year, represent only a small proportion of the ‘per vehicle’ cost.

⁸⁰ Articles 22 and 23 of Framework Directive 2007/46/EC

⁸¹ https://clepa.eu/wp-content/uploads/2017/09/CLEPA-Members_catalogue.pdf

The total costs for the manufacturer per individual vehicle at mandatory introduction of proposed measures are assumed to go down due to e.g. economies of scale and improved productivity. The breakdown of costs per measure is available in Tables 76 to 79 of Annex 4.8.7.

Non-quantified costs, notably enforcement costs, are incurred by public authorities linked to the implementation of legislation and particularly in the development of type-approval requirements. These activities are supported by the automotive industry and so the cost burden is shared, to some extent. However, the part attributable to the public authorities and the costs incurred by the vehicle manufacturers developing the regulations are considered to be negligible compared to the overall cost of complying with the policy options.

Further non-quantified indirect costs, through potential vehicle retail price increases, have been considered. However, substantial increases due to the additional proposed new vehicle safety measures in the medium and long term are not expected. Vehicle manufacturers in the past have found strategies and practices to balance production costs and regulatory compliance for investments of a similar magnitude which did not translate to an increase in vehicle retail prices, for instance CO₂ emissions legislation (see section 6.3.3).

1.1.14. Benefits

The Direct regulatory benefits as modelled in the cost-benefit analysis consist of casualties avoided due to the intervention. Societal unit cost values for fatalities (€1 870 000), serious injuries (€243 100) and slight injuries (€18 700) were assigned per casualty prevented or mitigated.

The casualty simulation model that has been used to determine the benefits summarised the safety measures in three main groups that allowed to take into account their interactions, in order to avoid double-counting of casualties prevented (see also Figure 33 in Annex 4.4.8). These groups are:

- Assisting the driver with the driving task (permanent/ongoing collision mitigation)
- Active Safety (mitigation immediately pre-collision)
- Passive Safety (protection during collision)

The groups were modelled as three ‘layers’ **acting one after the other** on the overall casualty population, which allows a breakdown of the benefits per ‘layer’ based on the reduction of casualty numbers between them.

- The first layer determines mainly the proportion of **casualties that are prevented** by e.g. reducing speed, avoiding distraction
- The second layer subsequently determines the proportion of **casualties that are prevented** by in e.g. rear end collisions, pedestrian impact
- The third layer **mitigates accident outcome with a given effectiveness** in those that still will happen

Indirect benefits of the interventions which are not modelled, due to the complexity of quantifying, include the increased productivity due to reductions in congestion, improvements in air quality due to reduced vehicle emissions, reductions in emergency service requirements, possible reductions in car insurance premiums and the potential for harmonisation of technical requirements across world regions and between vehicle manufacturers. Their benefits have been considered but they are not quantified for this impact assessment. The effect of considering them would increase the benefit-to-cost ratios in favour of implementing the relevant policy options.

Also some of the measures included within the policy options are expected to provide for cost savings for police enforcement and other public road safety authorities, such as intelligent speed assistance, which will increase speed limit compliance without the need for stricter enforcement.

1.1.15. Impact of additional safety measures on vehicle prices and sales prices

This section makes predictions of future new vehicle sales numbers and fleet growth based on extrapolation of historic trends. It is important, in this context, to analyse whether the cost of the additional safety measures to the vehicle manufacturers would be likely to result in a substantial increase in end-user vehicle prices and thereby negatively affect new vehicle sales price. If this was the case, slower dispersion of the safety measures into the fleet might partially diminish the safety returns, which should then be reflected in the cost-benefit calculation model.

The costs calculated in this study for fitment of the proposed safety measures are to be understood to reflect the costs to the vehicle manufacturers. The full set of proposed safety measures, as reflected in all relevant PO3s, is estimated to create additional costs in the region of € 516 per passenger car (M₁), € 521 per light commercial vehicle (N₁), € 970 per bus (M₂ and M₃), and in the region of € 1 013 per truck (N₂ and N₃), respectively. These costs incurred by the vehicle manufacturers are not expected to be entirely translated into a change in vehicle retail prices, because the markets for consumer, as well as commercial, vehicles are highly competitive which is prohibitive of allowing costs to be passed on directly, as can be observed in historic pricing data.

Up until 2011, Directorate-General for Competition published annually the ‘Report on car prices within the European Union’⁸². These reports provide the most comprehensive and detailed guide to the historic development of car prices in Europe year-on-year by collating list prices for cars (i.e. before any dealership discounts) and determining the car price development in real terms, i.e. adjusted for inflation. Table 6 shows the price development during the last decade of available data (2002 to 2011).

Table 6: Year-on-year change in real car prices for the last decade of available data

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Year-on-year price change	-0.2%	-0.7%	-1.9%	-1.5%	-1.6%	-1.0%	-3.2%	-3.1%	-0.6%	-2.5%
Note: 2012 and beyond - EU car price reports discontinued; no published data The source of the data is the “Report on car prices within the European Union – Technical annex, Years: 2002 to 2011”. The car price reports were discontinued after 2011 because the Commission did not find any significant competition shortcomings in the new cars sector.										

It can be seen that cars have become cheaper in real terms in every year of the last reported decade, despite this being a period in which technical development to meet new and more demanding emissions and safety standards increased, for example those listed in Annex 6.

The net effect of decrease in vehicle sales volumes will depend on two factors. The utility of safety to consumers and how consumers would react to any potential price increase. These effects are not homogenous across consumers. What the literature says is that demand increases more when safety increases in vehicles which are equipped with low safety standards (and vice-versa). At the same time, sensitivity to price increases (price elasticity) is

⁸² http://ec.europa.eu/competition/sectors/motor_vehicles/prices/report.html

higher for popular vehicle brands. Therefore, introduction of new safety measures could increase demand, especially of consumers planning to buy vehicles with lower initial standard safety measures, to the extent that this effect is not offset by a price increase. If the introduction of new measures pushes prices up, consumers of popular vehicle models with relatively low safety standards might instead buy on secondary market or continue using their old vehicles.

1.1.16. Competitiveness and drivers of innovation

The automotive industry, consisting of vehicle manufacturers (ACEA⁸³) as well as vehicle equipment suppliers (CLEPA⁸⁴), fully support a regulatory approach by the Commission. However it is also important to mention one of the stakeholders (MOBIVIA) has during the public consultation raised in detail the issue of competitiveness and called upon a quickly-adopted EU regulatory provision eventually requiring the introduction of an on-board application platform with an open access for all actors. Standardising the way that data is made available would help a fairer application of competition law.

The vehicle manufacturing industry has been categorised as a sector requiring global innovation, but retaining strong elements of regional production. Many EU based vehicle manufacturers are producing more of their products overseas for overseas markets, up to about 67% of total company sales⁸⁵. Still, a significant proportion of EU based car manufacturing, in the order of 30% to 40%, often in the luxury car segment, continues to be for export, and the EU has a large trade surplus in the sector. Hence the relative international competitiveness of EU based production remains a critical factor for the sector going forward. This can in particular be aided by the first mover advantage of EU automotive suppliers in the vehicle safety equipment market, the ability to set world standards by means of introduction of new EU vehicle safety legislation and its global harmonisation potential (e.g. through UNECE cooperation with non-EU Contracting Parties⁸⁶), the knock-on effect of increased safety reputation of EU vehicle brands and by allowing for economics of scale of vehicle safety equipment producers leading to lower unit cost and higher profit margins in markets where the safety technologies are fitted as for-purchase option.

For vehicle manufacturing the following main market dynamics megatrends have been identified. The shift in demand towards fast-growing emerging markets, tightening of environmental and energy efficiency standards, a greater urge for the integration of digital services, as well as changes in demographics and urban mobility, all likely to affect the automotive industry of the future. In this context, the EU has been a leader of automotive intellectual property and technology, however, this advantage is likely to decrease as emerging markets begin to develop increasingly sophisticated auto industries themselves. The EU should therefore aim to retain and increase its important competitive advantages relating to intangible factors, in particular the high innovation capacity of the EU vehicle industry, their supplier base and notably SMEs offering various relevant and crucial knowledge and skills based services in the sector. In particular, policy option “Regulatory approach” 3, to optimally achieve all sub-objectives, creates opportunities for the EU automotive industry in this context.

⁸³ <http://www.acea.be/publications/article/position-paper-general-safety-regulation-revision>

⁸⁴ <https://clepa.eu/mediaroom/clepa-position-paper-tyre-pressure-monitoring-systems-tpms-review-general-safety-regulation>

⁸⁵ https://ec.europa.eu/futurium/en/system/files/ged/13-_i24c-_report-understandingeusectorcompetitiveness_innewglobal_economy.pdf.

⁸⁶ <http://www.unece.org/fileadmin/DAM/trans/doc/2017/wp29grsg/GRSG-113-14e.pdf>,
<http://www.unece.org/fileadmin/DAM/trans/doc/2017/wp29grrf/GRRF-84-03e.pdf>

In the context of new vehicle safety measures that are considered for this initiative, it should be highlighted that many features offer a ‘basic’ safety capability, in other words, it works effectively when it has to. On the other hand the safety features make use of equipment such as sensors that may be used for a variety of other tasks that are geared towards driver assistance and comfort. This means that vehicle manufacturers have the opportunity to ‘up-sell’ highly desirable optional features such as adaptive cruise control and lane keeping assistance, indeed nearly autonomous driving functions. For these features the essential hardware will already be incorporated within the vehicle for the safety functions. The manufacturer can enable the more sophisticated use of automated driving features by simply reprogramming the control modules and the possible addition of a few buttons on a ‘multi-function steering wheel’ that is in turn also sold for an additional premium, thus without the basic initial costs and thus for a higher profit.

7. HOW DO THE OPTIONS COMPARE?

1.22. Effectiveness

Table 7: List of separated policy options per vehicle category cluster and benefit to cost ratios

	Benefit-Cost ratio		
	PO1	PO2	PO3
Passenger cars (M₁)	2.95	2.14	1.39
Vans (N₁)	1.78	1.35	0.53
Buses and coaches (M₂ & M₃)	4.64	3.11	2.11
Trucks (N₂ & N₃) and trailers	0.56	1.52	1.03

Based on present values over entire evaluation period 2021–2037 relative to the baseline scenario (best estimate with indication of uncertainty ranges from scenario analysis) with indication of uncertainty margin

1.1.17. Effectiveness in achieving the general objective

Table 8 to Table 11 provide a summary of the effectiveness of the policy options in achieving the general objective for each vehicle category cluster. The tables compare the total sum of casualties prevented by the vehicle safety measures across all vehicle categories over the evaluation period 2021 – 2037 across EU-28 compared to the baseline option.

It can be observed for all vehicle categories that the number of casualties prevented by implementation of PO2 or PO3 exceeds the number prevented by PO1 by a considerable margin. Between all four vehicle category clusters, implementation of PO2 has the potential to prevent an additional 8 312 fatalities and 51 286 serious casualties compared to PO1 across EU-28 over the period 2021 – 2037. PO3 exceeds the potential of PO2 by further 1 843 fatalities and 21 807 serious casualties.

Table 8: Comparison of the effectiveness of the policy options for passenger cars (M_1) in achieving the general objective relative to the baseline option

<i>Passenger cars (M_1)</i>	PO0	PO1	PO2	PO3
Fatal casualties prevented	0	13 785	20 081	21 337
Serious casualties prevented	0	63 493	107 913	126 390
Impact compared to baseline	n/a	+	++	++
Initial cost per vehicle	0	€ 201	€ 360	€ 516

Table 9: Comparison of the effectiveness of the policy options for light commercial vehicles (N_1) in achieving the general objective relative to the baseline option

Light commercial vehicles (N_1)	PO0	PO1	PO2	PO3
Fatal casualties prevented	0	852	1 005	1 283
Serious casualties prevented	0	4 074	5 068	6 917
Impact compared to baseline	n/a	+	++	++
Initial cost per vehicle	0	€ 131	€ 206	€ 521

Table 10: Comparison of the effectiveness of the policy options for medium and large buses (M_2 & M_3) in achieving the general objective relative to the baseline option

Medium and large buses (M_2 & M_3)	PO0	PO1	PO2	PO3
Fatal casualties prevented	0	2	207	227
Serious casualties prevented	0	33	2 064	2 410
Impact compared to baseline	n/a	≈	+	++
Initial cost per vehicle	0	€ 6	€ 607	€ 970

Table 11: Comparison of the effectiveness of the policy options for medium and heavy trucks (N_2 & N_3) in achieving the general objective relative to the baseline option

Medium and heavy trucks (N_2 & N_3)	PO0	PO1	PO2	PO3
Fatal casualties prevented	0	0	1 658	1 947
Serious casualties prevented	0	47	3 888	5 023
Impact compared to baseline	n/a	≈	+	++
Initial cost per vehicle	0	€ 6	€ 607	€ 1 013

1.1.18. Effectiveness in achieving the specific objectives

Table 12 to Table 15 summarize the effectiveness of the policy options in achieving the specific objectives for each vehicle category cluster. With regard to specific objective 1, it can be observed in general that PO1 is not effective for buses and trucks, and only moderately effective for passenger cars and light commercial vehicles. PO2 and in particular PO3 are considerably more effective. With regard to specific objective 2, PO2 and in particular PO3 are highly effective, whereas PO1 is not effective.

Table 12: Comparison of the effectiveness of the policy options for passenger cars (M_1) in achieving the specific objectives relative to the baseline option

<i>Passenger cars (M_1)</i>	Occupant protection in vehicles	Pedestrians and cyclists protection	Assessment
PO0	=	=	This is the baseline option.
PO1	+	≈	PO1 comprises seven measures primarily designed to protect vehicle occupants. The impact on pedestrians and cyclists is minimal.
PO2	++	++	PO2 contains additional active measures designed to address driver

			drowsiness and inattention and speeding, passive measures to protect vehicle occupants, and active (autonomous emergency braking) and passive measures (head impact protection) to protect pedestrians and cyclists. The additional pedestrian and cyclist casualties saved (fatal and serious) in relation to PO1 are considerable.
PO3	++	++	PO3 contains additional advanced measures against driver distraction and reversing accidents with pedestrians and cyclists. It prevents additional casualties in both groups, at the serious casualty level.

Table 13: Comparison of the effectiveness of the policy options for light commercial vehicles (N_1) in achieving the specific objectives relative to the baseline option

<i>Light commercial vehicles (N_1)</i>	Occupant protection in vehicles	Pedestrians and cyclists protection	Assessment
PO0	=	=	This is the baseline option.
PO1	+	≈	PO1 comprises five measures primarily designed to protect vehicle occupants. The impact on pedestrians and cyclists is minimal.
PO2	++	++	PO2 contains additional active measures designed to address driver drowsiness and inattention, and active (autonomous emergency braking) and passive measures (head impact protection) to protect pedestrians and cyclists. The additional pedestrian and cyclist casualties saved (fatal and serious) added to PO1 are considerable.
PO3	++	++	PO3 contains additional advanced active measures against driver distraction and speeding, passive measures to protect vehicle occupants, and measures to prevent reversing accidents with pedestrians & cyclists. It prevents additional casualties, in particular vehicle occupants at fatal and serious level.

Table 14: Comparison of the effectiveness of the policy options for medium and large buses (M_2 & M_3) in achieving the specific objectives relative to the baseline option

<i>Medium and large buses (M_2 & M_3)</i>	Occupant protection in vehicles	Pedestrians and cyclists protection	Assessment
PO0	=	=	This is the baseline option.
PO1	≈	≈	PO1 consists of only two measures. The impact on casualty numbers amongst both vehicle occupants and pedestrians and cyclists is minimal. This option is not expected to prevent fatalities.
PO2	+	++	PO2 contains additional measures designed to address driver drowsiness and inattention and speeding and also detection and visibility measures to protect pedestrians and cyclists. The additional casualties prevented added to PO1 are considerable.
PO3	++	++	PO3 contains additional measures for both casualty groups (occupants and pedestrians and cyclists) that are technologically more advanced and prevents further casualties, in particular seriously injured casualties.

Table 15: Comparison of the effectiveness of the policy options for medium and heavy trucks (N_2 & N_3) in achieving the specific objectives relative to the baseline option

<i>Medium and heavy trucks (N_2 & N_3)</i>	Occupant protection in vehicles	Pedestrians and cyclists protection	Assessment
PO0	=	=	This is the baseline option.
PO1	≈	≈	PO1 consists of only two measures. The impact on casualty numbers amongst both vehicle occupants and pedestrians and cyclists is minimal. This option is not expected to prevent fatalities.
PO2	+	++	PO2 contains additional measures designed to address driver drowsiness and inattention and speeding and also detection and visibility measures to protect pedestrians and cyclists. The

			additional casualties prevented added to PO1 are considerable.
PO3	++	++	PO3 contains additional measures for both casualty groups (occupants and pedestrians and cyclists) that are technologically more advanced and prevents further casualties, in particular seriously injured casualties.

1.23. Efficiency and proportionality

Table 16 to Table 19 present an overview comparing the efficiency and proportionality of the policy options based on the benefit-to-cost ratios (BCR) relative to the baseline option, over the evaluation period 2021 – 2037 for each vehicle category cluster. It can be observed that PO1 and PO2 generally offer favourable cost-effectiveness ratios, except for trucks where PO1 is not cost-effective. The total monetary benefit realised by PO2 is considerably higher compared to PO1 for all vehicle category clusters. Favourable cost-effectiveness ratios for PO3 were found for passenger cars and buses; a marginal value was found for PO3 for trucks. For light commercial vehicles, the costs for PO3 exceed the benefits by a large margin.

Table 16: Comparison of the monetary benefits and costs of the policy options for passenger cars (M₁) relative to the baseline option

<i>Passenger cars (M₁)</i>	PO0	PO1		PO2		PO3	
Present value benefit	€ 0	€ 37.5 bn		€ 57.4 bn		€ 64.1 bn	
Present value cost	€ 0	€ 12.7 bn		€ 26.9 bn		€ 46.0 bn	
BCR (best estimate)	n/a	2.95		2.14		1.39	
BCR (uncertainty range lower/upper)	n/a	2.28	3.31	1.58	2.69	1.01	1.85
Efficiency compared to baseline	n/a	++		++		+	

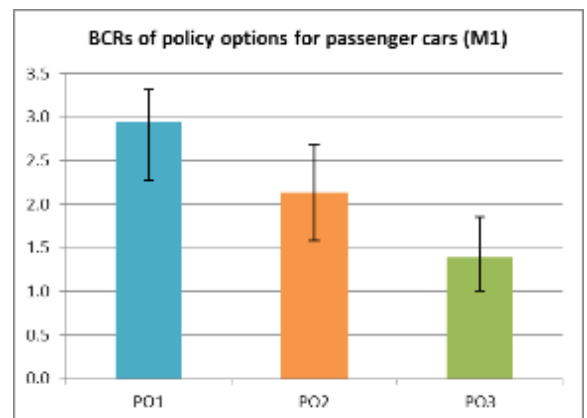


Table 17: Comparison of the monetary benefits and costs of the policy options for light commercial vehicles (N₁) relative to the baseline option

<i>Light commercial vehicles (N₁)</i>	PO0	PO1		PO2		PO3	
Present value benefit	€ 0	€ 2.3 bn		€ 2.8 bn		€ 3.7 bn	
Present value cost	€ 0	€ 1.3 bn		€ 2.0 bn		€ 6.9 bn	
BCR (best estimate)	n/a	1.78		1.35		0.53	
BCR (uncertainty range lower/upper)	n/a	1.39	1.83	0.98	1.51	0.39	0.65
Efficiency compared to baseline	n/a	++		+		--	

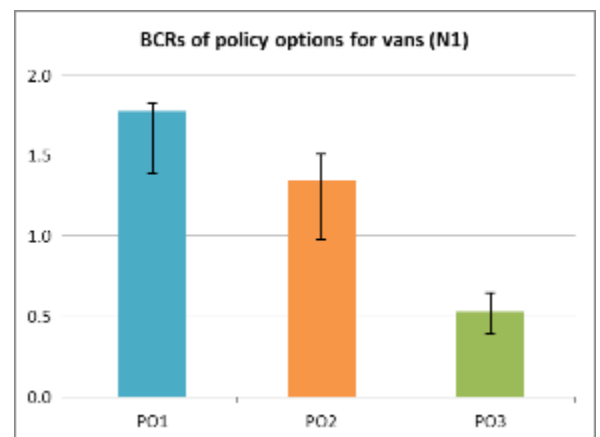


Table 18: Comparison of the monetary benefits and costs of the policy options for medium and large buses (M₂ & M₃) relative to the baseline option

<i>Medium and large buses (M₂ & M₃)</i>	PO0	PO1		PO2		PO3	
Present value benefit	€ 0	€ 11.2 mn		€ 813.7 mn		€ 937.0 mn	
Present value cost	€ 0	€ 2.4 mn		€ 262.0 mn		€ 444.5 mn	
BCR (best estimate)	n/a	4.64		3.11		2.11	
BCR (uncertainty range lower/upper)	n/a	3.17	14.32	1.91	4.42	1.46	2.56
Efficiency compared to baseline	n/a	++		++		+	

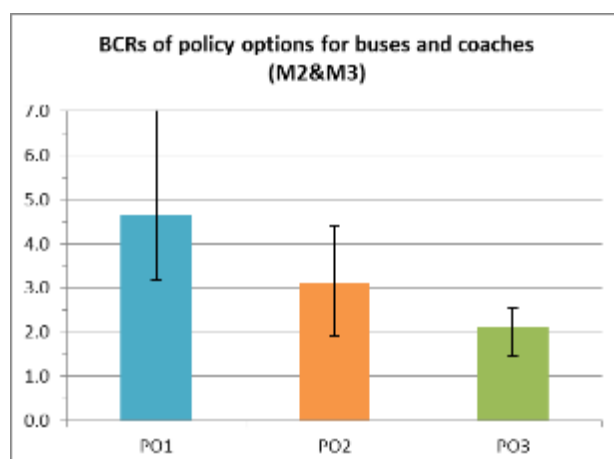
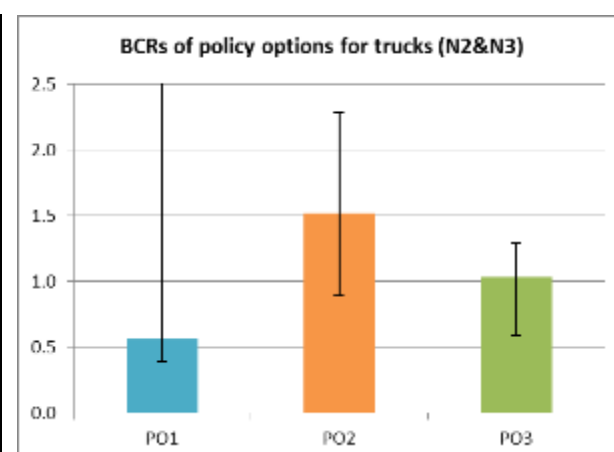


Table 19: Comparison of the monetary benefits and costs of the policy options for medium and heavy trucks (N₂ & N₃) relative to the baseline option

<i>Medium and heavy trucks (N₂ & N₃)</i>	PO0	PO1		PO2		PO3	
Present value benefit	€ 0	€ 0.01 bn		€3.4 bn		€4.1 bn	
Present value cost	€ 0	€ 0.02 bn		€2.2 bn		€4.0 bn	
BCR (best estimate)	n/a	0.56		1.52		1.03	
BCR (uncertainty range lower/upper)	n/a	0.39	2.93	0.89	2.28	0.59	1.29
Efficiency compared to baseline	n/a	--		+		≈	



1.24. Coherence

Road traffic safety is an EU priority⁸⁷. The proposed new vehicle safety measures serve to protect EU citizens from the loss of life and health caused by road traffic accidents. They should indeed be able to expect systematic and continuous road safety improvement, and in this particular case in vehicle safety improvement as well.

In principle everyone has the right to use roads and streets without threats to life or health. This includes access for everyone to equal, safe and sustainable mobility, with due attention for vulnerable road users, including the elderly and children.

As regards coherence in future forecast and baseline determination between different remits within the EU, e.g. road safety and vehicle safety, the best estimate provided for the general

⁸⁷ COM(2010) 389 final

future casualty trend depends on many unknown factors and potentially diverging views on the matter. The approach that has been opted for in terms of forecast is represented in a constant casualty number at all severity levels from 2016 onward, showing that the continued effects in all non-vehicle sectors are expected to offset the increase in traffic volume but not be strong enough to result in a net casualty reduction. The calculations to arrive at the casualty baseline were performed based on this general casualty trend and using detailed input values and calculation methods as described in Annex 4. The resulting casualty baseline reflects the effects of continued dispersion of existing mandatory vehicle safety measures with new vehicles into the legacy fleet and continued voluntary uptake of the safety measures under consideration, as well as the generally agreed contribution by improved infrastructure and e.g. tunnel safety.

Generally, road infrastructure and vehicle safety measures can be regarded as complementary (e.g. for measures like alcohol interlock installation facilitation, autonomous emergency braking for pedestrians and cyclists, distraction recognition, better follow-up of road safety management procedures etc.) although there are also some measures which are mutually reinforcing (e.g. visible road markings to support lane keeping assistance technologies). The baseline scenario assumes the application of the existing RISM Directive in line with the current legislation, as required by the Better Regulation principles. No further policy action is considered at the EU level in the baseline. Including additional road infrastructure safety measures in the baseline would result in lower numbers of fatalities and serious injuries. Consequently, the impact of vehicle safety policy options in terms of lives saved and serious injuries avoided may be slightly reduced when compared to such an alternative baseline. This is due to the overlapping effects between the impacts of the policies, in the same way as there is nearly always more than one factor in accident causation. The individual influence of each factor is virtually impossible to determine. In other words the combined effect of road infrastructure and vehicles safety measures deployed together, is going to be somewhat lower than the sum of their individual effects.

8. THE PREFERRED OPTION

The analysis of the policy options has been carried out for each of the four vehicle category clusters. This was done in order to transparently present the results of the impact assessment in terms of cost-effectiveness of the foreseen vehicle safety measures. Table 20 provides an overview that summarises the preferred option for each vehicle category.

Table 20: List of policy options and key performance indicators

Policy options and key performance indicators		Applicable vehicle categories			
		Passenger cars	Light commercial vehicles	Buses	Trucks and trailers
		M ₁	N ₁	M ₂ & M ₃	N ₂ & N ₃
PO1	Benefit-to-cost ratio	2.95	1.78	4.64	0.56
	Total cost per vehicle	€ 201	€ 131	€ 6	€ 6
	Fatalities prevented	13 785	852	2	0
	Severe injuries prevented	63 493	4 074	33	47
PO2	Benefit-to-cost ratio	2.14	1.35	3.11	1.52
	Total cost per vehicle	€ 360	€ 206	€ 607	€ 607
	Fatalities prevented	20 081	1 005	207	1 658
	Severe injuries prevented	107 913	5 068	2 064	3 888

PO3	Benefit-to-cost ratio	1.39	0.53	2.11	1.03
	Total cost per vehicle	€ 516	€ 521	€ 970	€ 1,013
	Fatalities prevented	21 337	1 283	227	1 947
	Severe injuries prevented	126 390	6 917	2 410	5 023

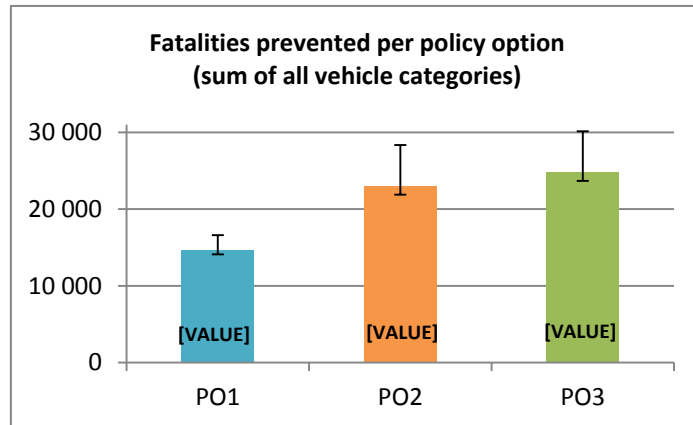


Figure 6: Fatal casualties prevented by PO1, PO2 and PO3 relative to the baseline option across all vehicle categories with indication of uncertainty margin over the evaluation period 2021 – 2037

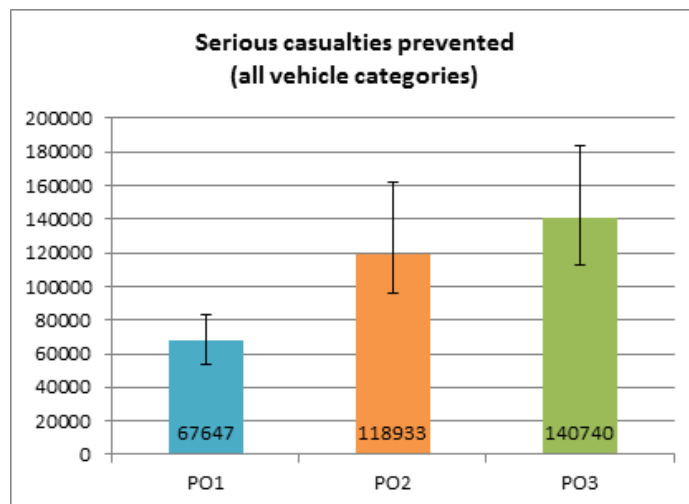


Figure 7: Severe injuries prevented by PO1, PO2 and PO3 relative to the baseline option across all vehicle categories with indication of uncertainty margin over the evaluation period 2021 – 2037

For passenger cars (category M_1), medium and large buses (categories M_2 and M_3), medium and heavy trucks (categories N_2 and N_3) the preferred policy option is PO3 for reasons of effectiveness, efficiency and policy coherence, while cost-effective.

It is noted that for the above vehicle category clusters the additional lives saved in PO3 compared to PO2 is not proportional to the cost increase. However, the reduction in serious injuries is significant for all vehicles categories and varies between 17% and 36%. Furthermore, the indicated cost per vehicle for vehicle manufacturers in each policy option should be strongly considered in relation to the much higher sales price of the motor-vehicle in question and not in isolation. Finally, the initial safety measures' cost for manufacturers will drop due to e.g. economies of scale and vehicle manufacturers will continue to find additional ways to compensate so that vehicles will not get significantly more expensive for the buyer.

For light commercial vehicles (category N₁) the preferred policy option on the basis of the benefit to cost considerations should in principle be PO2 (PO3 benefit to cost ratio is 0.53). However, additional considerations must be taken into account.

For light commercial vehicles, most EU manufacturers already provide for safer than currently required vehicles since light commercial vehicles often share platform and other hardware with passenger cars. This is reflected in the relatively low overall calculated benefit for this option. On top of that, the cost estimate can be considered as conservative since the industry has already implemented certain features (frontal crash test, airbags) and will face lower costs due to economies of scale with the passenger cars category.

Several stakeholders, notably the European Traffic Safety Council ETSC⁸⁸ and Transport and Environment T&E, have explicitly called for the Commission to apply consistent measures between the different vehicle categories. In addition, Transport and Environment provided evidence that there is an increasing share of light commercial vehicles, also resulting from their increased use to transport goods in the Union in an effort to circumvent driving times and rest legislation that applies to heavy goods vehicles. Light commercial vehicles are also more commonly used to comply with Urban Mobility initiatives that require adapted logistical arrangements in an increasing number of cities.

If PO3 is not pursued for light commercial vehicles, persons in these vehicles may be faced with an increased risk of an accident (because of less accident avoidance measures), a higher crash severity (less accident mitigation measures) and lower protection levels (lack of advanced crash testing), in comparison to regular passenger cars. Distribution effects would be concentrated on one single category of people, i.e. workers using this category of vehicles. Exposing workers to higher risks is not consistent with the Commission's approach to reduce accidents at the workplace⁸⁹.

PO3 for N₁ vehicles also allows ensuring a level playing field since all producers would be subject to same standards.

As regards N₂/N₃ heavy goods vehicles cost effectiveness and the broad uncertainty range it should be explained that all measures, except driver direct vision for cabs, has been evaluated by the two 'opposing' stakeholders, vehicle industry vs. supplier industry which has led to validated costs that are generally considered as more realistic. In all these cases the vehicle manufacturers are relying on suppliers for certain components or systems. In case of cab design this is different. In particular truck manufacturers are completely alone responsible for cab design without supplier input. This means that the indicated costs that the stakeholders have provided in the context of the consultations could not be truly validated by third parties. This is reflected in the broad cost range that has been taken on board. For transparency reasons this is then clearly and conservatively reflected in the uncertainty range. In any event, the cost of PO3 (i.e. EUR 1 013) should be viewed in context with the usual price of a truck (i.e. starting from around EUR 80-100 000).

⁸⁸ European Transport and Safety Council: <http://etsc.eu/wp-content/uploads/2017-03-ETSC-position-paper-general-safety-regulation.pdf>, Transport & Environment: <https://www.transportenvironment.org/sites/te/files/publications/2017%2009%2018%20Eurovignette%20Position%20Paper.pdf>

⁸⁹ COM(2017)12 final. "Safer and Healthier Work for All - Modernisation of the EU Occupational Safety and Health Legislation and Policy".

As far as costs are concerned, the vast majority of manufacturers⁹⁰ producing N₁ vehicles are also producing M₁ and other categories of vehicles for which PO3 is recommended. In addition, N₁ vehicles usually share platforms with M₁ vehicles. They will thus be able to benefit from economies of scale for all their production.

A proposal to amend the General Safety Regulation (EC) No 661/2009 and Pedestrian Safety Regulation (EC) No 78/2009 should therefore reflect PO3 for all vehicle category clusters as the preferred policy option. Over the evaluation period (2021 – 2037) it will address the target population (see section 2.1) as follows:

Fatalities prevented: 24 794	occupant protection in frontal, side and rear impact: reduction by 16.0% of the vehicle occupant fatalities
	pedestrian and cyclist protection in frontal, side and rear impact: reduction by 14.4% of the vulnerable road user fatalities
Severe injuries prevented: 140 740	

The analysis and comparison shows that road infrastructure measures could save over 3 200 lives and avoid more than 20 700 serious injuries during 2020 – 2030 relative to the baseline.⁹¹ Vehicle safety measures would have higher impact, reducing the number of fatalities by 4 380 to 7 300 and of serious injuries by 19 850 to 38 900 during 2020 – 2030. For 2030 alone road infrastructure measures would result in 562 lives saved and 3 675 serious injuries avoided, while vehicle safety measures would result in 1 030 to 1 769 fewer fatalities and 4 721 to 9 824 serious injuries avoided. Thus, additional measures going beyond road infrastructure and vehicle safety will be needed to achieve the EU's strategic objectives.

9. HOW WOULD ACTUAL IMPACTS BE MONITORED AND EVALUATED?

The European Commission will continue to monitor technical progress developments in the automotive sector and, wherever appropriate, will propose to amend the relevant legislation in order to include new safety features. It will also continue to actively participate and lead the vehicle standard harmonisation process at international level (UNECE).

In order to make the new Regulation future proof, it has been deemed more appropriate to address any review of these vehicle safety rules in a more dynamic fashion, namely linked to the overall technical progress and occurrences of new safety needs. In this context, the international regulatory developments through UNECE as well as the frequent need for the adaptation of those rules tend to prompt this reviewing process automatically.

EU wide in depth accident data that currently does not exist on a wide enough scale is indispensable for a comprehensive monitoring of vehicle safety measures.

The introduction of event (accident) data recorders (following the preferred option), storing a range of crucial vehicle data over a short timeframe before, during and after a triggering event, most commonly airbag deployment, should however be seen as a valuable step in the right direction to obtain much more and more accurate in depth accident data that is in turn used for road safety analysis and by extension to assess effectiveness of specific measures. For this reason Member States should be strongly encouraged to perform (much) more in depth accident analysis on EU roads and make available comprehensive reporting on a

⁹⁰ Renault, Citroën, Fiat, VW, Mercedes, Peugeot, Ford Opel, Nissan, Toyota had a combined EU market share of almost 90% in 2015 (source ICCT).

⁹¹ Add reference to the IA on road infrastructure safety

national basis. In this context Member States should also be further stimulated in their activities to analyse and improve road safety on national level through different knowledge sharing platforms at their disposal⁹².

⁹² https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/national-road-safety-strategies_en.pdf

ANNEX 1 – PROCEDURAL INFORMATION

1.1. Lead DG, Decide Planning/CWP references

Lead Directorate-General

This initiative is led by Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW).

Agenda planning and Work Programme References

The Agenda Planning Reference is PLAN/2016/497. The revision of legislation on the General Safety of Vehicles and Pedestrian Safety is part of Commission's 2018 Work Programme⁹³

1.2. Organisation and timing

The inter-service steering group for this initiative was chaired by the DG GROW. The following Directorates-General (DG) participated: SJ, SG; DG MOVE; DG TRADE; DG CNECT; DG RTD; JRC; DG CLIMA; DG JUST.

The following meetings took place

- 28 April 2017 – on the inception impact assessment; consultation strategy
- 8 June 2017 – email consultation of ISG on questionnaire for public consultation
- 27 October 2017 – on draft Impact Assessment
- 6 December 2017 - on draft final Impact Assessment and synopsis report of public consultation

1.3. Consultation of the RSB

The Regulatory Scrutiny Board (RSB) of the European Commission assessed a draft version of the present impact assessment 17 January 2018 and issued its opinion on XX January 2018. The Board made several recommendations. Those were addressed in the revised IA report as follows:

⁹³ Commission Work Programme 2016 - https://ec.europa.eu/info/sites/info/files/cwp_2018_en.pdf

Area	RSB recommendations	Modifications of the Impact Assessment report
Scope and objectives	<p>The report does not sufficiently delimit the expected contribution of this initiative within the comprehensive approach to road safety of the Safe System.</p> <p>It does not well explain the relationship and complementarity with the parallel road infrastructure and tunnel safety initiative</p>	<p>The report now clarifies in chapter 1.4. the overlap and contribution of this initiative to the overall road safety objectives in terms of the relation, prioritisation and complementarity with the parallel initiative on road infrastructure and tunnel safety.</p> <p>A description and clarification of the Safe System approach has been added to chapter 2.1. explaining the respective contributions to the common objectives of the initiatives on vehicle safety and road infrastructure safety and the interactions.</p> <p>In chapter 2.1. both initiatives are also put into the context of the common baseline approach (detailed in Annex 4), notably the methodologies of the studies for the two proposals that have been developed to avoid double counting within and between proposals.</p>
Problem definition and options	<p>There is no coherence between the problem (stagnation in the reduction of road fatalities), its drivers, the objectives of the initiative and the design of options.</p> <p>There is a need for a more coherent intervention logic, linking problems, objectives and options in a consistent way. The report should revise the design or naming of the objectives and options.</p>	<p>A new chapter 2.2. has been developed binding the main road safety problems to those linked to vehicles and vehicle safety performance. This in turn allows for a better comprehension of the structure of the problem definition and drivers that are arguably of a less holistic nature, but much more to the point on vehicle system level, while being still fully relevant.</p> <p>More possible reasons for the stagnation in the reduction of road fatalities and severe injuries since 2013 have been provided in chapter 2.1. whereas they are now also put into context of sources of accidents, population diversity, road user factors and general driving behaviour concerns, for which it has been expressively clarified when they are based more on assumptions than facts.</p> <p>The intervention logic in chapters 5.1. to 5.4. has been more consistently linked to main problems, objectives and options. The naming of the objectives and options were clarified to ensure that it is clear that this initiative is not focussing on the protection of specific groups of traffic participants, while neglecting the others (i.e. occupants of vehicles versus pedestrians and cyclists) as the clusters of vehicle safety measures indeed work on in the different areas simultaneously. The objectives were further clarified with the notion of protection in case of an accident together with potential to completely prevent and avoid accidents from happening altogether.</p>

	<p>The report does not clarify how the individual measures were selected and what their estimated costs and benefits are. It does not sufficiently explain the role and opinions of stakeholders in this process.</p>	<p>Chapter 5. now explains in clear steps the interaction and role of the stakeholders in this process, how the individual measures were selected, how their benefits and effectiveness were determined (in multiple steps), assessed and eventually validated prior to use in the Impact Assessment study and how the final costs and benefits assessment of individual measures vis-à-vis clustered measures was developed through stakeholder input and insistence.</p> <p>Given that the stakeholders insisted on an approach that would evaluate clusters of safety measures instead of individual measures, the benefit to cost ratios have not been provided on the level of individual measures, as they may be misinterpreted in the context of the Impact Assessment. The individual costs and benefits of each measure has however been provided in Annexes 4.4.2. to 4.4.5. to the Final Report “In depth cost-effectiveness analysis of the identified measures and features regarding the way forward for EU vehicle safety” of May 2017 (see also point 1.4. on Evidence, Sources and Quality of this Annex as well as point 2.1. on General Stakeholder Consultations of Annex 2).</p>
<p>Simplification</p>	<p>The analysis should include a discussion of the REFIT dimension of the initiative.</p>	<p>Chapter 2.8. has been modified to better explain the expected simplification of the legislative framework, the way forward in terms of possible outdated regulatory dispositions, and giving indications on future updates of vehicle safety rules.</p>
<p>Preferred policy option</p>	<p>The report should explain further the preference for option 3 for light commercial vehicles.</p>	<p>The justification and clarification of the choice to include PO3 for light commercial vehicles has been added to chapter 8 and explain the issues of most EU manufacturers already providing for safer than currently required vehicles, level playing field for manufacturers, vehicle design synergies, cost sharing, stakeholder opinions, and finally the increased risk of harm to a limited category of of people, namely workers using light commercial vehicles in their workplace.</p>

1.4. Evidence, sources and quality

In preparation of this initiative, and specifically to develop the Commission Report on “Saving lives: boosting car safety in the EU”, a specific study was carried out covering more than 50 potential safety measures for consideration. This work included several stakeholder engagements, such as through the 124th meeting of the Working Group on Motor Vehicles (i.e. the Commission’s expert group involving public and private stakeholders), which was followed by a targeted (face-

to-face) stakeholder consultation in October 2014⁹⁴. The study on “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”⁹⁵ was finalised in March 2015.

Generally, the safety features that have been selected to be assessed as part of this work were chosen to operate in parallel with and in addition to the safety features that are presently mandated in the GSR and PSR. The safety features that have been assessed were chosen not to be interfering with or amending specific existing safety requirements that are still dispersing into the EU vehicle fleet, as the real-world effectiveness of those measures should then first be known.

As a follow-up to this first study, a second commissioned study covered a thorough review of measures that were concluded by the first study as likely to be cost-effective as well as feasible from a technical perspective. This second study was made available to the public in August 2017. In order to assess the “in depth cost effectiveness analysis of the identified measures and features regarding the way forward for vehicle safety in the EU”⁹⁶, a significant quantity of updated information on costs and benefits as well as other relevant amendments and additions in relation to the initial study were taken on board. Again, targeted stakeholder consultations were held at the end of 2016, this time to specifically support all previous and new analysis, providing reassurance that the relevant benefit and cost information sources, as well as those for the target population, uptake estimates and effectiveness were appropriately captured and reported. The relevant input values were thus agreed and validated by an expert group of over 70 members that took part in the extensive stakeholder consultation strategy as set up for this purpose, in a highly transparent and open peer-evaluation exercise.

Given the trigger of the road safety problem that is explained in section 2 above, it was decided that the information would be transformed in a final step to feed directly into the calculation of cost/benefit ratios for the implementation of the specific Policy Option packages of this Impact Assessment.

⁹⁴ http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_type=250&lang=en&item_id=7803

⁹⁵ TRL, Hynd *et al.*, March 2015 – <https://publications.europa.eu/en/publication-detail/-/publication/47beb77e-b33e-44c8-b5ed-505acd6e76c0>

⁹⁶ TRL, Seidl *et al.*, May 2017 – <https://publications.europa.eu/en/publication-detail/-/publication/77990533-9144-11e7-b92d-01aa75ed71a1>

ANNEX 2 – STAKEHOLDER CONSULTATION

2.1. General stakeholder consultations

Two stakeholder consultations were carried out during the preparation of the studies:

- “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”⁹⁷
- “In depth cost effectiveness analysis of the identified measures and features regarding the way forward for vehicle safety in the EU”⁹⁸

The first stakeholder consultation exercise was undertaken on 27 and 28 October 2015, in Brussels. Prior to the meeting, stakeholders were provided with an overview of the study’s scope and objectives, a brief overview of the interim benefits and costs for all measures in the subject area, and drafts of the evidence reviews for each potential measure. Minutes of the stakeholder consultation meeting may be found in the project report (as referenced above). Following the consultation meeting, stakeholders were given three weeks to provide any additional evidence relating to the potential measures under review. The feedback from the consultation meeting and the evidence submitted subsequently were then incorporated into updates of the evidence reviews as presented in this report.

The second stakeholder consultation was held to discuss the preliminary findings of the subsequent study and to agree preliminary recommended input values for a cost-benefit assessment. Stakeholders had the opportunity to provide written feedback on preliminary findings and/or participate in a two-day stakeholder consultation meeting on 28 and 29 November 2016, in London. Invitations were sent to the General Safety Stakeholders Contact List. 72 people from 54 organisations attended the meeting. A breakdown of the type of organisation of the attendees is given in Figure 8. The meeting minutes documenting the discussion in the stakeholder meeting for each of the measures may be found in the GSR2 report.

Type of organisations represented at the GSR2 consultation meeting

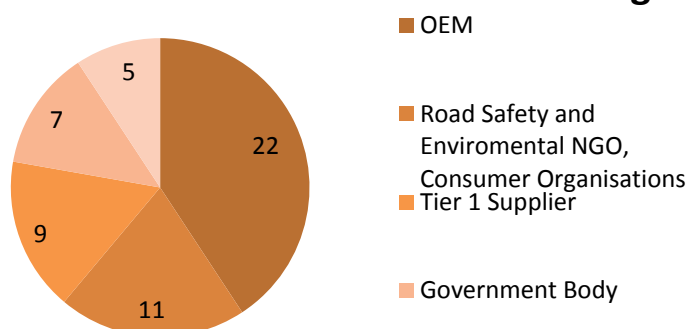


Figure 8: Type of organisations represented during the GSR2 stakeholder consultation meeting in November 2015

⁹⁷ GSR1 – TRL, Hynd *et al.*, March 2015 – <https://publications.europa.eu/en/publication-detail/-/publication/47beb77e-b33e-44c8-b5ed-505acd6e76c0>

⁹⁸ GSR2 – TRL, Seidl *et al.*, May 2017 – <https://publications.europa.eu/en/publication-detail/-/publication/77990533-9144-11e7-b92d-01aa75ed71a1>

A list of organisations that provided written feedback is given in Table 21.

All stakeholder inputs, provided in writing or during the two-day face-to-face meeting, were documented and used to update and refine the results of the study where appropriate.

Table 21: List of organisations that provided input during the GSR2 stakeholder consultation

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

2.2. Public consultation

Consultation activities

1. INTRODUCTION

This synopsis documents all the consultation activities accompanying the preparation of the proposal for revision of General Safety Regulation and the Pedestrian Safety Regulation.

The formal Commission's public consultation on the proposal took place between 31 July and 22 October 2017. However, there were significant additional targeted consultations namely: in the context of our initial study, finalised early 2015, there was a general stakeholder engagement in July 2014 through the 124th meeting of the Working Group on Motor Vehicles (the Commission's expert group involving public and private stakeholders), which was then followed by a targeted (face-to-face) stakeholder two-day consultation event in October 2014. The findings, opinions and detailed discussions on the extensive list of over 50 new and unregulated vehicles safety measures were accurately captured in the report as published by the Commission, forming the basis for a 'shortlist' for further consideration. Discussions with Member States' authorities and international partners also took place prior to the completion of the study.

On 16 February 2016, the Commission presented to the Member States and stakeholders (at the 131st meeting of the Working Group on Motor Vehicle) a set of 19 potential 'shortlist' measures that could be considered for the revision of the Regulations under the present initiative. In the context of the follow up review study, in November 2016 a further intensive two-day stakeholder consultation seminar took place with 72 attendees representing 32 scholars/research organisations, safety advocacy groups, vehicle manufacturers, vehicle supplier industry, local/national governments and other relevant experts.

The key objectives of these in depth consultations were on the one hand to inform stakeholders of the Commission's views on the way forward for vehicle safety, and on the other hand to present to all stakeholders in the most transparent way possible, all data, parameters, expert views and its sources that would form the backbone of the impact assessment in terms of data sets of in particular the vehicle safety system voluntary uptake rates, technology cost, technology effectiveness and traffic victim target population, as well as in particular the stakeholder's judgement and validation of this key data being sufficiently and appropriately robust, relevant and up-to-date. In other words, an elaborate and very extensive form of peer-reviewing the data and impact assessment approach.

The results of these consultations were subsequently used for the preparation of the proposal and accompanying impact assessment.

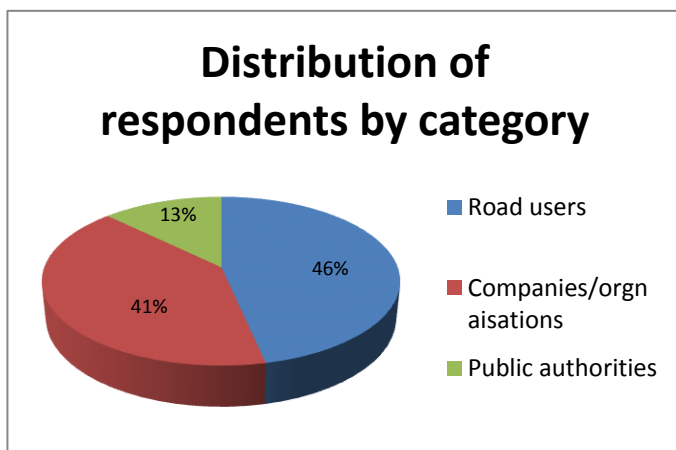
2. RESULTS OF THE PUBLIC CONSULTATION

The on-line public consultation consisted of three dedicated questionnaires for public authorities, companies/organisations and road users and was available in six languages: German, English, French, Polish, Italian and Spanish. 31 position papers or further explanations of the replies in the questionnaires were received by email or as attachment to the questionnaire.

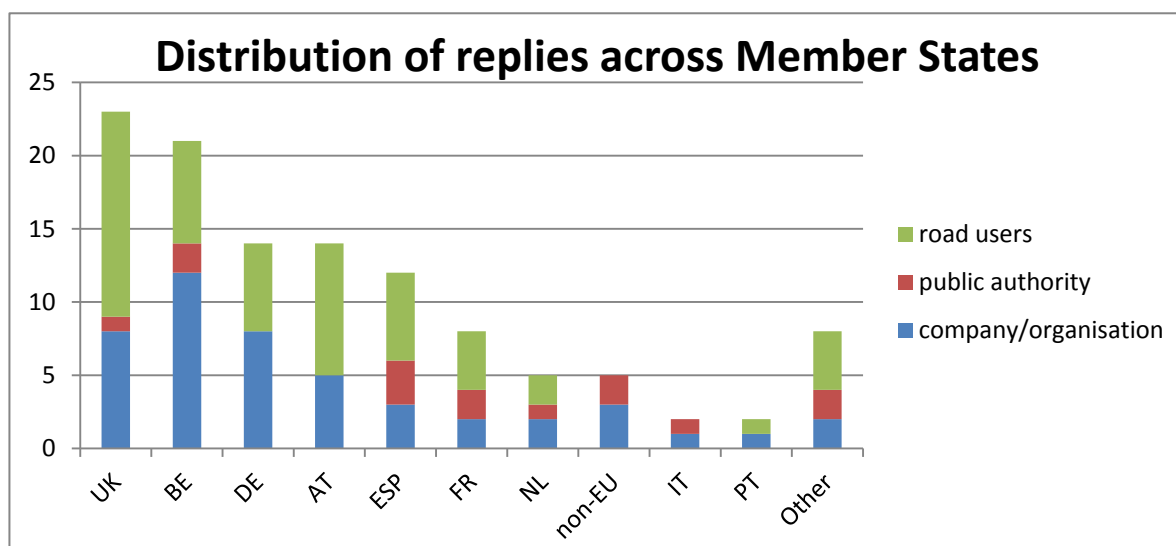
27 organisations/companies and two public authorities were registered in the EU Transparency Register⁹⁹.

Responses to the public consultation are voluntary and represent only views of the respondents. Consequently they cannot be interpreted as representative in a statistical sense to the whole EU.

2.1. Description of respondents



Responses are classified based on self-identification by the respondent. By the end of the consultation period the Commission received 118 replies: 15 replies from public authorities¹⁰⁰ (13%), 48 replies from companies and organisations (41%), and 55 replies from road users (46%). The replies came from 18 EU Member States,¹⁰¹ an EEA country (Norway), an EFTA country (Switzerland) and one non-European country (Israel). 21 Organisations/companies, 6 public authorities and 4 road users submitted position papers.¹⁰²



Below, we offer detailed information on the profile of each respondent group

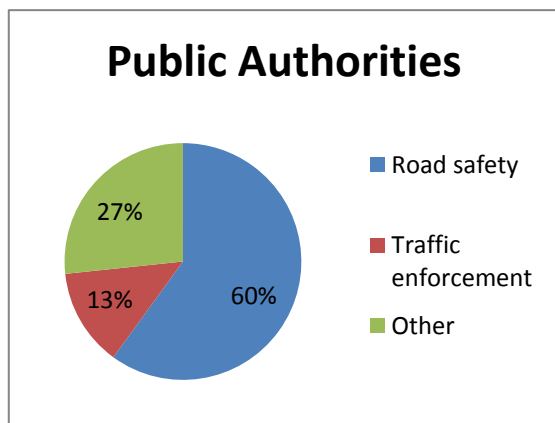
⁹⁹ <http://ec.europa.eu/transparencyregister/public/homePage.do>

¹⁰⁰ For some Member States different authorities replied.

¹⁰¹ Under category "other" we have listed EU countries represented in a smaller proportion of replies such as: Ireland (2 replies) and Czech Republic, Estonia, Finland, Hungary, Latvia, Poland, Romania and Slovakia (one reply each).

¹⁰² Numerical analysis of responses is based only on those that came via EU Survey. Position papers not following the questionnaire of the EU Survey are used only for describing arguments presented by stakeholders and for description of respondents.

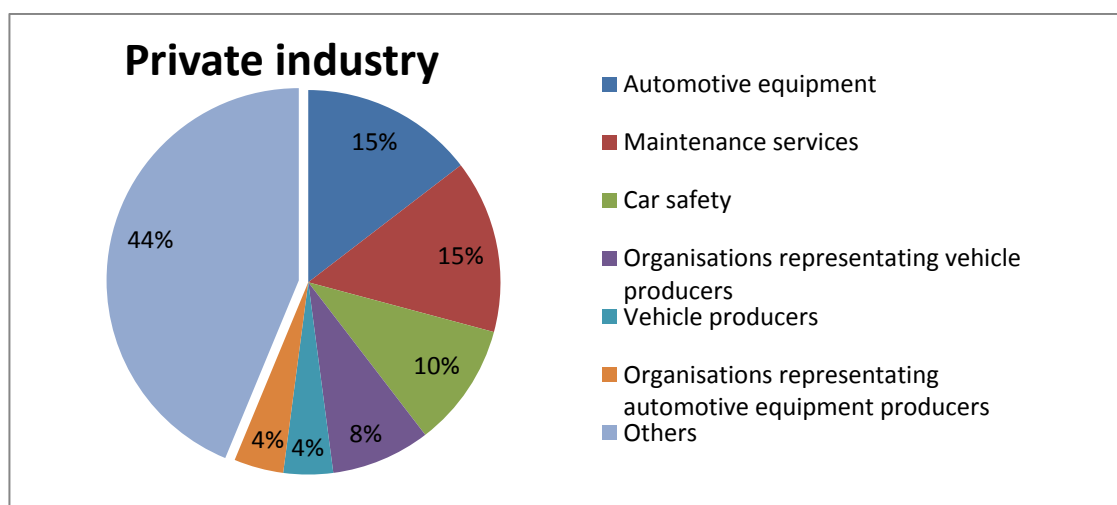
2.2 Breakdown of Public authorities



Most public authorities participating in the public consultation represent road safety organisations (9), followed by traffic enforcement (2).

More than half of these institutions are big organisations, employing 250 or more employees.

2.3 Breakdown of private companies and organisations



The spectrum of sectors representing private companies has been quite broad and balanced, with 15% of the sample representing automotive equipment producers, 15% of companies working on maintenance services, 10% dealing with car safety and 8% being organisations representing vehicle producers.

Private industry remained silent on the types of vehicles they produce. This could be in part be explained by the fact that vehicle producers have already provided extensive detailed input throughout the preliminary stakeholder engagements that we have organised in preparation of the initiative and did not deem it necessary to provide it again at a later stage.

Around 2/3 of the companies and organisations did not provide information on the number of employees. From those that did provide an answer, eight are big firms, with 250 or more employees and nine are SMEs.

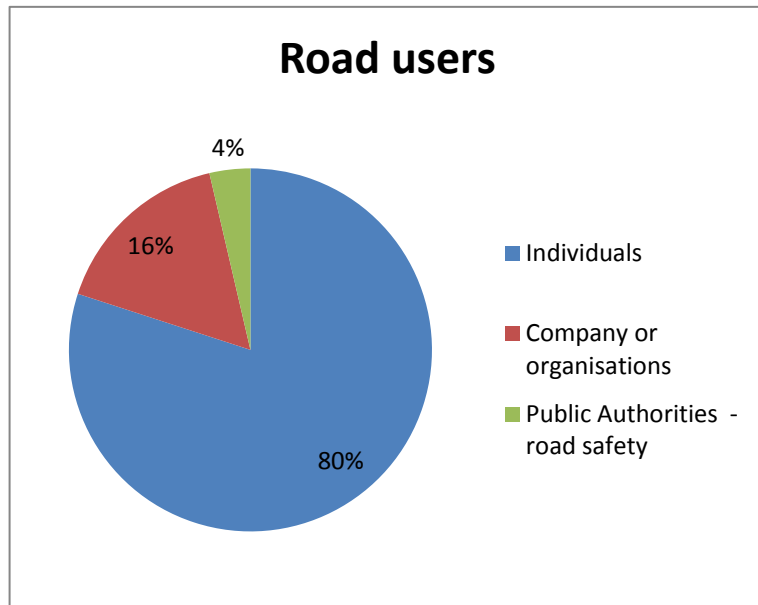
The majority of organisation/companies also did not want to reveal their annual turnover in 2015, only about 35% (17) provided information, out of which six had above € 50 million; four had € 10-50 million; three had less than € 2 million.

The majority of organisations/companies did not provide information on their turnover and employment figures most probably as they didn't find it relevant or they didn't want to reveal their size. Therefore data on the size of all companies/organisations that participated in the public consultation is not complete.

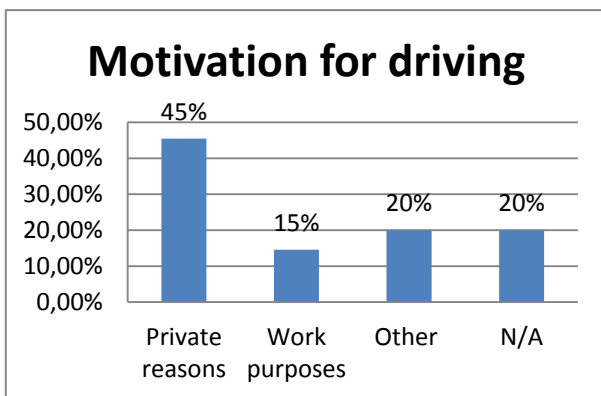
The list of private companies and organisations which participated in the public consultation and voluntarily accepted to be publicly identified is provided in the Annex.

2.4 Breakdown of Road Users

Most road users participating in public consultation identified themselves as individuals (80%), while only 16% were identified as companies or organisations (two passenger transport companies or organisations; one vehicle traffic consulting company or organisation; one vehicle safety or safety company or organisation five other type of companies or organisations) and only 4% as public authorities.



the
road
and



The majority of road users indicated to drive mostly for private reasons (around 45%), while only few (15%) stated to drive mostly for work purposes.

Results of consultation activities

The individual contributions received in response to the public stakeholder consultation will be publicly available.

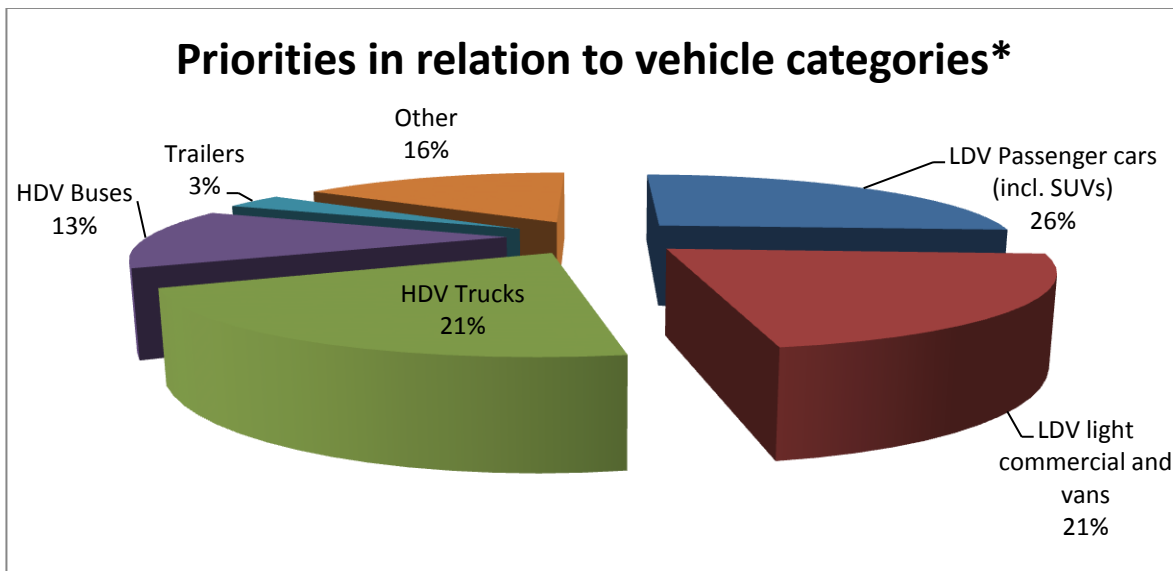
The following sections summarise the replies received from the respondents. Since some of the questions allow for more than one answer, for those questions the number of total replies received is indicated, instead of percentage value.

3.1 Need for new legislation

A broad majority of the respondents (87%) support mandatory introduction of the new vehicle safety features and requirements in the EU legislation, while a minority (6 respondents) consider this should be done as a voluntary agreement within industry. The share of supporters for the mandatory introduction of the suggested safety measures among the public authorities who replied in the consultation is high, namely 80% (12 respondents out of 15 in total), with no public authority stating preference for voluntary implementation by manufacturers. However, a notorious share of road users and organisations did not answer this question (38% and 33% respectively). Among those that answered, a large majority (more than 80% in both stakeholders' category) preferred a mandatory implementation. Only two road users and four organisations believe this should be done on the basis of the automotive industry's self-commitment or voluntary agreements.

3.2 Scope of the new legislation

As regards the scope of vehicles to be covered by the new safety measures, the preferences of the respondents are summarised in the chart below:



* Respondents could indicate multiple vehicle categories.

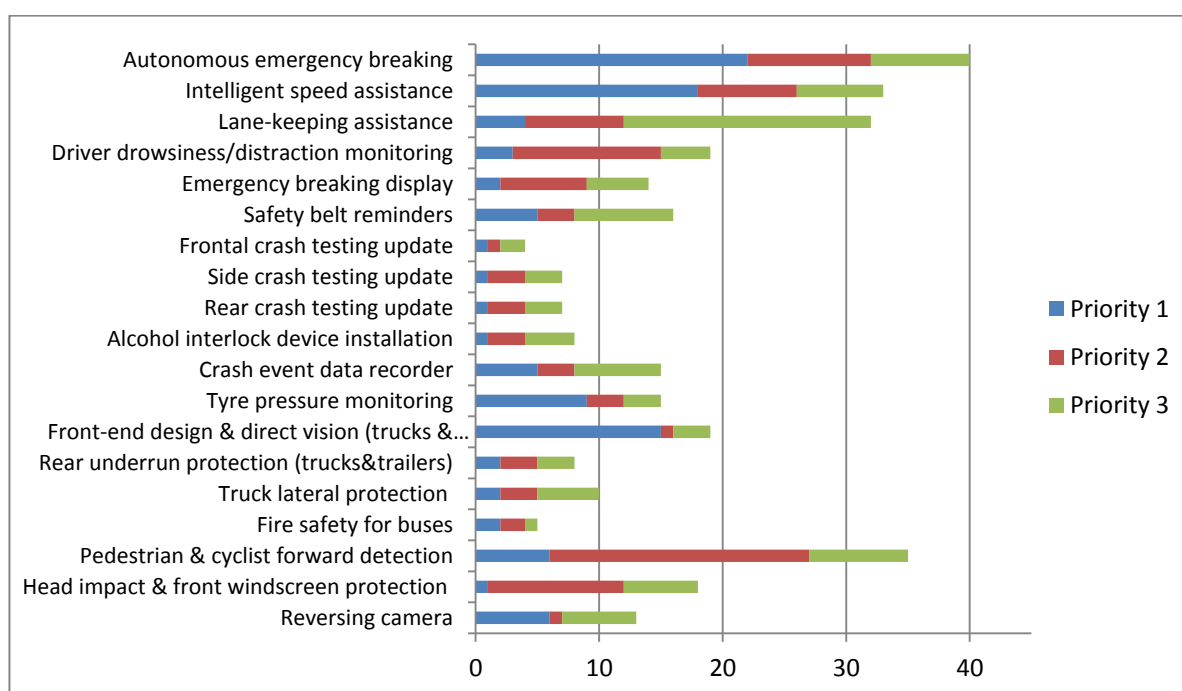
Concerning the scope of accidents to be covered by the new legislation the vast majority of the responses indicated that either all types of accidents or at least the most severe ones should be addressed (these measures received a 35.5% and 43.22% of support respectively), while a relatively small proportion gave priority to the most frequent accidents instead (19 replies). As most frequent accident types the respondents point to: (i) rear collision of motor vehicle into tail-end of another or multiple vehicles in a row (50% of stakeholders); (ii) collision of motor vehicle with pedestrians (44% of stakeholders); (iii) collision of motor vehicle with cyclists (39.8%) and (iv) frontal collision between two motor vehicles (33.9%).

A similar trend is reflected in the answers to the question on the top accidents types that should be addressed by further action at EU level. Stakeholders agree that priority action should be given to address accidents of motor vehicles with pedestrians (24.7%). Cyclists are also perceived as a vulnerable group. More than 21% of stakeholders consider that collision of motor vehicles with

cyclists should be further addressed by the EU. Finally, frontal and rear collisions between motor vehicles are also perceived as major concerns to be tackled further (18 and 13 replies respectively).

The most preferred method to address road accidents at EU level is the introduction of new vehicle safety features (29.4% of stakeholders). There was also a large consensus on the need to address road infrastructure, marking, signs and signalling in order to reduce road accidents. 26.7% of stakeholders identified this measure as the 2nd most important. Other measures, such as improving driver training and raising driver awareness and improving general training were also identified as important ones but to a lower extent (26.7% of stakeholders).

The charter below provides a global overview on the number of replies received that rank each of the suggested 19 safety requirements as **top three priority measures for the new legislation**:



Stakeholders agree on considering Autonomous emergency breaking (20.6%) and Intelligent speed assistance (16.8%) as the preferred safety requirements with more potential to reduce fatalities. Pedestrian and cyclist forwards detection (19.6%) has also been considered a safety measures with high potential, with a large share of stakeholders considering it its second priority. Lane keeping assistance had a large consensus among stakeholders (18.6%) as their 3rd priority measure to be introduced in legislation.

3.2.1 Position papers

21 organisations/companies sent position papers. The larger European associations representing the interests of automotive industry such as ACEA, CLEPA and ETRMA expressed their support for introduction of new measures. Position papers were sent, on commercial vehicles and passenger cars. For passenger cars, the importance of a cost/benefit analysis of all the measures was emphasized. Synergies between different measures and avoidance of double counting of benefits were mentioned. This aspect has indeed been taken fully on board in the cost/benefit calculation model. For trucks a concern about forced modification of direct visibility for trucks was raised and taken into account by means of a later introduction date. The other two associations highlighted their support for the measure

on Tyre Pressure Monitoring System (TPMS), the importance of its better implementation, and its positive impact on optimisation of fuel efficiency and reduction of CO₂. Two organisations representing the interests of small and ultra-small volume car manufacturers argued that different implementation period for new safety measures should apply for small volume manufacturers. In some cases they suggest complete exemption from new requirements due to significant cost of development and implementation of new requirements for such manufacturers, due to complexity or lack of access to technology. These issues are important, relevant and should thus be considered, especially in the context of SME activities. Matters related to small-series exemptions are however dealt with in the EU vehicle type-approval ‘Framework Directive’¹⁰³ and the relevant suggestions should be incorporated there in the same spirit of adapted implementing dates of the requirements for electronic stability control systems as done in the original GSR, recommending a similar mechanism for this initiative. Several organisations concerned about safety of cyclists and pedestrians expressed their strong support for the measure on direct vision for heavy duty vehicles and called upon earlier implementation dates than suggested in the previous studies. This was also the case for two organisations representing insurances with regard to Autonomous Emergency Braking for Pedestrians and Cyclists and Adult Head to Windscreen Area Protection. These opinions have indeed largely been taken on board in the cost/benefit model. Finally, just one organisation noted they are not in favour of a proposed vehicle safety measure, namely the one on mandatory installation of Event Data Recorder, pointing out concerns about privacy, reliability and robustness of data and liability and warranty. It was therefore noted in the impact assessment that it will not be possible to identify the specific unique vehicle (and thus potentially its owner) with data made available through the EDR.

Six supporting position papers were received from public authorities. Certain authorities sent letters accompanying their questionnaires to provide further context and support to their responses in the questionnaire and explain in more detail their position. One of them highlighted several detailed approaches for certain measures, in particular those tackling truck fatalities. One called for an earlier implementation date for minimum direct vision requirements. One emphasized the importance of appropriate timeline for fitment of measures that do not exist yet, i.e. not already fitted voluntarily by manufacturers.

Four position papers were submitted also by road users. Most of them expressed overall their support for new measures, one sent background information on road accidents.

3.3 Expected outcome from the new legislation

It is worth mentioning that the above measures are largely supported by all three groups of respondents, which see significant positive outcome thereof. Around 2/3 of the respondents believe that as a result of mandating the new vehicle safety features at EU level: (i) the number of traffic accidents will decrease (78.8% of stakeholders agree on this); (ii) safety features will become cheaper (on average 77.11% of stakeholders confirmed this); (iii) the number of road traffic deaths will go down significantly (average of 76% of stakeholders); and (iv) the number of severe injuries in road traffic accidents will also decrease considerably (average of 74.55% of stakeholders). Although the opinions are more diversified, a large share of stakeholders (44.9%) also believes that car insurances

¹⁰³ Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (OJ L 263, 9.10.2007, p. 1)

will decrease while at the same time the introduction of self-driving vehicles in Europe will be speeded-up (45.7%).

Regarding the final impact on vehicle's price, opinions are diverse. Almost 30% of stakeholders think that new legislation might impact final vehicle prices, although 24.7 % slightly disagree.

3.4 Time-line for implementation of the new legislation

On the time needed for the manufacturers to implement the new vehicle safety features, the information provided is not complete as only one of the respondents from the companies/organisation group replied to this set of questions. The reply shows that depending on the features different time line will be necessary. The stakeholder rightfully noted that some of the measures, as for example the safety belt reminder and the truck and trailer rear underrun protection (rear bumper) covered UNECE harmonised legislation as updated due to technical progress after the start of the preparations for this initiative in 2014, can be omitted from the initiative altogether. Other measures, such as tyre pressure monitoring, crash event data recorder, alcohol interlock device, emergency braking display and reverse monitoring, seems to be easily implemented in short-term, while for the rest e.g. driver's drowsiness and distraction monitoring, autonomous emergency braking, lane keeping assistance, intelligent speed assistance, etc. a longer lead time is needed.

4. RESULTS OF TARGETED CONSULTATIONS

The Commission discussed the possible revision of the two Regulations on several occasions with a broad range of stakeholder.

A targeted (face-to-face) stakeholder consultation took place in October 2014. All relevant stakeholders were represented, namely vehicle producers, automotive suppliers, road safety advocacy, Member States, scholars and several other NGOs. Several MEPs had also expressed interest to be kept informed. The discussion was focused on technological feasibility of a very broad range of measures proposed, more than 50, their feasibility from a technical standpoint and their potential cost-effectiveness based on available data. The measures were presented in the following ranking: Likely to be feasible and cost-effective ('green' measures), less-likely to be feasible or cost-effective ('orange' measures) and finally not likely to be feasible or cost-effective ('red' measures). There were no strong opposing views. Moreover where there was doubt, the relevant stakeholders offered to provide additional (objective) data either to support the cost/benefit calculations or to clarify that a measure was not feasible or cost-effective.

In the context of the 2016 review study, in November 2016 an intensive stakeholder consultation seminar took place (72 attendees representing associations, industry, NGOs and others). A further discussion was organised, this time on the shortlisted measures. New and updated data used for cost-effectiveness of measures was presented to the stakeholders. This specifically concerned voluntary uptake rates, technology cost, technology effectiveness and traffic victim target population. This data was presented in 24 separate fact sheets, each covering a specific topic, that were made available in advance of the stakeholder event to all registered participants. At the session, the fact sheets were discussed in depth in two dedicated groups, in a set order, divided according to specialism. This allowed participants to jump from one to another topic between the different groups if preferred. In principle, the main goal of applying this consultation strategy in the preparatory stage of this initiative was to ensure the acceptance by all the relevant stakeholders of the presented data to be used for the impact assessment and for them to explicitly validate it between experts as the best-available, robust,

relevant and up-to-date data. Thus as a result, the relevant data used for the impact assessment has been reviewed by ‘opposing’ stakeholders and is thus objective to a very large degree.

Several stakeholders raised the matter of interaction between the different measures if implemented on vehicles at the same time and the possible overlap or double counting of benefits. Technological synergies were also pointed out meaning that one type of hardware could be used for different measures, leading to reduced overall cost. Both these important observations were taken fully on board in the impact assessment’s cost/benefit calculation model.

In order to assure the transparency of the process, the Commission has further presented and discussed the measures at the Working Group on Motor Vehicles (124th meeting¹⁰⁴ and 131th meeting¹⁰⁵), where associations representing industry and other stakeholders were present as well as member states. There have been numerous other instances where the Commission presented the ongoing work, notably for members of the European Parliament, Member States and international expert fora, in order to raise awareness.

Use of consultation results

The suggestions by stakeholders are taken on board to a very large degree in the preparation of the impact assessment, and align mostly with the Commission’s intentions.

With 118 responses received and 31 position papers submitted, the public stakeholder consultation had a very satisfactory and sufficiently representative reply rate. This holds also for the distribution of the respondent’s affiliation which can be qualified as balanced with most significant participation from road users and organisations/companies; but also public authorities were well represented.

Overall, the consultation process went smoothly. As regards the written contributions/position papers received on the public consultation, the initiative appears very broadly accepted and well supported by all stakeholders. Objections were received from only one of the organisations, in particular on the safety measure related to mandatory installation of event (accident) data recorder, linked to privacy issues that can actually be adequately addressed when implemented.

Mandatory introduction of the new safety measures by the manufacturers appears generally to be the preferred way forward for most. Introduction of new vehicle safety features was selected as the preferred method to address the road accidents at EU level by most. The expected outcome by respondents, of the actions covered by the consultation, corresponds mostly to the objectives of the proposed initiative, namely that the number of traffic accidents will fall, the number of road deaths will go down and the number of severe injuries and road traffic accidents will also decrease considerably.

Much information submitted in position papers was already shared with the Commission at earlier stages, in particular during targeted consultations with relevant stakeholders. The whole process of involving different parties concerned has been throughout very transparent.

¹⁰⁴ <https://circabc.europa.eu/w/browse/23e5db20-3cd0-4e34-820f-1ba1d802a738>

¹⁰⁵ <https://circabc.europa.eu/w/browse/6e903b1e-4bf7-46b1-bccf-117cfaf0733b>

ANNEX 3 – WHO IS AFFECTED BY THE INITIATIVE AND HOW

3.1. Practical implications of the initiative

Comparison of the impact of policy options on stakeholders					
Stakeholder Policy option	Vehicle users	Pedestrians and cyclist	Vehicle manufacturers	Equipment manufactures	Member States
PO0	0	0	0	0	0
PO1	≈	≈	≈	+	≈
PO2	+	++	-	+	+
PO3	++	++	--	++	++
Aspects considered:	Increased occupant safety; no substantial increases in vehicle prices due to the additional safety measures in the medium and long term expected; potential for reduced insurance premiums; potential increase in vehicle repair costs; Reduced vehicle fuel efficiency due to	Increased vulnerable road user safety;	Increased OEM costs; potential for harmonisation of technical requirements across regions and between OEMs; encouraging innovative technologies/ R&D	Increased safety system and component sales; encouraging innovative technologies/ R&D	Reduction in emergency service requirements; reduction in road closures/congestion leading to increase in productivity; reduction in fatalities/serious casualties; increase equitable treatment of VRUs in vehicle safety legislation; increased VRU safety could encourage more cycling/walki

	increased vehicle mass; increased driving comfort; AID to maintain the mobility of rehabilitating drink-driving offenders, while minimising recidivism rates				ng; potential for increased CO ₂ emissions due to increased vehicle mass and potential for reduced emission due to TPM; cost of defining test regulatory requirements
Magnitude of impact as compared with the baseline scenario (the baseline is indicated as 0): ++ strongly positive; + positive; -- strongly negative; - negative; ≈ marginal/neutral; ? uncertain; n.a. not applicable					

Casualties:

All vehicle categories	PO3
Fatal casualties prevented	24 794
Serious casualties prevented	140 740

Monetary indicators:

All vehicle categories	PO3	
Present value benefit	€ 72.8 bn	
Present value cost	€ 57.4 bn	
BCR (best estimate)	1.27	
BCR (uncertainty range lower/upper ¹⁰⁶)	0.91	1.68

¹⁰⁶ € 70.5 bn / € 77.8 bn lower, € 92.9 bn / € 55.2 bn upper

3.2. SUMMARY OF COSTS AND BENEFITS

<i>I. Overview of Benefits (total for all provisions) – Preferred Option</i>		
<i>Description</i>	<i>Amount</i>	<i>Comments</i>
<i>Direct benefits</i>		
Casualties prevented (fatal, serious and slight) by safety measures	€ 72.8 bn	Value of safety per se (citizens), and avoidance of direct and indirect economic costs (businesses and administrations)
Reduced road congestion due to avoided collisions	<i>not quantified</i>	Reduced loss of time (citizens), increased productivity (businesses), and better use of existing road infrastructure (administrations)
Reduced vehicle emissions (speed assistance system, tyre pressure monitoring)	<i>not quantified</i>	Improved air quality (citizens)
<i>Indirect benefits</i>		
Potential for reduced motor insurance premiums due to avoided collisions	<i>not quantified</i>	Reduced cost of mobility (citizens)
Potential for harmonisation of technical requirements for safety measures	<i>not quantified</i>	Reduced costs for variants due to standardisation between vehicle manufacturers or across world regions (businesses)
Potential for reduced enforcement costs (speed assistance system)	<i>not quantified</i>	Reduced police cost for surveillance and enforcement of speed limit compliance (administrations)

II. Overview of costs – Preferred option						
	Citizens/Consumers		Businesses		Administrations	
	One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
Direct costs	No substantial vehicle retail price increases due to proposed safety measures in the medium and long term expected.		€ 57.4 bn (one-off costs and ongoing production costs incurred by vehicle manufacturers)		<i>Not quantified</i> (implementation of legislation)	
Indirect costs	Higher repair costs (only in case of defect or damage)		<i>Included in estimate above</i> (regulatory charges and administrative costs to vehicle manufacturers)		<i>Not quantified</i> (contribution to the development of type-approval requirements)	

3.3. Detailed discussion on road safety problem drivers

3.3.1. Slow market uptake of new safety features in the vehicle fleet

Features such as autonomous emergency braking, lane keeping assist and reversing camera, have a great potential to improve road safety, either by avoiding collisions altogether or reducing impact speed and mitigating the level of victims' injury levels. Improved active and passive safety features also play an important role to further reducing the number of fatalities or injuries in collisions that will inevitably still occur.

The voluntary market uptake of new vehicle safety features has shown to be rather unfavourable.

For instance, stability control systems reached an 80% voluntary fitment plateau in the period before it was made mandatory on all new vehicles.

Detailed analysis as carried out to establish the baseline scenario illustrates the situation for autonomous emergency braking systems on passenger cars with fleet fitment rates in 2015 of only 32% of new cars that were registered in the Netherlands, 30% in Belgium, 16% in Spain and 21% in the United Kingdom, whereas the technology became prominently available already since 2009. A negligible proportion of these cars are currently equipped with systems that can detect an impending collision with a pedestrian or cyclist.

As concerns intelligent speed assistance systems on passenger cars, analysis revealed that only 1% to 10% of the passenger car fleet was equipped in 2015 with some form of built-in speed alert system, hence the proportion of an advanced intelligent system is estimated to be much lower. Finally, approximately 1% of the car fleet was equipped with lane keeping support systems in 2015 with a new vehicle fitment rate around just 5% according to available 2012 and 2013 data.

3.3.2. Outdated safety exemptions for SUVs, MPVs, vans and the like

Currently, heavy passenger cars (e.g. family van, SUV, MPV¹⁰⁷) and all light commercial vehicles (e.g. cargo delivery van, pick-up) are fully exempted from the frontal crash testing as introduced in 1996. At that time the exemptions were introduced based on either a very low market availability of such vehicles or the notion that utility vehicles would have severe difficulties to comply due to their size and mass. It was further suggested that compliance with the legislation would make larger and heavy cars stiffer at the front, and that this would create a specific problem for small non-compliant older cars in collisions with newer compliant heavy cars (i.e. compatibility mismatch). However, this issue has become increasingly obsolete over time, given that a high percentage of small cars in the fleet¹⁰⁸ now meet the frontal impact off-set crash requirements.

The absence of frontal crash testing requirements for light commercial vehicles as a whole, based on the notion of size and mass as with SUVs, presents the situation that workers that are required to drive light commercial vehicles to carry out their duties cannot rely on a harmonised minimum level of frontal crash protection. The actual safety level depends fully on the vehicle purchase choice made by their employers.

Vehicles that do not have a seating position under just 70 cm above ground level are in turn fully exempted from the side impact crash test. Also in this case it notably includes those passenger cars that can be characterised as SUVs as well as delivery type vans. The exemption was based on a lower risk of bodily injury of occupants, due to the ‘high’ seating position. In principle this reasoning is still valid, but the regulations contain other safety criteria covering spontaneous door opening in a crash or all doors being jammed shut after a crash, which are then also neglected, putting occupants of these vehicles at a risk.

Rear impact crash testing has been exempted altogether for all vehicle categories although the relevant test specifications and requirements have existed on UNECE level that apply in the EU since its accession in 1997¹⁰⁹. Its current application in the EU is mandatory, but with a specific exemption concerning the rear crash test.

When motor-vehicles are exempted from these types of crash tests, the post-crash protection against electric shock and fire risks can also not be guaranteed.

These perilous loopholes should be avoided especially in the light of proliferation of SUVs in the marketplace, up from only 3% in 1996 to 14% market penetration in 2016¹¹⁰ and the increasing sales figures¹¹¹ for light commercial vehicles with the market addressing urban mobility solutions. It should also be avoided in light of the accelerated shift towards zero-emission mobility, with electric vehicles and their heavy and high capacity batteries, viewed by the Commission as key enabling technology¹¹². For reference, in the first two quarters of 2017, there was significant growth in demand for both chargeable electric vehicles (+38%) and hybrid electric vehicles (+61%)¹¹³ compared to the same period the previous year. Clearly, these battery powered vehicles always need to offer adequate

¹⁰⁷ Family van is generally defined as a passenger car version of e.g. a cargo delivery van with windows all around and up to 9 seating positions – SUV means Sport Utility Vehicle generally defined as a large station wagon shaped vehicle with high riding position that is designed to be used on rough off-road surfaces, but that is rather often used on urban roads and motorways – MPV means Multi-Purpose Vehicle generally defined as a family van, but not derived from a cargo delivery van, with high riding position and up to 9 seating positions

¹⁰⁸ Eurostat, Road transport equipment – Stock of vehicles

¹⁰⁹ OJ L 346, 17.12.1997, p. 78

¹¹⁰ <http://www.acea.be/statistics/tag/category/4x4-penetration>

¹¹¹ <http://www.acea.be/statistics/tag/category/by-country-registrations>

¹¹² COM(2017) 283 final

¹¹³ <http://www.acea.be/statistics/tag/category/electric-and-alternative-vehicle-registrations>

protection against electric shock and vehicle fire after a crash has happened and thus the current exemptions must be revisited.

Available data that has been analysed to assess this issue provides a high confidence that current EU built large heavy vehicles will have no problems to pass the regulatory requirements, as is clear from various relevant Euro NCAP safety tests¹¹⁴ that show sufficiently adequate levels of protection are attained by such vehicles subjected to the evaluation tests, as represented in today's vehicle fleet. Hence, there is no justification to maintain these old exemptions.

It may be feared that these exemptions will be further exploited¹¹⁵ by vehicle manufacturers producing less sophisticated cars outside of the EU with the aim to provide cheaper alternatives or gain bigger profits than their competition that do take safety seriously. When they do not ensure an adequate level of safety protection of such vehicles, this is all unknown to the drivers, end-consumers or rescue workers. EU citizens should however be able to trust that all these vehicles also comply with minimum safety standards as set for passenger cars in general.

¹¹⁴ Business & Family Vans – <https://www.euroncap.com/en/ratings-rewards/business-family-vans>, SUVs – <https://www.euroncap.com/en/ratings-rewards/latest-safety-ratings/?selectedClasses=1197> and <https://www.euroncap.com/en/ratings-rewards/latest-safety-ratings/?selectedClasses=1198>

¹¹⁵ H-1033/05

4.1. Description of analytical models used

A model suite has been used for the analytical work: PRIMES-TREMOVE transport model, a specific model developed by TRL in the programming language Python¹¹⁶ with inputs and outputs produced in Microsoft Excel spreadsheets and an Excel-based tool developed by COWI. While PRIMES-TREMOVE is a transport model covering the entire transport system, used for the development of the EU Reference scenario 2016, TRL and COWI models specifically focus on evaluating the impacts of vehicle technologies and infrastructure measures on road safety, respectively. A brief description of each model is provided below, followed by an explanation of each model's role in the context of this impact assessment.

4.1.1. PRIMES-TREMOVE transport model

The PRIMES-TREMOVE transport model projects the evolution of demand for passengers and freight transport by transport mode and transport mean. It is essentially a dynamic system of multi-agent choices under several constraints, which are not necessarily binding simultaneously. The model consists of two main modules, the transport demand allocation module and the technology choice and equipment operation module. The two modules interact with each other and are solved simultaneously.

The projections include details for a large number of transport means, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments for each EU Member State. They also include details about greenhouse gas and air pollution emissions (e.g. NO_x, PM, SO_x, CO), as well as impacts on external costs of congestion, noise and accidents.

In the transport field, PRIMES-TREMOVE is suitable for modelling *soft measures* (e.g. eco-driving, deployment of Intelligent Transport Systems, labelling), *economic measures* (e.g. subsidies and taxes on fuels, vehicles, emissions; ETS for transport when linked with PRIMES; pricing of congestion and other externalities such as air pollution, accidents and noise; measures supporting R&D), *regulatory measures* (e.g. CO₂ emission performance standards for new passenger cars and new light commercial vehicles; EURO standards on road transport vehicles; technology standards for non-road transport technologies), *infrastructure policies for alternative fuels* (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG). Used as a module which contributes to a broader PRIMES scenario, it can show how policies and trends in the field of transport contribute to economy wide trends in energy use and emissions. Using data disaggregated per Member State, it can show differentiated trends across Member States.

PRIMES-TREMOVE has been used for the 2011 White Paper on Transport, Low Carbon Economy and Energy 2050 Roadmaps, the 2030 policy framework for climate and energy and more recently for the Effort Sharing Regulation, the review of the Energy Efficiency Directive, the recast of the Renewables Energy Directive, the European strategy on low-emission mobility, the revision of the Eurovignette Directive and the recast of the Regulations on CO₂ standards for light duty vehicles.

¹¹⁶ <https://www.python.org/>

The PRIMES-TREMOVE is a private model that has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens¹¹⁷, based on, but extending features of the open source TREMOVE model developed by the TREMOVE¹¹⁸ modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model¹¹⁹. Other parts, like the component on fuel consumption and emissions, follow the COPERT model.

As module of the PRIMES energy system model, PRIMES-TREMOVE¹²⁰ has been successfully peer reviewed¹²¹, most recently in 2011¹²².

4.1.2. TRL model

A simulation model was developed by TRL to estimate the benefits (monetary values of casualties prevented by safety measures) and costs (cost to vehicle manufacturers of fitment of safety measures to new vehicles) associated with policy measures assessed in the context of the revision of the General Safety Regulation and Pedestrian Safety Regulation. The model was implemented in the programming language Python¹²³ with inputs and outputs produced in Microsoft Excel spreadsheets. Figure 0-1 presents a simplified visualisation of the structure and calculation steps of the model. The scope of the cost-effectiveness evaluation was:

- Geographic scope: EU28
- Vehicle categories covered: M1, M2&M3, N1, N2&N3
- Evaluation period: 2021–2037
- Baseline scenario: No further policy intervention in the transport sector, but voluntary improvements and effects of already implemented policies continue. Continued dispersion of mandatory vehicle safety measures into the legacy fleet and continued voluntary uptake of the safety measures under consideration.
- Evaluated scenarios: Three sets of safety measures (PO1, PO2 and PO3) implemented on a mandatory basis
- Benefits considered: Monetary values of casualties prevented by safety measures
- Costs considered: Cost to vehicle manufacturers of fitment of safety measures to new vehicles
- Treatment of uncertainty: Interval analysis and scenario analysis
- Results: Benefit-to-cost ratios (BCRs), based on present monetary values and casualties prevented, compared to the baseline scenario over the entire evaluation period

¹¹⁷ Source: <http://www.e3mlab.ntua.gr/e3mlab/>

¹¹⁸ Source: <http://www.tmluven.be/methode/tremove/home.htm>

¹¹⁹ Several model enhancements were made compared to the standard TREMOVE model, as for example: for the number of vintages (allowing representation of the choice of second-hand cars); for the technology categories which include vehicle types using electricity from the grid and fuel cells. The model also incorporates additional fuel types, such as biofuels (when they differ from standard fossil fuel technologies), LPG and LNG. In addition, representation of infrastructure for refuelling and recharging are among the model refinements, influencing fuel choices. A major model enhancement concerns the inclusion of heterogeneity in the distance of stylised trips; the model considers that the trip distances follow a distribution function with different distances and frequencies. The inclusion of heterogeneity was found to be of significant influence in the choice of vehicle-fuels especially for vehicles-fuels with range limitations.

¹²⁰ The model can be run either as a stand-alone tool (e.g. for the 2011 White Paper on Transport and for the 2016 Strategy on low-emission mobility) or fully integrated in the rest of the PRIMES energy systems model (e.g. for the Low Carbon Economy and Energy 2050 Roadmaps, for the 2030 policy framework for climate and energy, for the Effort Sharing Regulation, for the review of the Energy Efficiency Directive and for the recast of the Renewables Energy Directive). When coupled with PRIMES, interaction with the energy sector is taken into account in an iterative way.

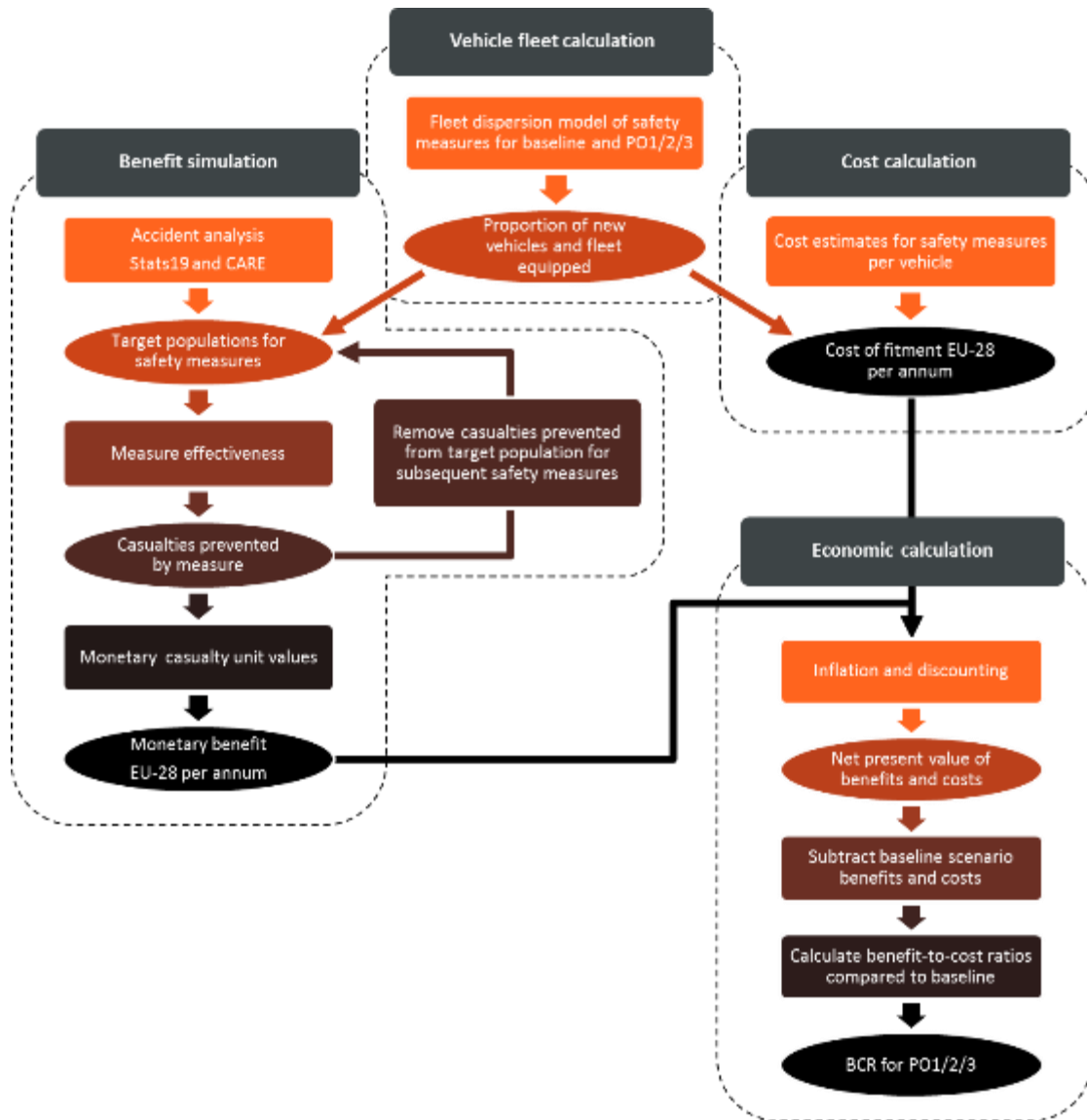
¹²¹ Source: http://ec.europa.eu/clima/policies/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf

¹²² https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1569_2.pdf

¹²³ <https://www.python.org/>

The vehicle fleet calculation model determines how the vehicle safety measures disperse into the fleet. The model determines the effect of mandating a measure for all new types, and two years later for all new registered vehicles, on the overall proportion of the fleet equipped. Benefits conferred by a safety measure, that is, casualties prevented, will only be realised by equipped vehicles. However, the legacy fleet will also be affected by active safety measures; for example, if a rear-end shunt is avoided by autonomous emergency braking for driving and still-standing vehicles ahead (AEB-VEH), the vehicle in front, will benefit from the measure even if it is a legacy vehicle. This is taken into account in the benefit calculations.

Figure 0-1: Flowchart of the TRL simulation model to calculate benefit-to-cost ratios



To simulate the casualties prevented by each measure, an accident data analysis was performed based on Great Britain national road accident data (Stats19) to determine the casualty target population for each proposed measure, i.e. the number of fatal, serious and slight injuries that could potentially be affected by a safety measure based on relevant characteristics of the collision (e.g., collision geometry or contributory factors). The target populations were scaled to EU28 level using weighting factors, based on severity and vehicle categories involved, derived from analysis of the pan-European CARE

database. The target populations found are multiplied with effectiveness values for each safety measure, i.e. a percentage value indicating what proportion of the relevant accidents will be avoided or mitigated by the measure. Mitigated casualties (fatal turned to serious casualty, or serious to slight casualty) are added to the target population of the next lower injury severity level for other measures. The casualties prevented are multiplied with monetary values for casualty prevention to calculate the monetary benefit.

Evaluation period

To model the costs and benefits of the safety measures, it was necessary to set an evaluation window which allowed technology sufficient time to propagate through the vehicle fleet and into the collision population. This was set by considering the earliest time at which a measure could affect all new vehicles (year 2023, 2 years after introduction for new approved types); then an allowance was added for the age of the traffic population (mileage contribution to total miles driven is not constant over the vehicle age). Previous evidence, established for the car fleet in London, has demonstrated that about 88% of the traffic is 0 to 11 years old and 97% of the traffic is 0 to 14 years old. Vehicles which are 15 years old account for about only 1% of the traffic and about 2% of the collision involved cars. Therefore, 14 years was added to new vehicle implementation date to allow the full cycle of fleet benefits to be captured. This period also matches the length of time allocated for the majority of voluntary uptake measures to reach close-to-full adoption levels. As such, the evaluation period was set to extend from 2021 to 2037.

The model also addresses the interaction of different safety measures on overlapping casualty groups. To give an example, there are collisions where a driver was exceeding the speed limit, left the lane and suffered a frontal impact. These collisions will be in the target populations for multiple measures, but they can only be prevented once by either one of these systems. This is addressed in the model by removing casualties prevented by one measure from the subsequent target population of the other measures. The impact of highly effective existing safety measures, which have been mandatory for a few years, but are still dispersing into the vehicle fleet is also modelled to reduce the remaining target populations for the proposed measures.

Fleet dispersion of vehicle technology safety measures

There are two aspects to the fleet fitment estimates which are vital to the process of establishing the cost-effectiveness for the measures related to vehicle technologies.

- The voluntary uptake which defines a ‘do nothing’ scenario. In this case, the propagation of technology is led by the willingness of manufacturers to fit the necessary components to vehicles and the willingness of consumers to pay for them.
- The mandatory uptake brought about by a policy intervention. In this case, all new vehicles or all vehicle types will be required to meet the regulatory requirements by an implementation date. The effects of this will be superimposed at that moment in time.

To model the uptake of technology alongside each of the measures, it was necessary to define the uptake by new vehicles and also the penetration into the fleet due to fleet expansion and ‘churn’ (the rolling addition of new vehicles and scrapping of old). This textbox provides an illustration on the way in which the model accounts for technology propagation on a voluntary or mandatory basis. The model accounts for the fact that some of the vehicles being scrapped in the churn process would also have the technology fitted. Otherwise, an overly optimistic estimate of technology penetration would be generated.

Voluntary fleet fitment estimates were based on evidence identified previously (Seidl *et al.*, 2017), comments provided by stakeholders and, in the absence of other information, opinions of an expert panel within TRL based on observations of similar technologies and expectations of pressures on the industry (for instance, whether a measure is likely to be incentivised by Euro NCAP).

The launch date for a technology was used to define the x-axis (time) start point for s-shaped curves of fitment. This relates to the first time a system was released with the characteristics likely to be required in order to meet the regulatory requirements. As a general rule, the launch date was intended to be independent of vehicle category; assuming general transfer of technologies was possible, with some exceptions. The year that full voluntary implementation is achieved

dictates the gradient or slope of the s-shaped curve and represents the time necessary for the measure to reach maturity in terms of full voluntary adoption into new vehicle registrations.

The voluntary take up of technology and the implementation within the fleet was selected to be one of three possible options:

- None = No voluntary uptake, regulatory action required to drive adoption
- Medium = 40% voluntary propagation within the fleet without additional stimuli
- High = 80% voluntary propagation leaving the 20% of vehicles which wouldn't be equipped without regulatory action

These values represent point estimates for the resulting final take up in the fleet. The s-shaped curve for percentage of newly registered cars equipped is modelled to form a plateau at this value.

Examples of model outputs for measure uptake and fleet dispersion of pedestrian-capable autonomous emergency braking (AEB-PCD) in cars are shown in Figure 21, Figure 22 (voluntary uptake scenario) and Figure 23, Figure 24 (mandatory uptake scenario). In the voluntary uptake scenario it can be seen that this high-uptake measure levels off at approximately 80% fleet fitment by the end of the evaluation period (Figure 22). The mandatory uptake scenario follows the voluntary uptake curve up until 2023 and elevates the new vehicle fitment rates from then onward gradually over two years to 100% (Figure 23). Even with full fitment in new vehicles, it still takes time for those vehicles to replace existing vehicles on the road, but the effect of regulation can be seen in the resulting higher fleet fitment of more than 90% by the end of the study period (Figure 24). The difference between these curves is responsible for the casualties prevented of a policy option compared to the baseline option.

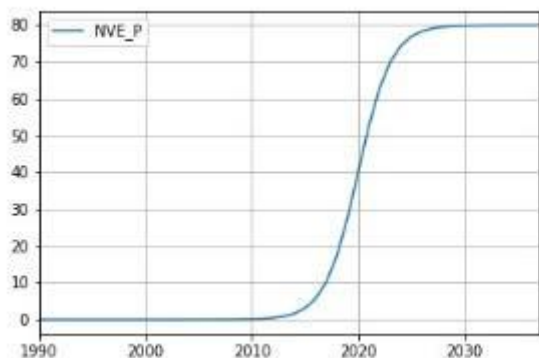


Figure 10: Percentage of newly registered cars equipped with pedestrian-capable AEB in voluntary uptake scenario

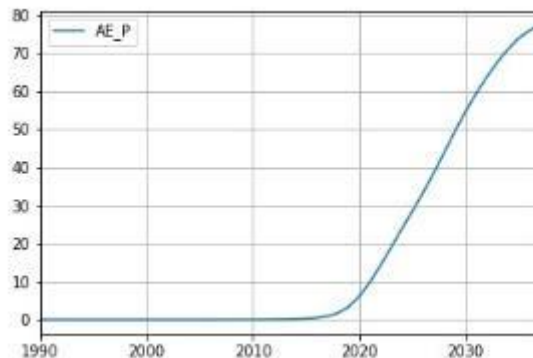


Figure 11: Percentage of all cars within the vehicle fleet equipped with pedestrian-capable AEB in voluntary uptake scenario

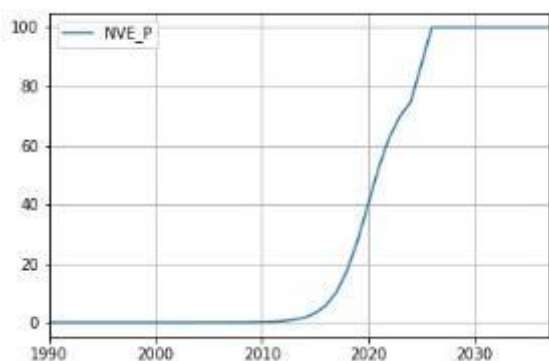


Figure 12: Percentage of newly registered cars equipped with pedestrian-capable AEB in mandatory implementation scenario (new approved types from 2023, all new cars from 2025)

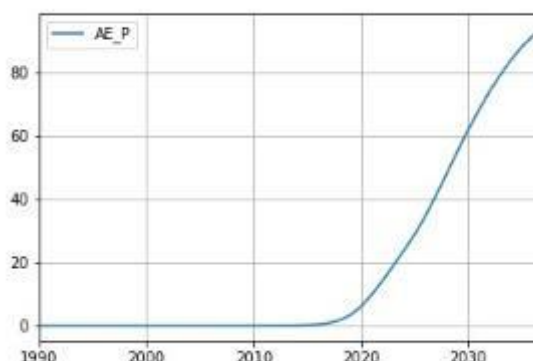


Figure 13: Percentage of all cars within the vehicle fleet equipped with pedestrian-capable AEB in mandatory implementation scenario (new approved types from 2023, all new cars from 2025)

The cost of a policy option is calculated by multiplying per-vehicle cost estimates for each measure with the number of new vehicles of each vehicle category across EU28 that are equipped with the measure in the given year of the analysis according to the output of the fleet calculation model. In the economic calculation model, the monetary values of costs and benefits are subjected to inflation and discounting to determine their present value. The present values of benefits and costs exceeding the baseline, calculated for individual years and summed over the study period, are compared in order to arrive at cost-effectiveness estimates.

A more detailed description of the TRL analytical model is provided in the impact assessment support study outlined in the sub-Annexes below.

4.1.3. COWI model

An Excel-based tool was developed by COWI to assess the impacts of measures related to infrastructure on road safety. The tool covers each EU Member State individually and distinguishes between the TEN-T and non-TEN-T network, drawing on the CARE database¹²⁴ and the TENtec information system¹²⁵.

The approach to quantify impacts on fatalities and injuries includes a number of calculation steps:

- Estimation of the effect of each measure expressed as a percentage reduction of the baseline number of fatalities and serious injuries;
- Estimation of the share of fatalities and serious injuries that the measure apply to;
- Calculation of the expected reduction in the number of fatalities and serious injuries by Member State for the proportion of the fatalities and injuries that are covered by the measure;
- Application of social unit costs of fatalities and serious injuries to the above-calculated reduction to derive the estimated benefits.

The sources for the estimation of the impacts on the number of fatalities and serious injuries are based on two main studies: the Safety Cube project and the Handbook of Road Safety Measures. These studies include almost all evidence available on the impacts of infrastructure on road safety.

SafetyCube review project¹²⁶

The SafetyCube project is a Horizon2020 research project, which aims at *“...developing an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select and implement the most appropriate strategies, measures and cost-effective approaches to reduce casualties of all road user types and all severities”*.

The project involves a review of some 50 infrastructure related road **safety risk factors** and 48 associated **improvement measures**. In total, some 800 papers/studies were coded. Many of the studies reviewed as part of the SafetyCube project are specific **Case studies**, where certain risk factors are analysed in certain geographical locations, including examples of measures applied to address these factors.

The Handbook of Road Safety Measures¹²⁷

Contains summaries regarding the effects of 128 road safety measures. It covers various areas of road safety including: traffic control; vehicle inspection; driver training; publicity campaigns; police

¹²⁴ Source: https://ec.europa.eu/transport/road_safety/specialist/statistics_en

¹²⁵ Source : https://ec.europa.eu/transport/themes/infrastructure-ten-t-connecting-europe/tentec-information-system_en

¹²⁶ See e.g. Filtness A. & Papadimitriou E. (Eds) (2016), Identification of Infrastructure Related Risk Factors, Deliverable 5.1 of the H2020 project SafetyCube.

¹²⁷ Elvik, R., T. Vaa, A. Hove and M. Sorensen eds. (2012) The Handbook of Road Safety Measures: Forth Edition in Norwegian Second ed. In English, 2009.

enforcement; and, general policy instruments. It also covers topics such as post-accident care, and speed cameras.

The main sections and topics of the handbook are:

- Literature Survey and Meta-Analysis
- Factors Contributing to Road Accidents
- Basic Concepts of Road Safety Research
- Assessing the Quality of Evaluation Studies
- Road Design and Road Equipment
- Road Maintenance
- Traffic Control
- Vehicle design and protective devices
- Vehicle and Garage Inspection
- Driver Training and Regulation of Professional Drivers
- Public Education and Information
- Police Enforcement and Sanctions
- Post-Accident Care
- General-Purpose Policy Instruments

The handbook builds upon a large number of case studies, research papers and reports and studies undertaken in many different projects. It is recognised among road safety experts as a central reference point.

The compliance costs¹²⁸ are closely related to the share of fatalities and injuries that are influenced by each measure. For the calculation of the compliance costs (costs of applying the road infrastructure safety management procedures and subsequent investments in changes to the infrastructure), the calculation steps include:

- Estimation of the relevant unit costs per kilometre of road of each measure;
- Estimation of the share of roads (typically in km) where the measure would be applied;
- Calculation of the total compliance costs of the measure.

In the compliance costs estimation, it is assumed that the same share (length) of roads is subject to each measure as the one used for the estimation of the reduced number of fatalities and injuries. There are, however, deviations from this general assumption. For example, the assumption is changed when considering motorcycle friendly guard rails. Such rails are installed where the risk of a crash is high (in turns where there are road side objects etc.). This will typically not be along the entire stretch of road. Therefore, we assume a smaller number of kilometres where the rails are installed, but retain the full impact of the measure on all VRU fatalities and injuries.

Another important assumption is that investments are made firstly where the impacts are highest. This is also the approach outlined in the 14 *case studies* of the EuroRAP SENSOR project¹²⁹ looking at Southern and Eastern European countries. The textbox below outlines how the case study has been used to estimate investment costs needed to correct the safety defects in Member States where there is no specific information about costs of making upgrades.

¹²⁸ In the quantification of economic impacts, 'compliance costs' are costs both to undertake the different procedures and the costs of investing in the safety changes recommended as part of the procedures.

¹²⁹ These case studies are documented in a set of national reports and in a joint summary report: EuroRAP (2016)

SENSOR case studies and the use to estimate costs

The outcome of the SENSOR study is an application of the iRAP EuroRAP method to assess roads using automated detection vehicles. The results are shown in section 4 of the impact assessment support study for the investigated EU Member States¹³⁰.

Part of the work also included a bottom up approach to calculate investments costs in order to remedy the detected safety issues. For the broad categories of issues (e.g. obstacles placed close to the road, missing centre and edge lines, barriers, road surface, additional lanes etc.), measures to correct the defects were proposed and cost-benefit analysis was carried out. For measures with an overall positive evaluation, these were added up in so-called *Safer Roads Investment Plans (SRIP)*.

The costs per km of road is the factor that has been used to calculate the total costs. The costs are adjusted by using *Price level index* and the *Purchase Power Parity (PPP)* to undertake value transfer to other countries.

When calculating costs, it has been assumed that the costs in the SRIP correspond to lifting all roads in the observed countries to 3 star roads.¹³¹ This means that 1 star roads must be “lifted by two stars”, whereas 2 star roads must be “lifted only one star”. This implies that on average, there are twice as many defects to be adjusted on 1 star roads compared to 2 star roads.¹³² For each country, we therefore assume that one km of 1 star roads is twice as costly to adjust compared to one km of 2 star road. The distribution between 1 and 2 star roads in the observed SENSOR countries is used to calculate the weighted average of lifting a road by one star. Or in mathematical terms:

Cost per star lifted per km

$$= 2 * \frac{\#km_{1\ star}}{\#km_{1\ star} + \#km_{2\ star}} SRIP\ costs\ per\ km$$
$$+ \frac{\#km_{2\ star}}{\#km_{1\ star} + \#km_{2\ star}} SRIP\ costs\ per\ km$$

The resulting weighted average costs per km to lift a road by one star is then applied to other countries where specific costs are not provided (after adjusting to the price level in this country).

The resulting average unit costs per km using the approach outlined in the text box are shown in Table 0-1. The resulting compliance costs per km of road that is improved by one star are shown for each country in annex G of the impact assessment support study.

¹³⁰ Final report – Support study for an impact assessment of the revision of Directive 2008/96/EC on road infrastructure safety management and Directive 2004/54/EC on minimum safety requirements for road tunnels in the trans-European network (to be published)

¹³¹ IRAP and EuroRAP use 3 star roads as the reference point for safe roads. Hence, on average the identified defects in the SENSOR study is aiming at lifting roads to 3 stars.

¹³² In reality there may be more individual things to change in lifting a 1 star road to 2 star than a road lifted from 2 star to 3 stars. On the other hand, the possibly fewer things to improve on 2-star roads will be on average more expensive. Due to variations between the specific roads, the assumption is that the total costs per km “per star” that is lifted is the same.

Table 0-1 Estimated costs per km of carriageway¹³³ to address the identified safety defects using the EuroRAP methodology

Country	Country code	Price adjusted million euro/carriageway km
Bulgaria	BG	0.3369
Croatia	HR	0.1102
Greece	EL	0.1556
Hungary	HU	0.0852
Romania	RO	0.2201
Slovakia	SK	0.1052
Slovenia	SI	0.0624
Average		0.1537

Source: SENSOR case study. Note: Prices are adjusted according to price level indexes.

The assessment of administrative costs is based on the EU Standard Cost Model, covering the costs of reporting obligations.

To calculate the present values of the benefits (and the costs), the following set of assumptions has been applied.

Table 0-2 Cost benefit analysis - assumptions

Parameter	Unit	Assumption	Comment
Time horizon	years	2020-2050	A sensitivity analysis is carried out, where only a ten year period is analysed (2020-2030)
First year of effect from measures	year	2020	It is assumed that the measures will have an effect on the number of fatalities and injuries from 2020 onwards
Implementation period	years	10	It is assumed that all measures are implemented gradually over ten years and the effects follow the implementation.
Social discount rate (SDR)	%	4%	The Better Regulation Guidelines suggest the use of 4% as the social discount rate for impact assessments. It is mentioned that when considering road infrastructure with long life times, a lower or a declining rate could be used.
Inflation	% per year	Harmonized Index of Consumer Prices (HICP)	All costs and benefits have been expressed in 2016 prices based on the HICP from Eurostat.
Price Level Index	Index	Calculated for all countries	The price level index, drawing on Eurostat and European Central Bank, is used to account for the different price levels in each country.

4.1.4. PRIMES-TREMOVE, TRL and COWI models role in the impact assessment

The *PRIMES-TREMOVE transport model* is a building block of the modelling framework used for developing the EU Reference scenario 2016, and has a successful record of use in the Commission's transport, climate and energy policy analytical work – it is the same model as used for the 2011 White Paper on Transport and the 2016 European strategy on low-emission mobility.

¹³³ Carriageways corresponds to main roads and motorways, but not to smaller roads, nor to general urban roads. The costs are estimated in the SENSOR study. They are not the result of actual investments made.

The *TRL model* is a simulation tool assessing the impact of vehicle technologies on road safety in the context of the revision of the General Safety Regulation and Pedestrian Safety Regulation.

In this impact assessment, building on an update of the EU Reference scenario 2016 (including few policy measures that have been adopted after its cut-off date i.e. end of 2014), the PRIMES-TREMOVE model together with the TRL model have been used to define the common Baseline scenario used for the purpose of the present impact assessment report and for the impact assessment accompanying the revision of the General Safety Regulation and Pedestrian Safety Regulation. In the first step, the TRL model has been calibrated on the projected evolution of the vehicle stock from the update of the EU Reference scenario 2016. In the second step, the impact of mandatory and voluntary vehicle technology measures on the number of fatalities, serious and slight injuries has been assessed at EU28 and Member State levels with the TRL and PRIMES-TREMOVE models drawing on input from TRL.

The COWI tool has been calibrated on the Baseline scenario developed with the PRIMES-TREMOVE and TRL model and has been subsequently used for assessing the impacts of infrastructure measures on road safety and performing cost-benefit analysis in the context of this impact assessment. The TRL model has been used for assessing the impacts of vehicle technologies on road safety and performing cost-benefit analysis in the context of the impact assessment accompanying the revision of the General Safety Regulation and Pedestrian Safety Regulation.

4.2. Baseline scenario

4.2.1. Scenario design, consultation process and quality assurance

The Baseline scenario used in this impact assessment builds on the EU Reference scenario 2016 but additionally includes few policy measures adopted after its cut-off date (end of 2014) and some updates in the technology costs assumptions.

Building on the EU Reference scenario is a regular exercise by the Commission. It is coordinated by DGs ENER, CLIMA and MOVE in association with the JRC, and the involvement of other services via a specific inter-service group.

For the EU Reference scenario 2016, Member States were consulted throughout the development process through a specific Reference scenario expert group which met three times during its development. Member States provided information about adopted national policies via a specific questionnaire, key assumptions have been discussed and in each modelling step, draft Member State specific results were sent for consultation. Comments of Member States were addressed to the extent possible, keeping in mind the need for overall comparability and consistency of the results.

Quality of modelling results was assured by using state of the art modelling tools, detailed checks of assumptions and results by the coordinating Commission services as well as by the country specific comments by Member States.

The EU Reference scenario 2016 projects EU and Member States energy, transport and GHG emission-related developments up to 2050, given current global and EU market trends and adopted EU and Member States' energy, transport, climate and related relevant policies. "Adopted policies" refer to

those that have been cast in legislation in the EU or in MS (with a cut-off date end of 2014¹³⁴). Therefore, the binding 2020 targets are assumed to be reached in the projection. This concerns greenhouse gas emission reduction targets as well as renewables targets, including renewables energy in transport. The EU Reference scenario 2016 provides projections, not forecasts. Unlike forecasts, projections do not make predictions about what the future will be. They rather indicate what would happen if the assumptions which underpin the projection actually occur. Still, the scenario allows for a consistent approach in the assessment of energy and climate trends across the EU and its Member States.

The report "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"¹³⁵ describes the inputs and results in detail. In addition, its main messages are summarised in the impact assessments accompanying the Effort Sharing Regulation¹³⁶ and the revision of the Energy Efficiency Directive¹³⁷, and the analytical work accompanying the European strategy on low-emission mobility¹³⁸.

PRIMES-TREMOVE is one of the core models of the modelling framework used for developing the EU Reference scenario 2016 and has also been used for developing the Baseline scenario of this impact assessment in connection with the TRL model. The model was calibrated on transport and energy data up to year 2013 from Eurostat and other sources.

4.2.2. Main assumptions of the Baseline scenario

The projections are based on a set of assumptions, including on population growth, macroeconomic and oil price developments, technology improvements, and policies.

Macroeconomic assumptions

The Baseline scenario uses the same macroeconomic assumptions as the EU Reference scenario 2016. The population projections draw on the European Population Projections (EUROPOP 2013) by Eurostat. The key drivers for demographic change are: higher life expectancy, convergence in the fertility rates across Member States in the long term, and inward migration. The EU28 population is expected to grow by 0.2% per year during 2010-2030 (0.1% for 2010-2050), to 516 million in 2030 (522 million by 2050). Elderly people, aged 65 or more, would account for 24% of the total population by 2030 (28% by 2050) as opposed to 18% today.

GDP projections mirror the joint work of DG ECFIN and the Economic Policy Committee, presented in the 2015 Ageing Report¹³⁹. The average EU GDP growth rate is projected to remain relatively low at 1.2% per year for 2010-2020, down from 1.9% per year during 1995-2010. In the medium to long term, higher expected growth rates (1.4% per year for 2020-2030 and 1.5% per year for 2030-2050) are taking account of the catching up potential of countries with relatively low GDP per capita, assuming convergence to a total factor productivity growth rate of 1% in the long run.

¹³⁴ In addition, amendments to two Directives only adopted in the beginning of 2015 were also considered. This concerns notably the ILUC amendment to the Renewables Directive and the Market Stability Reserve Decision amending the ETS Directive.

¹³⁵ ICCS-E3MLab et al. (2016), EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050

¹³⁶ SWD(2016) 247

¹³⁷ SWD(2016) 405

¹³⁸ SWD(2016) 244

¹³⁹ European Commission/DG ECFIN (2014), The 2015 Ageing Report: Underlying Assumptions and Projection Methodologies, European Economy 8/2014.

Fossil fuel price assumptions

Oil prices used in the Baseline scenario are the same with those of the EU Reference scenario 2016. Following a gradual adjustment process with reduced investments in upstream productive capacities by non-OPEC¹⁴⁰ countries, the quota discipline is assumed to gradually improve among OPEC members and thus the oil price is projected to reach 87 \$/barrel in 2020 (in year 2013-prices). Beyond 2020, as a result of persistent demand growth in non-OECD countries driven by economic growth and the increasing number of passenger cars, oil price would rise to 113 \$/barrel by 2030 and 130 \$/barrel by 2050.

Techno-economic assumptions

For all transport means, except for light duty vehicles (i.e. passenger cars and light commercial vehicles), the Baseline scenario uses the same technology costs assumptions as the EU Reference scenario 2016.

For light duty vehicles, the data for technology costs and emissions savings has been updated based on a recent study commissioned by DG CLIMA¹⁴¹. Battery costs for electric vehicles are assumed to go down to 205 euro/kWh by 2030 and 160 euro/kWh by 2050; further reductions in the cost of both spark ignition gasoline and compression ignition diesel are assumed to take place. Technology cost assumptions are based on extensive literature review, modelling and simulation, consultation with relevant stakeholders, and further assessment by the Joint Research Centre (JRC) of the European Commission.

Specific policy assumptions

The key policies included in the Baseline scenario, similarly to the EU Reference scenario 2016, are¹⁴²:

- CO₂ standards for cars and vans regulations (Regulation (EC) No 443/2009, amended by Regulation (EU) No 333/2014 and Regulation (EU) No 510/2011, amended by Regulation (EU) No 253/2014); CO₂ standards for cars are assumed to be 95gCO₂/km as of 2021 and for vans 147gCO₂/km as of 2020, based on the NEDC test cycle, in line with current legislation. No policy action to strengthen the stringency of the target is assumed after 2020/2021.
- The Renewable Energy Directive (Directive 2009/28/EC) and Fuel Quality Directive (Directive 2009/30/EC) including ILUC amendment (Directive 2015/1513/EU): achievement of the legally binding RES target for 2020 (10% RES in transport target) for each Member State, taking into account the use of flexibility mechanisms when relevant as well as of the cap on the amount of food or feed based biofuels (7%). Member States' specific renewable energy policies for the heating and cooling sector are also reflected where relevant.
- Directive on the deployment of alternative fuels infrastructure (Directive 2014/94/EU).
- Directive on the charging of heavy goods vehicles for the use of certain infrastructures (Directive 2011/76/EU amending Directive 1999/62/EC).

¹⁴⁰ OPEC stands for Organization of Petroleum Exporting Countries.

¹⁴¹ Source: https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/technology_results_web.xlsx

¹⁴² For a comprehensive discussion see the Reference scenario report: "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"

- Relevant national policies, for instance on the promotion of renewable energy, on fuel and vehicle taxation, are taken into account.

In addition, a few policy measures adopted after the cut-off date of the EU Reference scenario 2016 at both EU and Member State level, have been included in the Baseline scenario:

- Directive on weights & dimensions (Directive 2015/719/EU);
- Directive as regards the opening of the market for domestic passenger transport services by rail and the governance of the railway infrastructure (Directive 2016/2370/EU);
- Directive on technical requirements for inland waterway vessels (Directive 2016/1629/EU), part of the Naiades II package;
- Regulation establishing a framework on market access to port services and financial transparency of ports¹⁴³;
- The replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonized Light-vehicles Test Procedure (WLTP) has been implemented in the Baseline scenario, drawing on work by JRC. Estimates by JRC show a WLTP to NEDC CO₂ emissions ratio of approximately 1.21 when comparing the sales-weighted fleet-wide average CO₂ emissions. WLTP to NEDC conversion factors are considered by individual vehicle segments, representing different vehicle and technology categories¹⁴⁴.
- Changes in road charges in Germany, Austria, Belgium and Latvia.

Safety measures assumptions

Reflecting the plateauing in the number of fatalities and injuries in the recent years, in the Baseline scenario it has been assumed that post-2016 vehicle technologies would be the main source of reduction in fatalities, serious and slight injuries while measures addressing infrastructure safety (such as the existing RISM and Tunnel Directives), and driver behaviour (such as legislation improving enforcement across borders, namely Directive 2015/413/EU facilitating cross-border exchange of information on road safety related traffic offences) would compensate for the increase in traffic over time. The following vehicle technologies safety measures are covered by the Baseline scenario:

- The impact of highly effective existing vehicle technologies safety measures, which have been mandatory for a few years, but are still dispersing into the vehicle fleet (standard electronic stability control systems for all vehicle categories, and advanced emergency braking systems and lane departure warning systems for all new heavy goods vehicles and buses), are modelled to reduce the remaining target populations for the proposed measures.¹⁴⁵
- Voluntary uptake of vehicle technology safety measures. The list of these measures is provided in Table 1.

¹⁴³ Awaiting signature of act (Source :

[http://www.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2013/0157\(COD\)&l=en](http://www.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2013/0157(COD)&l=en)

¹⁴⁴ Simulation at individual vehicle level is combined with fleet composition data, retrieved from the official European CO₂ emissions monitoring database, and publicly available data regarding individual vehicle characteristics, in order to calculate vehicle CO₂ emissions and fuel consumption over different conditions. Vehicle CO₂ emissions are initially simulated over the present test protocol (NEDC) for the 2015 passenger car fleet; the accuracy of the method is validated against officially monitored CO₂ values and experimental data.

¹⁴⁵ Standard electronic stability control systems are mandatory for all new vehicles and vehicle categories since 1 November 2014 and from 1 November 2015, all new trucks and buses must also be equipped with advanced emergency braking systems as well as lane departure warning systems.

Table 0-3: List of vehicle technology safety measures considered for voluntary uptake

Measure	Description	Applicable vehicle categories			
AEB-VEH	Autonomous emergency braking for vehicles (moving and stationary targets)	M1		N1	
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	M1		N1	
ALC	Alcohol interlock installation document	M1	M2&M3	N1	N2&N3
DDR-DAD	Drowsiness and attention detection	M1	M2&M3	N1	N2&N3
DDR-ADR	Advanced distraction recognition	M1	M2&M3	N1	N2&N3
EDR	Event data recorder	M1		N1	
ESS	Emergency stop signal	M1	M2&M3	N1	N2&N3
FFW-137	Full-width frontal occupant protection (current R137 configuration with Hybrid III ATDs)	M1		N1	
FFW-THO	Full-width frontal occupant protection (introduction of THOR-M ATDs and lower appropriate injury criteria thresholds to encourage adaptive restraints)	M1		N1	
HED-MGI	Adult head-to-windscreen impact (mandatory HIC limit in headform-to-glass impact tests; no mandatory A-pillar impact)	M1		N1	
ISA-VOL	Intelligent speed assistance (voluntary type system; can be overridden by driver and switched off for the rest of journey)	M1	M2&M3	N1	N2&N3
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	M1		N1	
PSI	Pole side impact occupant protection	M1		N1	
REV	Reversing camera system	M1	M2&M3	N1	N2&N3
TPM	Tyre pressure monitoring system		M2&M3	N1	N2&N3
VIS-DET	Front and side vulnerable road user detection and warning (no auto braking)		M2&M3		N2&N3
VIS-DIV	Minimum direct vision requirement (best-in-class approach)		M2&M3		N2&N3

The year that full voluntary implementation is achieved represents the time necessary for the measure to reach maturity in terms of full voluntary adoption into new vehicle registrations. All but three measures were assumed to have a long voluntary implementation phase, with 14 years between launch of the technology and full voluntary implementation. Car fitment Event Data Recorders (EDR) and Full-width frontal protection based on current UN Regulation No. 137 with the Hybrid III dummy (FFW-137) were given a shorter voluntary uptake period of 6 years. This was justified based on the percentage of vehicles in the fleet already expected to meet the regulatory requirements for the system, which matches the predicted final voluntary uptake levels. A medium and a long length adoption period were used for vans and heavier vehicle uptake of EDRs, respectively.

The voluntary take up of technology and the implementation within the fleet was selected to be one of three possible options:

1. None = No voluntary uptake, regulatory action required to drive adoption
2. Medium = 40% voluntary propagation within the fleet without additional stimuli
3. High = 80% voluntary propagation leaving the 20% of vehicles which wouldn't be equipped without regulatory action

These values represent point estimates for the resulting final uptake in the fleet. The full voluntary uptake levels for each measure are provided in Table 0-4.

Table 0-4: Maximum voluntary uptake of vehicle technologies for new registrations

	M1	M2&M3	N1	N2&N3
AEB-VEH	High	High	High	High
AEB-PCD (pedestrian)	High	n/a	Medium	n/a
AEB-PCD (cyclist)	High	n/a	Medium	n/a
ALC	None	None	None	None
DDR-DAD	Medium	Medium	Medium	Medium
DDR-ADR	None	None	None	None
EDR	Medium	n/a	Medium	n/a
ESC	High	High	High	High
ESS	High	High	High	High
FFW-137	High	n/a	Medium	n/a
FFW-THO	High	n/a	Medium	n/a
HED-MGI	None	n/a	None	n/a
ISA-VOL	None	None	None	None
LDW	n/a	High	n/a	High
LKA-ELK	Medium	n/a	Medium	n/a
PSI	High	n/a	None	n/a
REV	Medium	None	Medium	None
TPM	n/a	None	None	None
VIS-DET	n/a	None	n/a	None
VIS-DIV	n/a	Medium	n/a	Medium

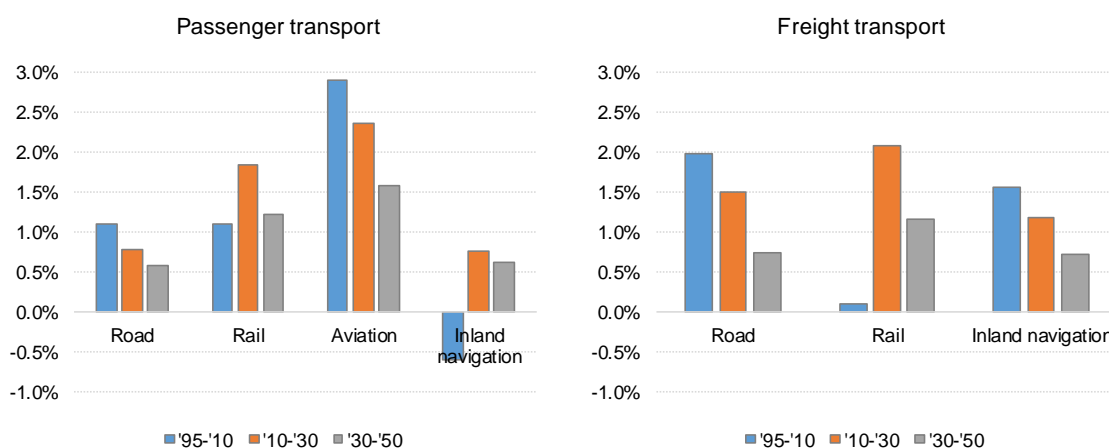
4.2.3. Summary of main results of the Baseline scenario

EU transport activity is expected to continue growing under current trends and adopted policies beyond 2015, albeit at a slower pace than in the past. Freight transport activity for inland modes is projected to increase by 36% between 2010 and 2030 (1.5% per year) and 60% for 2010-2050 (1.2% per year). Passenger traffic growth would be slightly lower than for freight at 23% by 2030 (1% per year) and 42% by 2050 (0.9% per year for 2010-2050). The annual growth rates by mode, for passenger and freight transport, are provided in Figure 0-14¹⁴⁶.

¹⁴⁶ Projections for international maritime and international extra-EU aviation are presented separately and not included in the total passenger and freight transport activity to preserve comparability with statistics for the historical period.

Road transport would maintain its dominant role within the EU. The share of road transport in inland freight is expected to slightly decrease at 70% by 2030 and 69% by 2050. The activity of heavy goods vehicles expressed in tonnes kilometres is projected to grow by 35% between 2010 and 2030 (56% for 2010-2050) in the Baseline scenario, while light goods vehicles activity would go up by 27% during 2010-2030 (50% for 2010-2050). For passenger transport, road modal share is projected to decrease by 4 percentage points by 2030 and by additional 3 percentage points by 2050. Passenger cars and vans would still contribute 70% of passenger traffic by 2030 and about two thirds by 2050, despite growing at lower pace (17% for 2010-2030 and 31% during 2010-2050) relative to other modes, due to slowdown in car ownership increase which is close to saturation levels in many EU15 Member States and shifts towards rail.

Figure 0-14: EU passenger and freight transport projections (average growth rate per year)



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

Note: For aviation, domestic and international intra-EU activity is reported, to maintain the comparability with reported statistics.

High congestion levels are expected to seriously affect road transport in several Member States by 2030 in the absence of effective countervailing measures such as road pricing. While urban congestion will mainly depend on car ownership levels, urban sprawl and the availability of public transport alternatives, congestion on the inter-urban network would be the result of growing freight transport activity along specific corridors, in particular where these corridors cross urban areas with heavy local traffic. The largest part of congestion will be concentrated near densely populated zones with high economic activity such as Belgium and the Netherlands – to a certain extent as a result of port and transshipment operations – and in large parts of Germany, the United Kingdom and northern Italy.

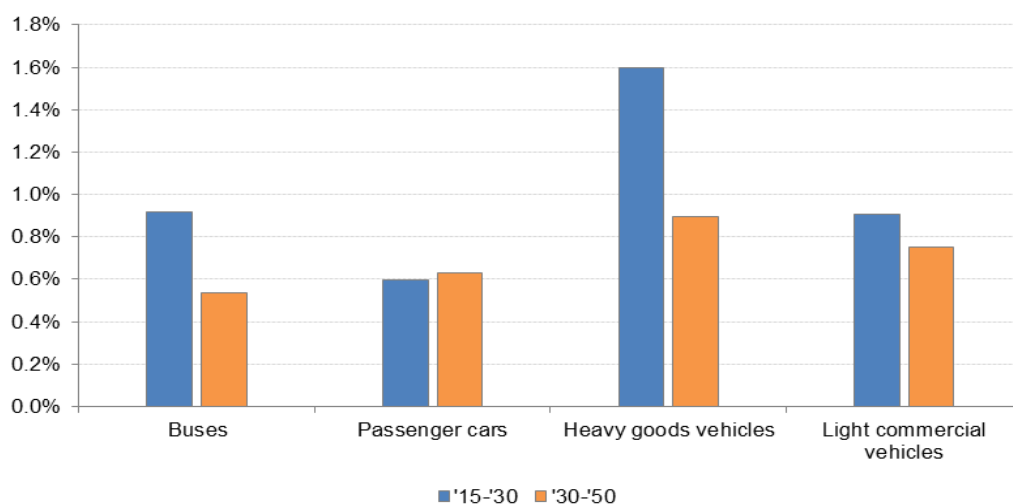
The PRIMES-TREMOVE model considers the stock of transport means inherited from previous periods, calculates scrapping due to technical lifetime, evaluates the economics of possible premature scrapping and determines the best choice of new transport means, which are needed to meet demand. The choices are based on cost minimisation, which include anticipation factors.¹⁴⁷

¹⁴⁷ There are several factors influencing the choice of a new transport means, covering payable and non-payable elements. True payable costs include all cost elements over the lifetime of the candidate transport means: purchasing cost; annual fixed costs for maintenance, insurance and ownership/circulation taxation; variable costs for fuel consumption depending on trip type and operation conditions; other variable costs including congestion charges, parking fees, etc. Other factors, like perceived cost factors, which do not necessarily imply true payments by the user but may imply

The road transport vehicle fleet is projected to continue growing over time, driven by developments in transport activity. The heavy goods vehicle fleet is projected to grow by 27% between 2015 and 2030 (1.6% per year) and 52% for 2015-2050 (0.9% per year). Growth in the light commercial vehicle stock is projected to be somewhat lower at 15% between 2015 and 2030 (0.9% per year) and 33% during 2015-2050 (0.8% per year).

The passenger cars fleet would grow at a lower pace compared to heavy goods and light commercial vehicles: 9% by 2030 (0.6% per year) and 24% by 2050 (0.6% per year), driven by slowdown in car ownership increase which as explained above is close to saturation levels in many EU15 Member States. The buses and coaches fleet is also projected to go up, at rates similar to those of light commercial vehicles: 15% increase between 2015 and 2030 (0.9% per year) and 28% during 2015-2050 (0.5% per year).

Figure 0-15: Road transport vehicle stock projections by type of vehicle (average growth rate per year) at EU level

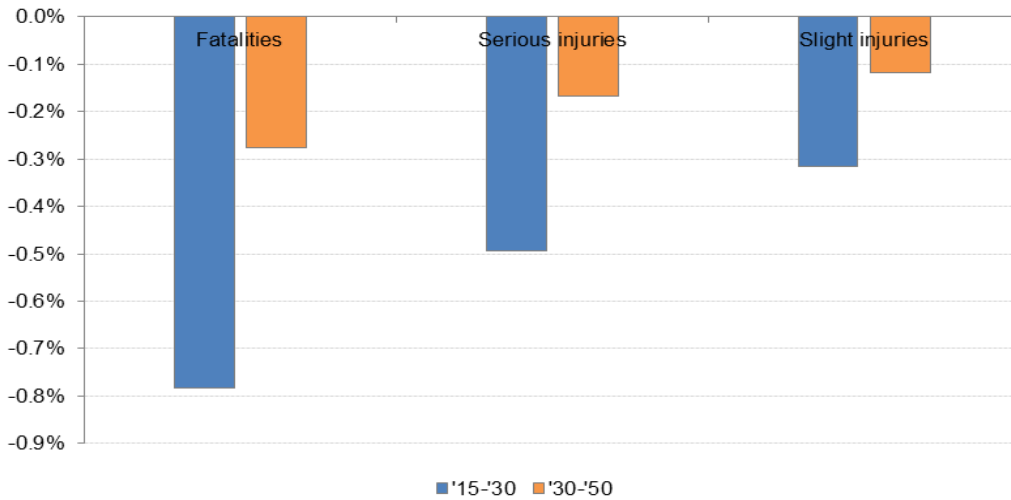


Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

Under current trends and adopted policies, measures addressing infrastructure safety and driver behaviour would compensate for the increase in traffic over time while the uptake of the mandatory and voluntary vehicle technology safety measures described above would result in further decreases in the number of fatalities, serious and slight injuries over time. The number of fatalities is projected to go down by 11% between 2015 and 2030 (9% for 2016-2030) and 16% during 2015-2050 (14% for 2016-2050), while the reduction in the serious injuries is expected to be lower at 7% by 2030 (6% for 2016-2030) and 10% by 2050 (10% for 2016-2050). Slight injuries are also projected to drop by 2050, however, at much lower pace than fatalities and serious injuries (5% for 2015-2030 and 7% for 2015-2050).

indirect costs are influencing decisions about choice of new vehicles. They reflect technical risk of yet immature technologies, acceptance factors representing market penetration, density of refuelling/recharging infrastructure applicable to technologies using alternative fuels and those that have range limitations.

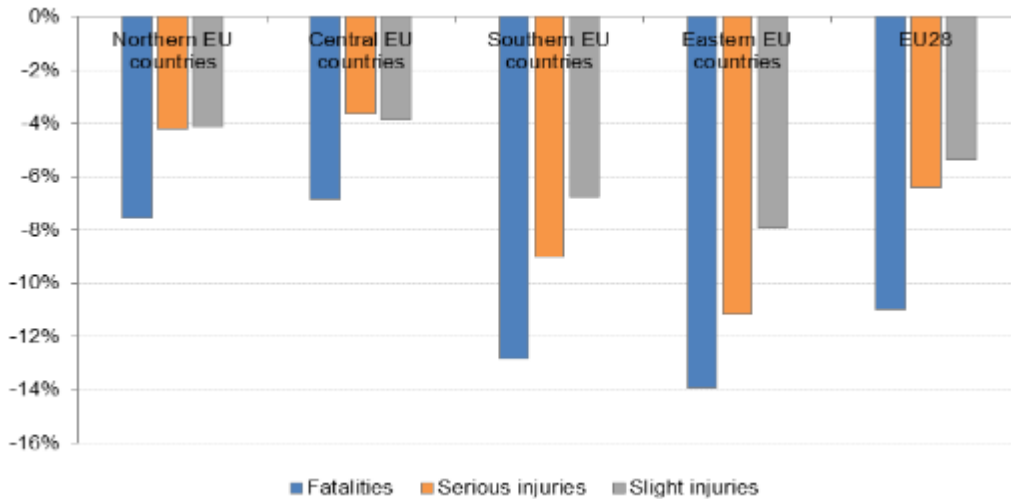
Figure 0-16: Evolution of fatalities, serious and slight injuries over the 2015-2050 time horizon (average growth rate per year)



Source: Baseline scenario, TRL model and PRIMES-TREMOVE transport model (ICCS-E3MLab)

In the Baseline scenario, the evolution of fatalities, serious and slight injuries by EU region continues recent trends observed in the historical data, with the Eastern and Southern EU countries showing the highest decrease in the number of casualties.

Figure 0-17: Evolution of fatalities, serious and slight injuries by EU region between 2015 and 2030 (cumulative growth rates)



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab) and TRL model

4.2.4. Baseline scenario – sensitivity analysis

Considering the high uncertainty surrounding the evolution of fatalities and injuries, sensitivity analysis has been performed on the Baseline scenario. An alternative optimistic and a pessimistic baseline scenario have been considered:

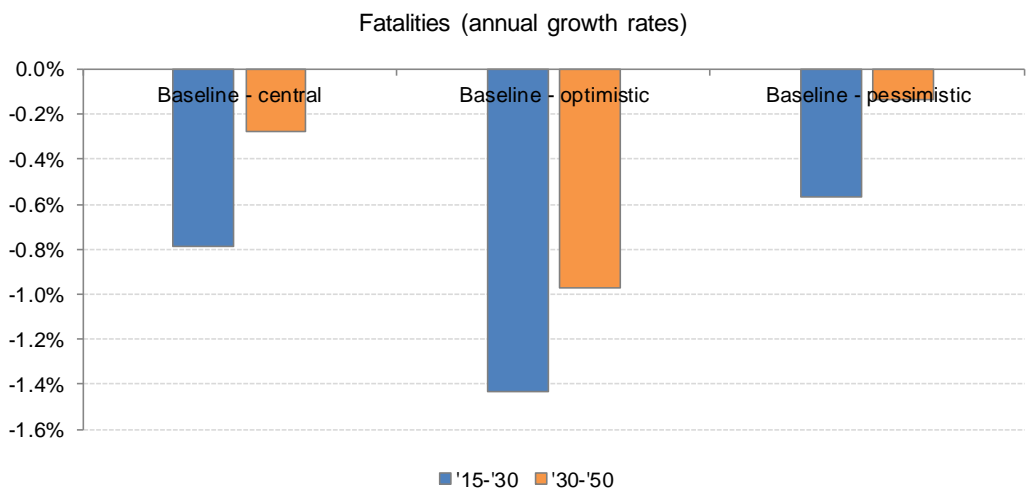
- In the optimistic baseline scenario, it is assumed that the slight reduction of fatalities and serious injuries observed during 2014-2016 (0.7% per year) would come from infrastructure, driver

behaviour and other factors (mandatory vehicles technologies) and the trend of a continuous 0.7% reduction relative to the previous year would be continued in time. In addition, the voluntary uptake of vehicle technologies measures is assumed to be the same as in the main Baseline scenario.

- In the pessimistic baseline scenario, it is assumed that post-2016 vehicle technologies would be the main source of reductions in fatalities, serious and slight injuries, while measures addressing infrastructure safety and driver behaviour and other factors would compensate for the increase in traffic over time. However, a lower estimate of technology take up was modelled to represent a scenario where voluntary fitment of the voluntary measures reaches only half the maximum percentages quoted in Section 0.

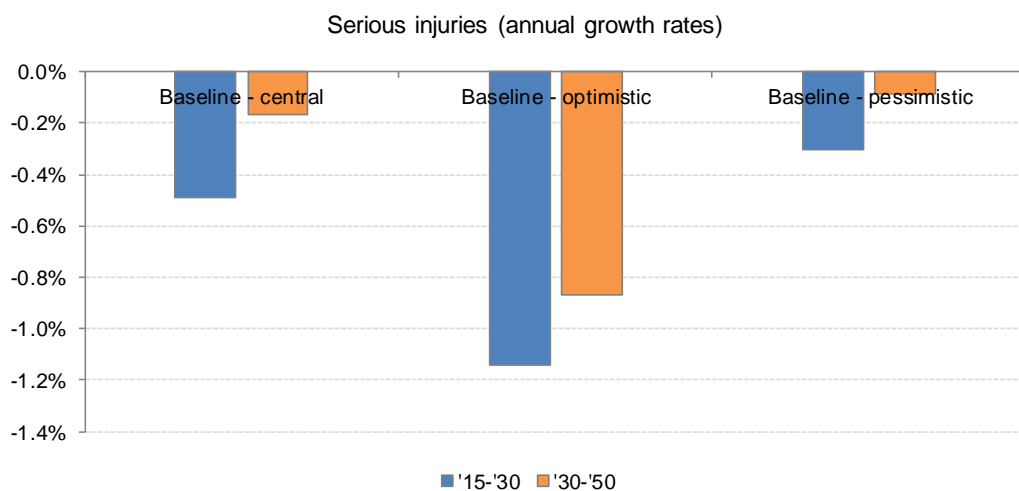
The projected evolution of fatalities, serious and slight injuries over the 2015-2050 horizon in the optimistic and pessimistic baseline scenarios is presented in figures 0-18 to 0-20. It is compared with the central baseline scenario described in the previous section. In cumulative terms, between 2016 and 2030 the number of fatalities is projected to go down by 18% in the optimistic baseline scenario and 6% in the pessimistic scenario relative to 9% in the central baseline scenario. Similarly, serious injuries would decrease by 15% in the optimistic baseline and 4% in the pessimistic baseline compared to 6% in the central baseline scenario while slight injuries would go down by 15% in the optimistic baseline and 4% in the pessimistic baseline relative to 7% in the central baseline scenario.

Figure 0-18: Evolution of fatalities over the 2015-2050 time horizon (average growth rate per year) in the optimistic and pessimistic baseline scenarios



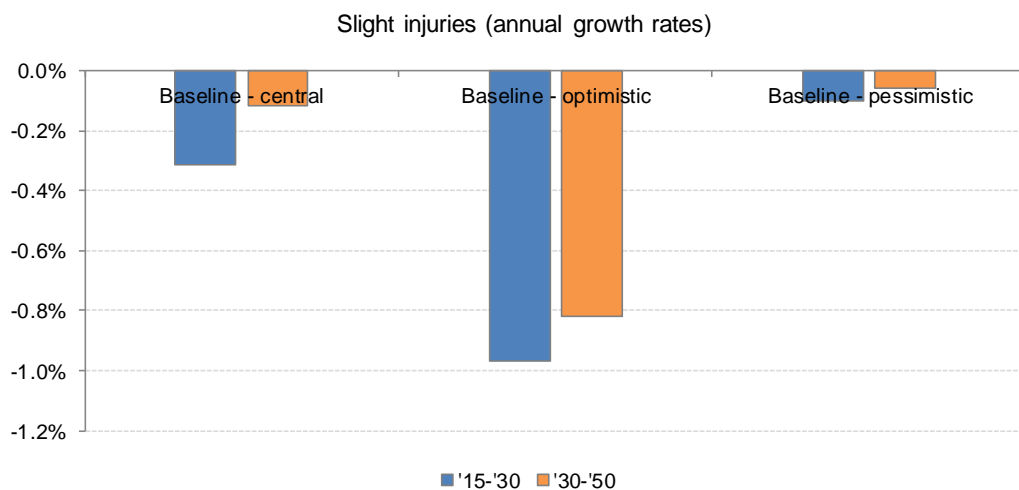
Source: Baseline scenario, TRL model and PRIMES-TREMOVE transport model (ICCS-E3MLab)

Figure 0-19: Evolution of serious injuries over the 2015-2050 time horizon (average growth rate per year) in the optimistic and pessimistic baseline scenarios



Source: Baseline scenario, TRL model and PRIMES-TREMOVE transport model (ICCS-E3MLab)

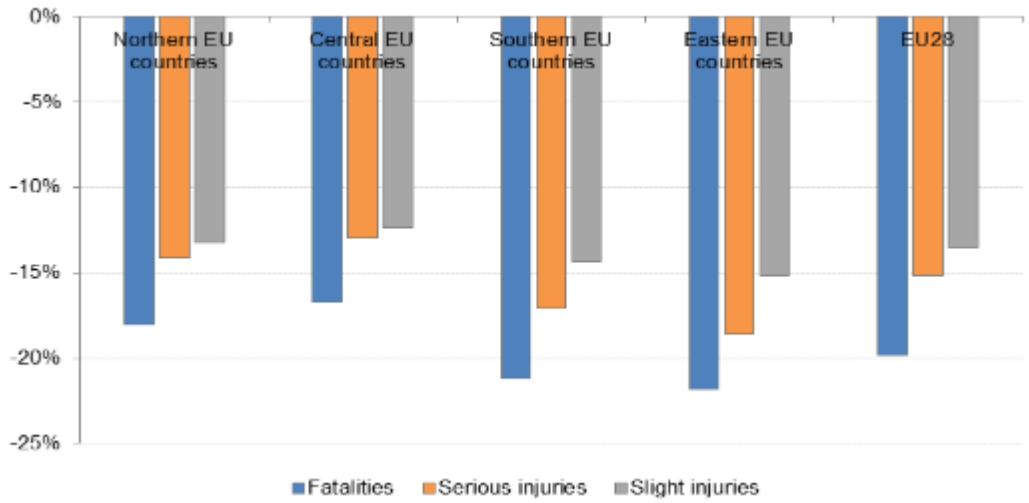
Figure 0-20: Evolution of slight injuries over the 2015-2050 time horizon (average growth rate per year) in the optimistic and pessimistic baseline scenarios



Source: Baseline scenario, TRL model and PRIMES-TREMOVE transport model (ICCS-E3MLab)

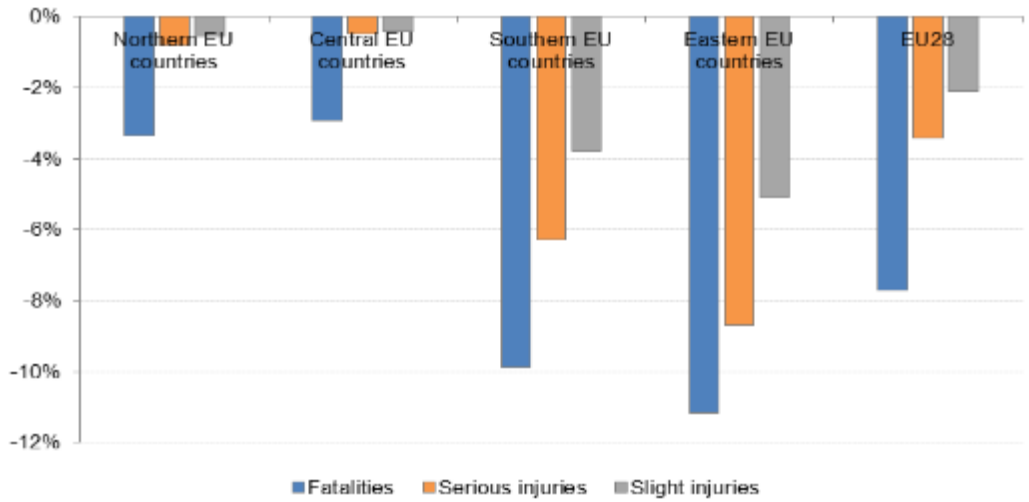
Similarly to the central baseline scenario, the evolution of fatalities, serious and slight injuries by EU region in the optimistic and pessimistic baseline scenarios continues recent trends observed in the historical data, with the Eastern and Southern EU countries showing higher decreases in the number of casualties relative to the Northern and Central EU countries.

Figure 0-21: Evolution of fatalities, serious and slight injuries by EU region between 2015 and 2030 (cumulative growth rates) in the optimistic baseline scenario



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab) and TRL model

Figure 0-22: Evolution of fatalities, serious and slight injuries by EU region between 2015 and 2030 (cumulative growth rates) in the pessimistic baseline scenario



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab) and TRL model

Annex 4.0 **Cost-effectiveness analysis of Policy Options for the mandatory implementation of different sets of vehicle safety measures – Review of the General Safety and Pedestrian Safety Regulations**

Annex 4.1 **Executive summary**

Objective:

The objective of this in-depth cost-benefit study was to calculate concrete cost-effectiveness indicators and numbers of future casualties that could be prevented at a European level for three sets of safety measures proposed by the European Commission and considered for mandatory implementation in new vehicles starting from 2021.

Methodology and scope:

The European Commission has defined three policy options, i.e. **sets of safety measures to be implemented on a mandatory basis**, for this cost-effectiveness study to assess:

- **PO1:** State-of-the-art and widely available package of safety solutions that are not yet mandatory in EU; their fitment varies from around 5–90%
- **PO2:** As PO1 with added safety solutions that focus on vulnerable road user protection and on ensuring driver attention to the driving task
- **PO3:** As PO2 with safety solutions that are either feasible or already exist in the marketplace, but that have a low fitment rate and market uptake, that maximises overall casualty savings and can boost safety solutions' innovation

The policy options are each studied for their cost-effectiveness compared to a baseline scenario (PO0), where none of the measures are implemented on a mandatory basis, but voluntary uptake would continue.

Table 5 presents a full list of the safety measures considered for vehicle categories M1 (passenger cars), M2&M3 (buses and coaches), N1 (vans), and N2&N3 (trucks). Table 6 to Table 9 presents an overview of the sets of measures to be implemented in each policy option and the proposed introduction dates. Table 10 presents the cost estimates per vehicle category for each of the policy options assessed.

A simulation and calculation model was developed to estimate the benefits and costs associated with each policy option. The scope of the cost-effectiveness evaluation was:

- Geographic scope: EU-28
- Vehicle categories covered: M1, M2&M3, N1, N2&N3
- Evaluation period: 2021–2037
- Baseline scenario: No further policy intervention in the transport sector, but voluntary improvements and effects of already implemented policies continue. Continued dispersion of mandatory vehicle safety measures into the legacy fleet and continued voluntary uptake of the safety measures under consideration.
- Evaluated scenarios: Three sets of safety measures (PO1, PO2 and PO3) implemented on a mandatory basis
- Benefits considered: Monetary values of casualties prevented by safety measures

- Costs considered: Cost to vehicle manufacturers of fitment of safety measures to new vehicles
- Treatment of uncertainty: Interval analysis and scenario analysis
- Results: Benefit-to-cost ratios (BCRs), based on present monetary values and casualties prevented, compared to the baseline scenario over the entire evaluation period

Note that the model takes into account:

- the interactions of all measures when implemented together (to avoid double-counting of casualties prevented by different measures), and
- the effects of already existing mandatory measures (AEB-VEH and LDW for M2&M3 and N2&N3, ESC for all categories) that are still dispersing into the fleet on the European casualty target populations.

Table 5: List of safety measures considered for mandatory implementation

Measure	Description	Applicable vehicle categories			
		M1	M2&M3	N1	N2&N3
AEB-VEH	Autonomous emergency braking for vehicles (moving and stationary targets)	M1		N1	
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	M1		N1	
ALC	Alcohol interlock installation document	M1	M2&M3	N1	N2&N3
DDR-DAD	Drowsiness and attention detection	M1	M2&M3	N1	N2&N3
DDR-ADR	Advanced distraction recognition	M1	M2&M3	N1	N2&N3
EDR	Event data recorder	M1		N1	
ESS	Emergency stop signal	M1	M2&M3	N1	N2&N3
FFW-137	Full-width frontal occupant protection (current R137 configuration with Hybrid III ATDs)	M1		N1	
FFW-THO	Full-width frontal occupant protection (introduction of THOR-M ATDs and lower appropriate injury criteria thresholds to encourage adaptive restraints)	M1		N1	
HED-MGI	Adult head-to-windscreen impact (mandatory HIC limit in headform-to-glass impact tests; no mandatory A-pillar impact)	M1		N1	
ISA-VOL	Intelligent speed assistance (voluntary type system; can be overridden by driver and switched off for the rest of journey)	M1	M2&M3	N1	N2&N3
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	M1		N1	
PSI	Pole side impact occupant protection	M1		N1	
REV	Reversing camera system	M1	M2&M3	N1	N2&N3
TPM	Tyre pressure monitoring system		M2&M3	N1	N2&N3
VIS-DET	Front and side vulnerable road user detection and warning (no auto braking)		M2&M3		N2&N3
VIS-DIV	Minimum direct vision requirement (best-in-class approach)		M2&M3		N2&N3

Table 6: Policy options for passenger cars (M1); letters indicate mandatory introduction dates¹⁴⁸, dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (M1)	PO2 (M1)	PO3 (M1)
AEB-VEH	–	A	A	A
AEB-PCD	–	–	B	B
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
EDR	–	A	A	A
ESS	–	A	A	A
FFW-137	–	A	A	A
FFW-THO	–	–	A	A
HED-MGI	–	–	B	B
ISA-VOL	–	–	A	A
LKA-ELK	–	A	A	A
PSI	–	A	A	A
REV	–	–	–	A

Table 28: Policy options for buses and coaches (M2&M3); letters indicate mandatory introduction dates, dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (M2&M3)	PO2 (M2&M3)	PO3 (M2&M3)
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
ESS	–	A	A	A
ISA-VOL	–	–	A	A
REV	–	–	–	A
TPM	–	–	–	A
VIS-DET	–	–	A	A
VIS-DIV	–	–	C	C

¹⁴⁸ The introduction dates for mandatory fitment are coded in the tables as follows:

- **A:** 1st September 2021 (new approved types), 1st September 2023 (new vehicles)
- **B:** 1st September 2023 (new approved types), 1st September 2025 (new vehicles)
- **C:** 1st September 2025 (new approved types), no mandatory introduction for new vehicles

Table 29: Policy options for vans (N1); letters indicate mandatory introduction dates¹⁴⁹, dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (N1)	PO2 (N1)	PO3 (N1)
AEB-VEH	–	A	A	A
AEB-PCD	–	–	B	B
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
EDR	–	A	A	A
ESS	–	A	A	A
FFW-137	–	–	–	A
FFW-THO	–	–	–	A
HED-MGI	–	–	B	B
ISA-VOL	–	–	–	A
LKA-ELK	–	A	A	A
PSI	–	–	–	A
REV	–	–	–	A
TPM	–	–	–	A

Table 9: Policy options for trucks (N2&N3); letters indicate mandatory introduction dates, dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (N2&N3)	PO2 (N2&N3)	PO3 (N2&N3)
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
ESS	–	A	A	A
ISA-VOL	–	–	A	A
REV	–	–	–	A
TPM	–	–	–	A
VIS-DET	–	–	A	A
VIS-DIV	–	–	C	C

¹⁴⁹ The introduction dates for mandatory fitment are coded in the tables as follows:

- **A:** 1st September 2021 (new approved types), 1st September 2023 (new vehicles)
- **B:** 1st September 2023 (new approved types), 1st September 2025 (new vehicles)
- **C:** 1st September 2025 (new approved types), no mandatory introduction for new vehicles

Table 10: Initial cost at mandatory introduction of policy options per vehicle (best estimate) inflated to year-2021 Euros

Initial cost per vehicle	PO1	PO2	PO3
Passenger cars (M1)	€201	€360	€516
Buses and coaches (M2&M3)	€6	€607	€970
Vans (N1)	€131	€206	€521
Trucks (N2&N3)	€6	€607	€1,013

Key results:

The benefit-to-cost ratios (BCRs) reported in Table 32 and Figure 23 allow a comparison of the different policy options based on the extent to which the benefits exceed (or fall short of) the costs created by a policy option over the entire evaluation period 2021–2037 compared to the baseline scenario (voluntary uptake). Values greater than 1 indicate that the benefits are greater than the costs incurred.

For passenger cars (M1) and for buses and coaches (M2&M3), the results indicate that implementation of any of the policy options considered would be cost-effective. For vans (N1), implementation of PO1 or PO2 was found to be cost-effective. For trucks (N2&N3), PO2 and PO3 exceeded the threshold to cost-effectiveness.

Table 32: Results: Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Benefit-to-cost ratios	PO1	PO2	PO3
Passenger cars (M1)	2.95	2.14	1.39
Buses and coaches (M2&M3)	4.64	3.11	2.11
Vans (N1)	1.78	1.35	0.53
Trucks (N2&N3)	0.56	1.52	1.03

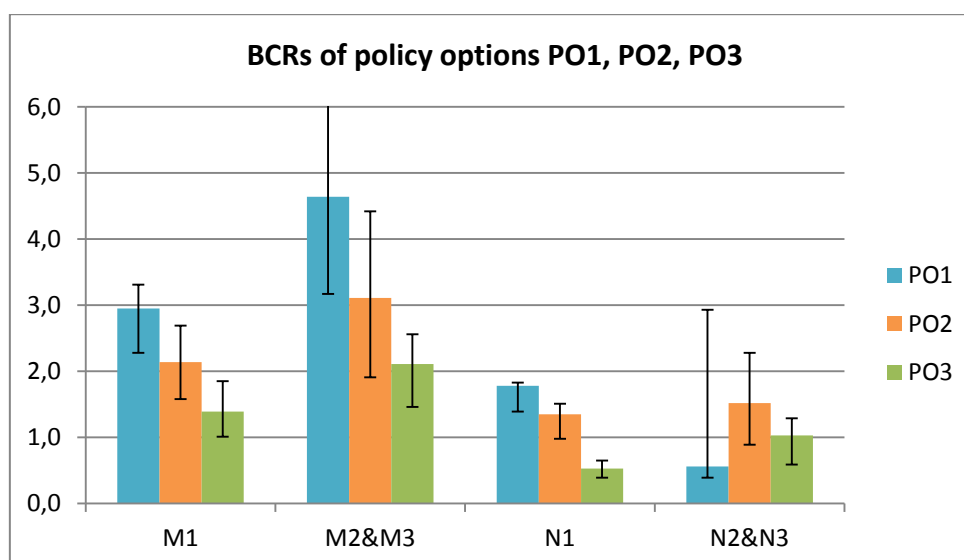


Figure 23: Results: Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate with indication of uncertainty ranges from scenario analysis)

The casualty prevention results reported in Table 33 and Figure 24 allow conclusions about which policy option prevents the highest number of fatalities across EU-28 when compared with the baseline scenario. To estimate the casualty prevention totals, the best estimate numbers for each year of the evaluation period 2021–2037 were summed.

It can be observed for all vehicle categories that the number of casualties prevented by implementation of PO2 or PO3 exceeds the number prevented by PO1 by a considerable margin. Between all four vehicle categories, implementation of PO2 has the potential to prevent an additional 8,312 fatalities and 51,286 serious casualties compared to PO1 across EU-28 over the period 2021–2037. PO3 exceeds the potential of PO2 by further 1,843 fatalities and 21,807 serious casualties.

Table 33: Results: Total number of fatal casualties prevented by safety measures of the respective vehicle category over the evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Fatalities prevented	PO1	PO2	PO3
Passenger cars (M1)	13,785	20,081	21,337
Buses and coaches (M2&M3)	2	207	227
Vans (N1)	852	1,005	1,283
Trucks (N2&N3)	0	1,658	1,947

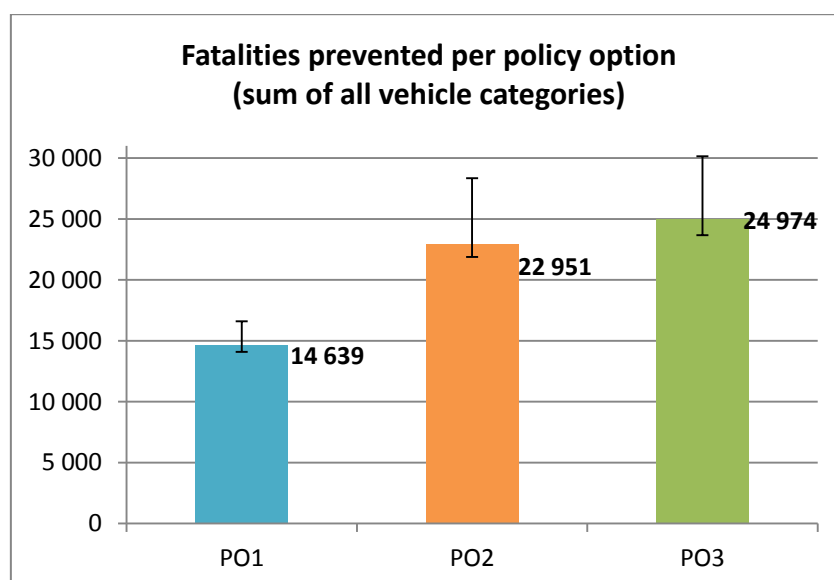


Figure 24: Results: Total sum of fatal casualties prevented by safety measures across all vehicle categories over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate with indication of uncertainty ranges from scenario analysis)

Implementation of the policy options would address the fatal casualty populations of vehicle occupants and vulnerable road users as detailed in

Table 34.

Table 34: Results: Overall percentage of all fatal vehicle occupant and vulnerable road user casualties prevented by the policy options over the evaluation period 2021–2037

Reduction of fatal casualties	Vehicle occupants	Pedestrians & cyclists
PO1	12.7%	11.6%
PO2	15.4%	14.0%
PO3	16.0%	14.4%

Conclusions:

From the results found in this cost-effectiveness study, it can be concluded overall that PO1 offers favourable cost-effectiveness ratios in most vehicle categories; however, these are achieved with only a small impact on both the costs and the benefits compared to the baseline scenario of continued voluntary uptake. The impacts of PO2 and PO3 are larger, with numbers of fatalities prevented exceeding those of PO1 by a considerable margin; however this is accompanied by a greater cost. Where PO2 or PO3 exceed the threshold to cost-effectiveness ($BCR > 1$), the considerably greater number of casualties prevented compared to PO1 could be a reason to favour implementation of PO2 or PO3.

Annex 4.2 **Introduction and objectives**

In 2015, the European Commission published the report conducted by TRL on the *Benefit and Feasibility of a Range of new Technologies and Unregulated Measures in the Fields of Occupant Safety and Protection of Vulnerable Road Users* ('GSR1') (Hynd *et al.*, 2015). This Report provided initial feasibility and cost vs. benefit reviews for over 50 new safety measures that could be implemented as part of the amendment to the General Safety and Pedestrian Safety Regulations.

The follow-up report, *In Depth Cost-Effectiveness Analysis of the Identified Measures and Features regarding the Way Forward for Vehicle Safety in the EU* ('GSR2') (Seidl *et al.*, 2017), has been published in September 2017, and contains a thorough review and collation of the available evidence regarding effectiveness, cost, fleet penetration and target population, alongside the results of a large-scale stakeholder consultation for a shortlist of 24 safety measures. Preliminary cost-effectiveness indicators for the individual measures and additional technical considerations were reported to enable the European Commission to select the final list of proposed safety measures considered to be taken forward for mandatory implementation.

The objective of this in-depth cost-benefit study is to build upon the outcomes of the GSR1 and GSR2 projects and calculate concrete cost-effectiveness indicators and numbers of casualties prevented at a European level for three proposed sets of safety measures (policy options), taking into account:

- the interactions of all measures when implemented together (to avoid double-counting of casualties prevented by different measures),
- the baseline effects of voluntary uptake into the fleet, and
- the effects of already existing mandatory measures still dispersing into the fleet on the European casualty target populations.

Annex 4.3 Policy options and baseline scenario

The European Commission defined, based on consideration of the initial cost-benefit indicators reported in GSR2 and additional information regarding technical feasibility received in the GSR2 stakeholder consultation, the list of proposed safety measures considered for implementation (Table 1). More detail about the measures is available in the GSR2 report (Seidl *et al.*, 2017). Note that some measures have been split into two compared to the GSR2 report to allow more detailed modelling (DDR, FFW and VIS) and the description of some measures has evolved (HED-MGI: head-to-glass impact test; LKA-ELK: emergency lane keeping systems; REV: reversing camera).

Table 35: List of safety measures considered for mandatory implementation

Measure	Description	Applicable vehicle categories			
AEB-VEH	Autonomous emergency braking for vehicles (moving and stationary targets)	M1		N1	
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists	M1		N1	
ALC	Alcohol interlock installation document	M1	M2&M3	N1	N2&N3
DDR-DAD	Drowsiness and attention detection	M1	M2&M3	N1	N2&N3
DDR-ADR	Advanced distraction recognition	M1	M2&M3	N1	N2&N3
EDR	Event data recorder	M1		N1	
ESS	Emergency stop signal	M1	M2&M3	N1	N2&N3
FFW-137	Full-width frontal occupant protection (current R137 configuration with Hybrid III ATDs)	M1		N1	
FFW-THO	Full-width frontal occupant protection (introduction of THOR-M ATDs and lower appropriate injury criteria thresholds to encourage adaptive restraints)	M1		N1	
HED-MGI	Adult head-to-windscreen impact (mandatory HIC limit in headform-to-glass impact tests; no mandatory A-pillar impact)	M1		N1	
ISA-VOL	Intelligent speed assistance (voluntary type system; can be overridden by driver and switched off for the rest of journey)	M1	M2&M3	N1	N2&N3
LKA-ELK	Lane keeping assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)	M1		N1	
PSI	Pole side impact occupant protection	M1		N1	
REV	Reversing camera system	M1	M2&M3	N1	N2&N3
TPM	Tyre pressure monitoring system		M2&M3	N1	N2&N3
VIS-DET	Front and side vulnerable road user detection and warning (no auto braking)		M2&M3		N2&N3
VIS-DIV	Minimum direct vision requirement (best-in-class approach)		M2&M3		N2&N3

This cost-effectiveness study also takes into account existing mandatory measures that are still dispersing into the fleet and thereby continue to contribute to casualty reductions; these will reduce the target populations for some of the proposed measures (see Table 2).

Table 36: List of existing mandatory safety measures which are modelled in this study

Measure	Description	Applicable vehicle categories			
AEB-VEH	Autonomous emergency braking for vehicles		M2&M3		M2&M3
ESC	Electronic stability control	M1	M2&M3	N1	M2&M3
LDW	Lane departure warning		M2&M3		M2&M3

The European Commission has defined **three policy options (POs), i.e. sets of safety measures from the above list to be implemented on a mandatory basis**, for this cost-effectiveness study to assess:

- **PO1:** State-of-the-art and widely available package of safety solutions that are not yet mandatory in EU and their fitment varies from around 5–90%
- **PO2:** As PO1 with added safety solutions that focus on vulnerable road user protection and on ensuring driver attention to the driving task
- **PO3:** As PO2 with safety solutions that are either feasible or already exist in the marketplace, but that have a low fitment rate and market uptake, that maximises overall casualty savings and can boost safety solutions' innovation

The sets of measures to be implemented in each policy option and the proposed introduction dates are shown in Table 37, Table 38, Table 39, and Table 40 for vehicle categories M1, M2&M3, N1, and N2&N3, respectively.

The introduction dates for mandatory fitment are coded in the tables as follows:

- **A:** 1st September 2021 (new approved types), 1st September 2023 (new vehicles)
- **B:** 1st September 2023 (new approved types), 1st September 2025 (new vehicles)
- **C:** 1st September 2025 (new approved types), no mandatory introduction for new vehicles

The policy options are each studied for their cost-effectiveness compared to a baseline scenario (PO0), where none of the measures are implemented on a mandatory basis, but voluntary uptake would continue. The reported cost-effectiveness results reflect a comparison between each policy option with the baseline, i.e. capture only the costs and benefits that exceed those estimated for the voluntary fitment scenario.

The evaluation period was chosen to extend to 2037 in order to capture the effects of dispersion of the measures into the vehicle fleet via fitment to new vehicles. Results are calculated for individual years, converted to present values and summed for the evaluation period extending from 2021 to 2037.

The following tables provide information on which of the safety measures are introduced under each policy option by vehicle type.

Table 37: Policy options 1, 2 and 3 for passenger cars (M1); letters indicate mandatory introduction dates (see key above), dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (M1)	PO2 (M1)	PO3 (M1)
AEB-VEH	–	A	A	A
AEB-PCD	–	–	B	B
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
EDR	–	A	A	A
ESS	–	A	A	A
FFW-137	–	A	A	A
FFW-THO	–	–	A	A
HED-MGI	–	–	B	B
ISA-VOL	–	–	A	A
LKA-ELK	–	A	A	A
PSI	–	A	A	A
REV	–	–	–	A

Table 38: Policy options 1, 2 and 3 for buses and coaches (M2&M3); letters indicate mandatory introduction dates (see key above), dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (M2&M3)	PO2 (M2&M3)	PO3 (M2&M3)
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
ESS	–	A	A	A
ISA-VOL	–	–	A	A
REV	–	–	–	A
TPM	–	–	–	A
VIS-DET	–	–	A	A
VIS-DIV	–	–	C	C

Table 39: Policy options 1, 2 and 3 for vans (N1); letters indicate mandatory introduction dates (see key above), dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (N1)	PO2 (N1)	PO3 (N1)
AEB-VEH	–	A	A	A
AEB-PCD	–	–	B	B
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
EDR	–	A	A	A
ESS	–	A	A	A
FFW-137	–	–	–	A
FFW-THO	–	–	–	A
HED-MGI	–	–	B	B
ISA-VOL	–	–	–	A
LKA-ELK	–	A	A	A
PSI	–	–	–	A
REV	–	–	–	A
TPM	–	–	–	A

Table 40: Policy options 1, 2 and 3 for trucks (N2&N3); letters indicate mandatory introduction dates (see key above), dash indicates measure is not included in the policy option

Measure	Baseline	PO1 (N2&N3)	PO2 (N2&N3)	PO3 (N2&N3)
ALC	–	A	A	A
DDR-DAD	–	–	A	A
DDR-ADR	–	–	–	B
ESS	–	A	A	A
ISA-VOL	–	–	A	A
REV	–	–	–	A
TPM	–	–	–	A
VIS-DET	–	–	A	A
VIS-DIV	–	–	C	C

Some measures considered in GSR2 (Seidl *et al.*, 2017) will not be taken forward for mandatory implementation, following negative initial cost-benefit results or based on concerns regarding technical feasibility:

- **FSO** for M1: Small overlap frontal occupant protection, based on likely unfavourable cost-effectiveness after introduction of relevant active safety measures.
- **SFS** for M1 and N1: Side impact collision protection for far-side occupants, based on technical concerns raised by stakeholders indicating that no design solutions were proven to be effective and no suitable ATD existed for far-side impact tests.

Note that the European Commission considers removing exemptions of certain vehicle categories or weights related to the following measures:

- **F94** for M1 and N1: UN Regulation No. 94 Frontal Offset Occupant Protection – Removal of Exemptions
- **S95** for M1 and N1: UN Regulation No. 95 Side Impact Occupant Protection – Removal of Exemptions

These removals of exemptions are not covered in this cost-benefit study.

Annex 4.4 **Methodology and input parameters**

Annex 4.4.1 Overview: Calculation model structure

A simulation and calculation model was developed to estimate the benefits (monetary values of casualties prevented by safety measures) and costs (cost to vehicle manufacturers of fitment of safety measures to new vehicles) associated with the policy options PO1, PO2 and PO3 compared to the baseline scenario. The model was implemented in the programming language Python¹⁵⁰ with inputs and outputs produced in Microsoft Excel spreadsheets. Figure 25 presents a simplified visualisation of the structure and calculation steps of the model. A brief description of the steps is given in the following paragraphs and a detailed description in Annex 4.4.2 to Annex 4.4.14.

¹⁵⁰ <https://www.python.org/>

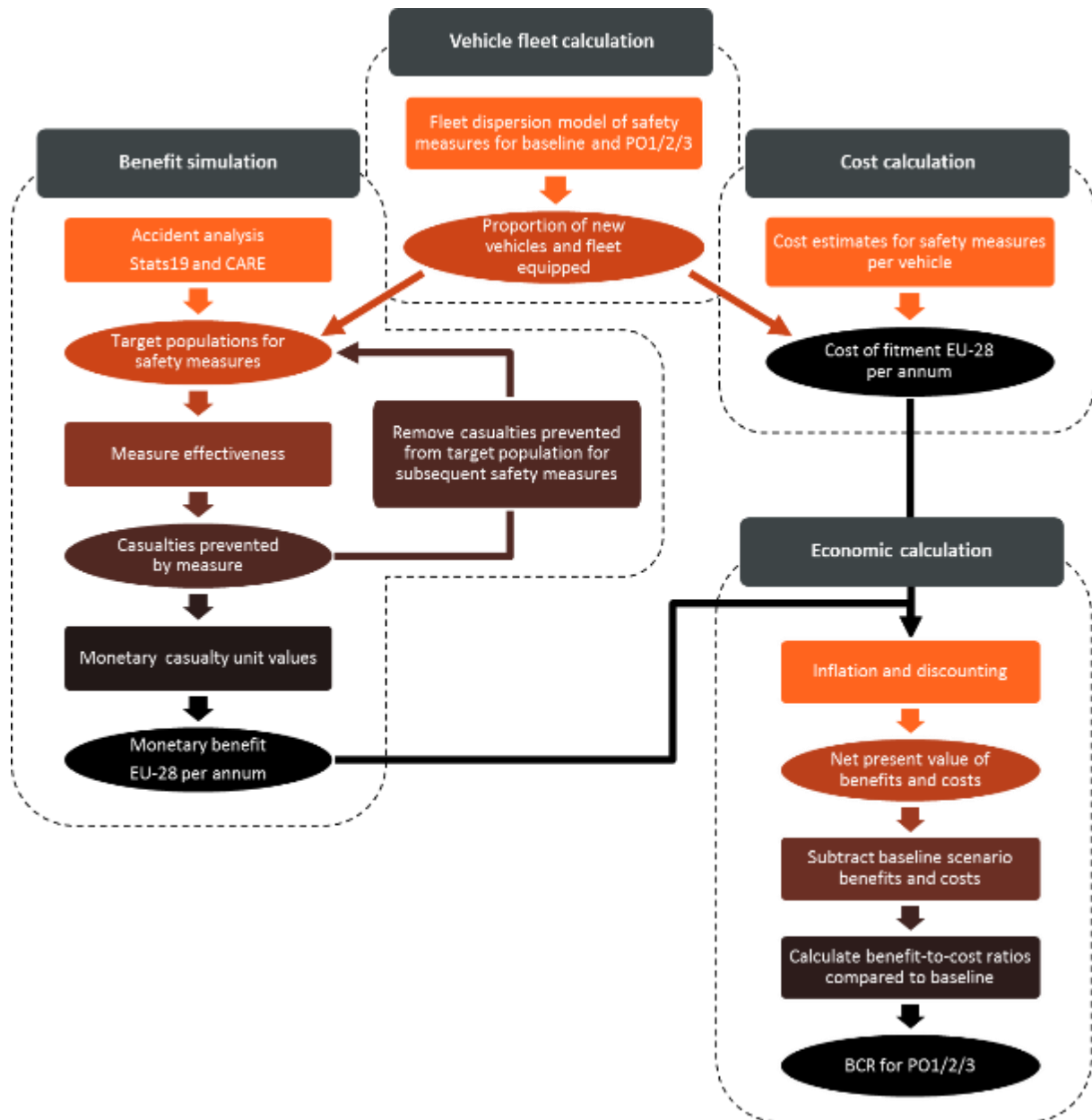


Figure 25: Flowchart of the simulation model to calculate benefit-to-cost ratios (BCRs) for policy options PO1, PO2 and PO3, respectively, compared to the baseline scenario

The vehicle fleet calculation model determines how the safety measures disperse into the fleet. The model determines the effect of mandating a measure for all new types, and two years later for all new registered vehicles, on the overall proportion of the fleet equipped. Benefits conferred by a safety measure, that is, casualties prevented, will only be realised by equipped vehicles. However, the legacy fleet will also be affected by active safety measures; for example, if a rear-end shunt is avoided by AEB-VEH, the vehicle in front, will benefit from the measure even if it is a legacy vehicle. This is taken into account in the benefit calculations.

To simulate the casualties prevented by each measure, an accident data analysis was performed based on GB national road accident data (Stats19) to determine the casualty target population for each proposed measure, i.e. the number of fatal, serious and slight casualties

that could potentially be affected by a safety measure based on relevant characteristics of the collision (e.g., collision geometry or contributory factors). The target populations were scaled to EU-28 level using weighting factors, based on severity and vehicle categories involved, derived from analysis of the pan-European CARE database. The target populations found are multiplied with effectiveness values for each safety measure, i.e., a percentage value indicating what proportion of the relevant accidents will be avoided or mitigated by the measure. Mitigated casualties (fatal turned to serious casualty, or serious to slight casualty) are added to the target population of the next lower injury severity level for other measures. The casualties prevented are multiplied with monetary values for casualty prevention to calculate the monetary benefit.

An added complication that had to be addressed is the interaction of different safety measures, which address overlapping casualty groups. To give an example, there are collisions where a driver was exceeding the speed limit, left the lane and suffered a frontal impact. These collisions will be in the target populations for multiple measures: ISA, LKA-ELK and FFW-137/FFW-THO, but in reality can only be prevented once by either one of these systems. This is addressed in the model by removing casualties prevented by one measure from the subsequent target population of the other measures. The impact of highly effective existing safety measures, which have been mandatory for a few years, but are still dispersing into the vehicle fleet (ESC for all vehicle categories, and AEB-VEH and LDW for M2&M3 and N2&N3), is also modelled to reduce the remaining target populations for the proposed measures.

The cost of a policy option is calculated by multiplying per-vehicle cost estimates for each measure with the number of new vehicles of each vehicle category across EU-28 that are equipped with the measure in the given year of the analysis according to the output of the fleet calculation model. All calculations are run separately for PO1, PO2, PO3, and for the baseline scenario, which assumes that none of the proposed measures will be mandated, so all the benefits and costs in the baseline scenario result from voluntary uptake of the safety measures. The results for the baseline scenario are subtracted from the results of each policy option, in order to only capture the benefits and costs of the legislative intervention which exceed the voluntary uptake.

In the economic calculation model, the monetary values of costs and benefits are subjected to inflation and discounting to determine their present value. The present values of benefits and costs, calculated for individual years and summed over the evaluation period, are compared in order to arrive at cost-effectiveness estimates (benefit-to-cost ratio, BCR). Individual BCRs are calculated per policy option (PO1, PO2, PO3) and per vehicle category (M1, M2&M3, N1, N2&N3). A total of 12 different best estimate BCRs is reported. In addition to the calculations using the best estimate values for all input parameters, an interval and a scenario analysis is carried out to quantify the range of uncertainty around the best estimate BCR values.

The following sub-sections describe in more detail the individual aspects of the model and the input data used.

Annex 4.4.2 Evaluation period

To model the costs and benefits of the safety measures fully, it was necessary to set an evaluation window which allowed technology sufficient time to propagate through the vehicle fleet and into the collision population. This was set by considering the earliest time at which a measure could affect all new vehicles (year 2023, 2 years after introduction for new approved types); then an allowance was added for the age of the traffic population (mileage contribution to total miles driven is not constant over the vehicle age). Previous evidence, established for the car fleet in London, has demonstrated that about 88% of the traffic is 0 to 11 years old and 97% of the traffic is 0 to 14 years old. Vehicles which are 15 years old account for about only 1% of the traffic and about 2% of the collision involved cars. Therefore, 14 years was added to new vehicle implementation date to allow the full cycle of fleet benefits to be captured. This period also matches the length of time allocated for the majority of voluntary uptake measures to reach close-to-full adoption levels. As such, the evaluation period was set to extend from 2021 to 2037.

Annex 4.4.3 Casualty baseline

The EU-28 casualty baseline is an important factor for the model because it determines the size of the overall casualty target population for all safety measures over the time period assessed. The casualty baseline (policy option PO0) is also the basis against which the costs and benefits of the other policy options (PO1, PO2 and PO3) are compared.

Historically, road casualty numbers of all severity levels (fatal, serious and slight) in Europe have declined continuously over the past decades up until 2013. In the years following 2013, a slight increase or plateauing of the numbers can be observed (Figure 26).

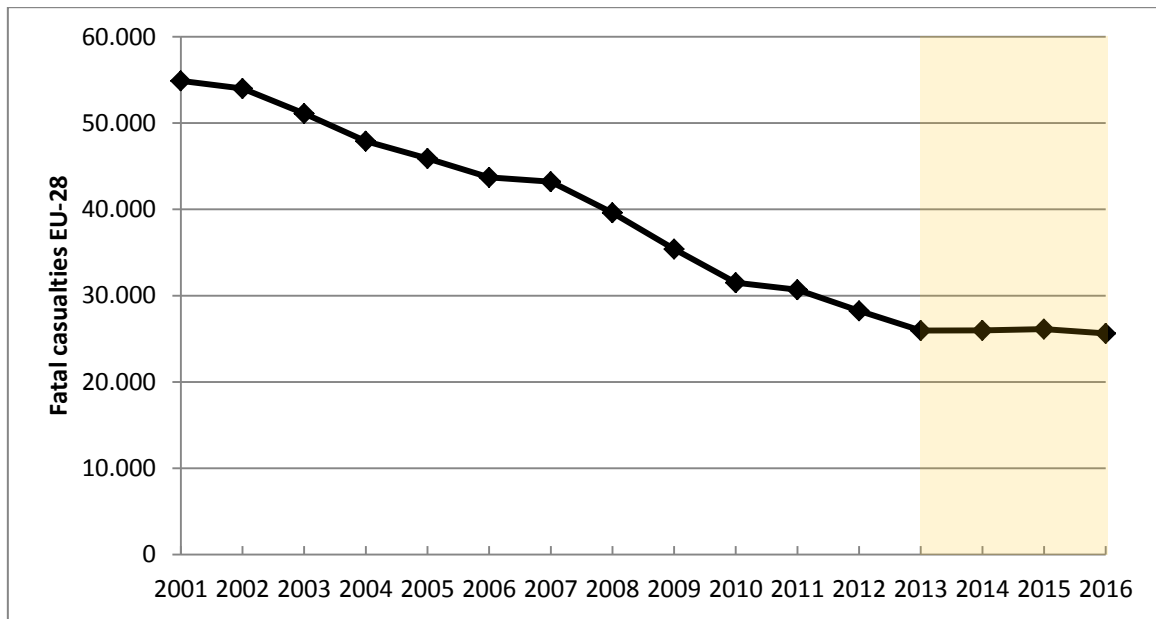


Figure 26: Historic road fatality trend EU-28¹⁵¹, highlighted period 2013–2016 with plateauing trend

The reasons for the long-term decline can be attributed to advancements in vehicle safety technology (driven by regulation, consumer information programmes such as Euro NCAP, vehicle manufacturers’ research and development efforts, and independent vehicle safety research), as well as certain other major factors, including improvements to the road and cycling infrastructure, improvements in post-collision medical care, and behavioural changes of drivers due to awareness campaigns and cultural shifts (e.g. seat belt wearing rates, drink-driving behaviour, and speeding behaviour).

It was not possible within the scope of this study to attribute fractions of the overall trend to these aspects and there is no conclusive study that shows why the casualty reductions have slowed over the past five years. The European Commission, therefore, provided estimates of the continued effects in all non-vehicle-related sectors (general road casualty trend), and the vehicle-related baseline effects were calculated using the model developed for this study to arrive at the casualty baseline. The basic assumption to define the general road casualty trend and the casualty baseline was that no further policy intervention would take place in the transport sector, but voluntary improvements and effects of already implemented policies would continue.

The European Commission’s best estimate provided for the general casualty trend was a constant casualty number at all severity levels from 2016 onward. This shows that the continued effects in all non-vehicle sectors are expected to offset the increase in traffic volume but not be strong enough to result in a net casualty reduction. The calculations to arrive at the casualty baseline were performed based on this general casualty trend and using

¹⁵¹ https://ec.europa.eu/transport/road_safety/specialist/statistics_en

input values and calculation methods as described in the subsequent sections of this report. The resulting casualty baseline reflects the effects of continued dispersion of existing mandatory vehicle safety measures with new vehicles into the legacy fleet and continued voluntary uptake of the safety measures under consideration (see Figure 27 for fatal casualties, and Annex 4.9.1 for other severity levels).

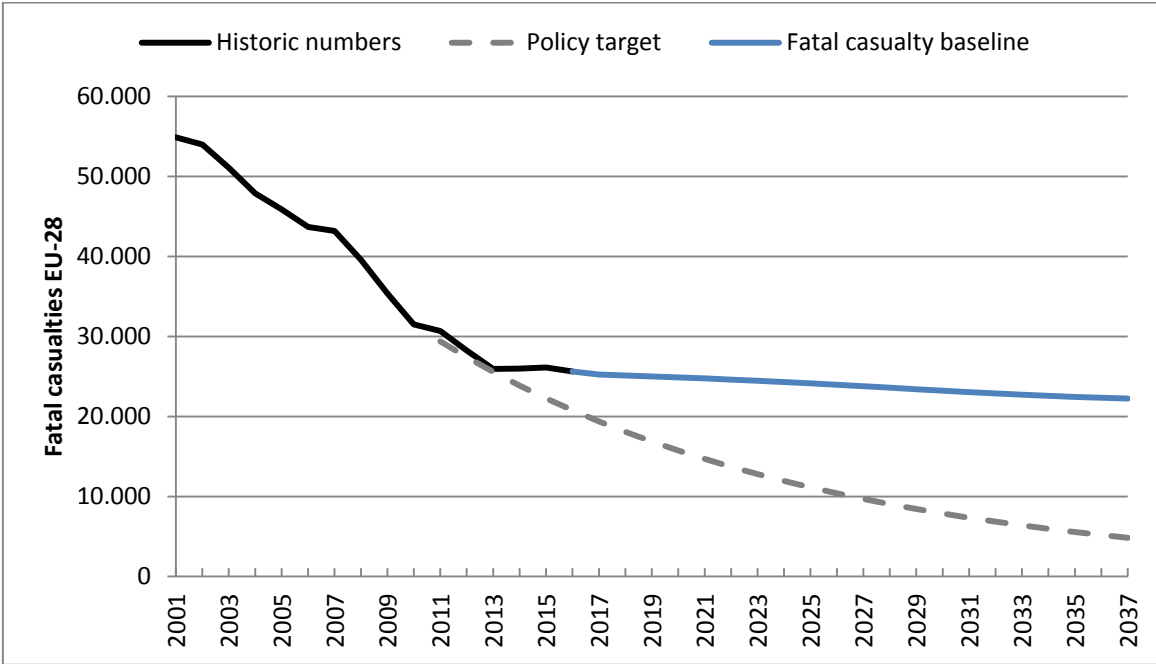


Figure 27: EU-28 fatal casualty baseline (2017–2037), historic fatality numbers (2001–2016), and indication of a potential continuation of the EU policy target (2011–2037)

Note that European member states have recently agreed on a new common definition of ‘serious traffic injury’ casualty, based on MAIS injury severity (MAIS3+ injuries). This is a more stringent definition than that applied in CARE (most member states report serious casualties as those where the casualty was treated as an in-patient in hospital). According to the new definition there are about 5.3 serious casualties per fatality, whereas the CARE definition captures 8.9 serious casualties per fatality. No historic numbers are available for MAIS3+ casualties across Europe and the published monetary values assigned for prevention of a serious casualty are more closely related to the CARE definition. Therefore, all calculations in this study are based on serious casualties as defined and captured in the CARE database.

In order to treat the inherent uncertainty in the forward projection of the general road casualty trend, the input numbers for fatal, serious and slight casualties were varied, along with other inputs, as part of the sensitivity analysis (see Annex 4.4.14). The European Commission’s lower estimate provided was a situation where the general casualty trend (at all severity levels) would continue at the rate of fatality reduction observed within the last three years (2014–2016). This is a continuous 0.7% reduction relative to the previous year.

Refer to Annex 4.8.1 for the general casualty trend estimates and Annex 4.9.1 for the resulting casualty baseline.

Annex 4.4.4 Vehicle fleet size

Two series of data regarding the vehicle fleet were required to provide a dynamic estimate of the total benefits and costs:

1. The total fleet size each year for the period of interest; with values separated to show the different vehicle categories.
2. The number of new vehicles registered each year in Europe, again broken down to the level of vehicle categories.

The European Commission provided input numbers for both series of data, created using the PRIMES-TREMOVE transport model¹⁵² (Table 41 and Table 42).

Table 41: EU-28 total vehicle fleet size (in thousand vehicles); Source: PRIMES-TREMOVE transport model (updated EU Reference scenario 2016)

	2010	2015	2020	2025	2030	2035	2040
Passenger cars (M1)	240,841.6	263,530.3	276,929.5	283,672.9	288,125.2	300,708.2	311,068.5
Buses and coaches (M2&M3)	818.9	905.8	980.8	1,018.3	1,039.0	1,070.8	1,107.7
Vans (N1)	27,979.6	29,645.6	30,945.4	32,230.3	33,944.6	35,871.5	37,395.6
Trucks (N2&N3)	5,876.1	7,006.8	7,842.9	8,451.2	8,888.6	9,448.6	9,965.7

Table 42: EU-28 new vehicle registrations (in thousand vehicles, aggregated over 5 years leading up to the year referenced); Source: PRIMES-TREMOVE transport model (updated EU Reference scenario 2016)

	2010	2015	2020	2025	2030	2035	2040
Passenger cars (M1)	110,716.6	75,137.2	90,611.3	99,106.8	104,355.5	107,329.5	109,279.0
Buses and coaches (M2&M3)	381.5	309.1	319.0	343.2	364.7	357.7	369.6
Vans (N1)	10,924.9	9,810.9	10,781.0	11,931.7	12,325.1	12,638.4	13,171.2
Trucks (N2&N3)	2,482.9	2,559.3	2,471.6	2,755.6	2,943.3	3,155.9	3,161.5

¹⁵²

<http://www.e3mlab.ntua.gr/e3mlab/PRIMES%2520Manual/The%2520PRIMES-TREMOVE%2520MODEL%25202013-2014.pdf>

The new registration data was aggregated in 5-year blocks and had to be split into individual years for this study. The middle year of each block was assigned the mean value and a slanted line was created through that value connecting each 5 year block to the next, thus avoiding to show implausible step changes every five years while obtaining the same total number.

An example of this is shown in Figure 28. In this case, the total fleet values are plotted with respect to the left axis and the new registration values with respect to the right. Refer to Annex 4.8.3 for data on other vehicle categories.

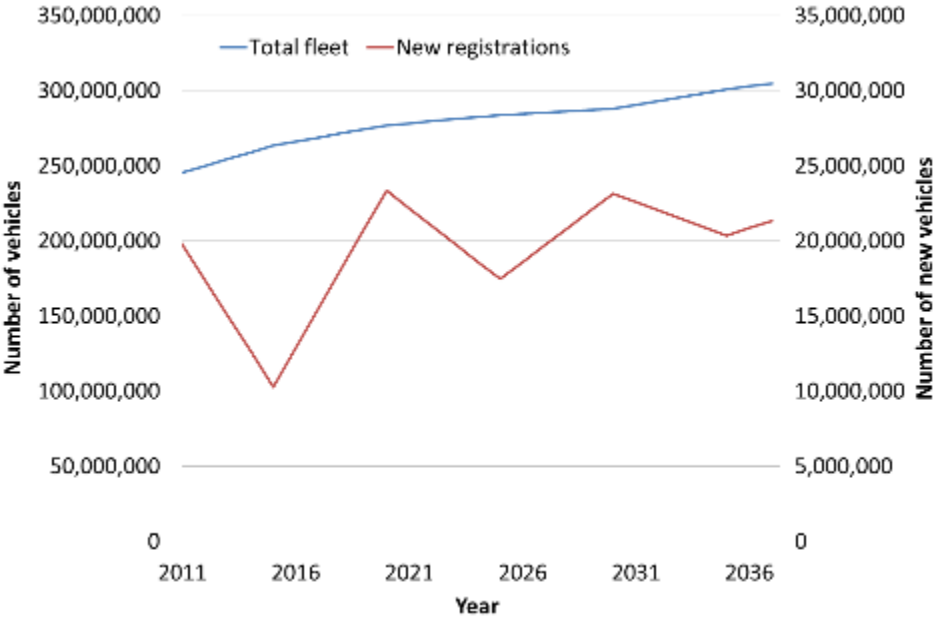


Figure 28: Passenger car (M1) fleet and new registrations 2011 to 2037

Note that the size of the fleet for the subset of M2/M3 vehicles with an extra-urban use mode (i.e. not city transport) was not available directly from the PRIMES-TREMOVE data. It was estimated using a single ratio of the M2/M3 values, which was derived from the number of vehicles in use in Europe, according to ‘Eurostat’ data (European Commission, 2017) and was set to be 37 % (for extra-urban type M2/M3 vehicles) for all years.

Annex 4.4.5 Fleet dispersion of safety measures

There are two aspects to the fleet fitment estimates which are vital to the process of establishing the cost-effectiveness for the measures within these policy options.

1. The voluntary uptake which defines a ‘do nothing’ scenario. In this case, the propagation of technology is led by the willingness of manufacturers to fit the necessary components to vehicles and the willingness of consumers to pay for them.
2. The mandatory uptake brought about by a policy intervention. In this case, all vehicles or all vehicle types will be required to meet the regulatory requirements by an

implementation date. The effects of this will be superimposed on the baseline fitment rates at that moment in time.

To model the uptake of technology alongside each of the measures, it was necessary to define the uptake by new vehicles and also the penetration into the fleet due to fleet expansion and ‘churn’ (the rolling addition of new vehicles and scrapping of old). The numbers of vehicles being registered newly each year and the numbers in the fleet were already determined, as per the previous section. This section describes the way in which the model accounted for technology propagation on a voluntary or mandatory basis. The model accounts for the fact that some of the vehicles being scrapped in the churn process would also have the technology fitted. Otherwise, an overly optimistic estimate of technology penetration would be generated.

Voluntary fleet fitment estimates were based on evidence identified previously (Seidl *et al.*, 2017), comments provided by stakeholders and, in the absence of other information, opinions of an expert panel within TRL based on observations of similar technologies and expectations of pressures on the industry (for instance, whether a measure is likely to be incentivised by Euro NCAP).

The launch date for a technology was used to define the x-axis (time) start point for s-shaped curves of fitment. This relates to the first time a system was released with the characteristics likely to be required in order to meet the regulatory requirements. As a general rule, the launch date was intended to be independent of vehicle category; assuming general transfer of technologies was possible, with some exceptions. The assumed launch dates and notes about supporting observations are provided in Table 63.

The year that full voluntary implementation is achieved dictates the gradient or slope of the s-shaped curve and represents the time necessary for the measure to reach maturity in terms of full voluntary adoption into new vehicle registrations. All but three measures were predicted to have a long voluntary implementation phase, with 14 years between launch of the technology and full voluntary implementation. However, ESC was given a shorter adoption window of only 10 years to match a medium length period. For car fitment Event Data Recorders (EDR) and Full-width frontal protection for UN Regulation No. 137 with the Hybrid III dummy (FFW-137) were given an even shorter voluntary uptake period of 6 years. This was justified based on the percentage of vehicles in the fleet already expected to meet the regulatory requirements for the system, which matches the predicted final voluntary uptake levels. A medium and a long length adoption period were used for van and heavier vehicle uptake of EDRs, respectively. The full voluntary implementation years for the various measures are provided in Table 64.

The voluntary take up of technology and the implementation within the fleet was selected to be one of three possible options:

1. None = No voluntary uptake, regulatory action required to drive adoption
2. Medium = 40% voluntary propagation within the fleet without additional stimuli
3. High = 80% voluntary propagation leaving the 20% of vehicles which wouldn't be equipped without regulatory action

These values represent point estimates for the resulting final take up in the fleet. The s-shaped curve for percentage of newly registered cars equipped is modelled to form a plateau at this value. The assignments of these uptake levels to the different measures and vehicle categories are shown in Table 65 in Annex 4.8.4.

Examples of model outputs for measure uptake and fleet dispersion of AEB-PCD in cars are shown in Figure 21, Figure 22 (voluntary uptake scenario, PO0) and Figure 23, Figure 24 (mandatory uptake scenario, PO3). In the voluntary uptake scenario it can be seen that this high-uptake measure levels off at approximately 80% fleet fitment by the end of the evaluation period (Figure 22). The mandatory uptake scenario follows the voluntary uptake curve up until 2023 and elevates the new vehicle fitment rates from then onward gradually over two years to 100% (Figure 23). Even with full fitment in new vehicles, it still takes time for those vehicles to replace existing vehicles on the road, but the effect of regulation can be seen in the resulting higher fleet fitment of more than 90% by the end of the study period (Figure 24). The difference between these curves is responsible for the casualties prevented of a policy option compared to the baseline option.

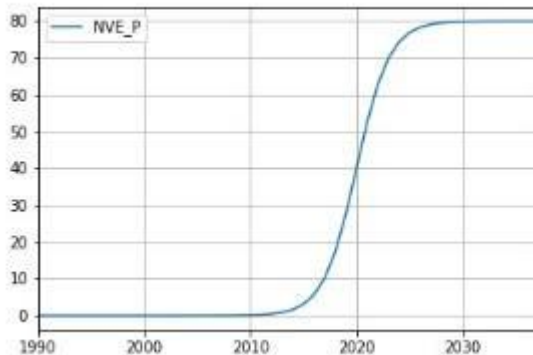


Figure 21: Percentage of newly registered cars equipped with pedestrian-capable AEB in voluntary uptake scenario

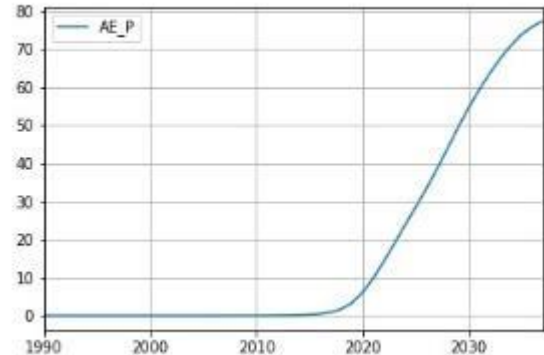


Figure 22: Percentage of all cars within the vehicle fleet equipped with pedestrian-capable AEB in voluntary uptake scenario

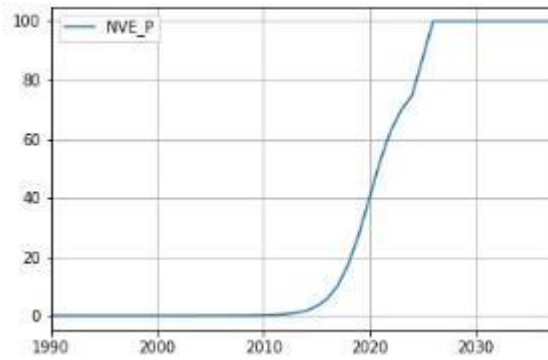


Figure 23: Percentage of newly registered cars equipped with pedestrian-capable AEB in mandatory implementation scenario (new approved types from 2023, all new cars from 2025)

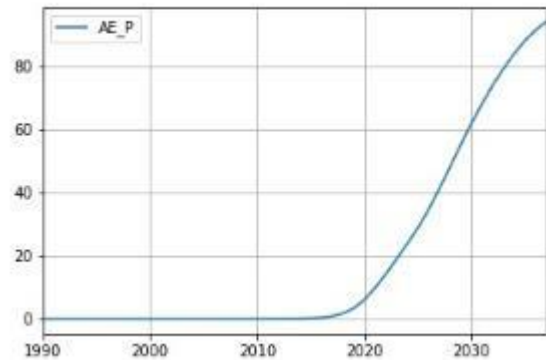


Figure 24: Percentage of all cars within the vehicle fleet equipped with pedestrian-capable AEB in mandatory implementation scenario (new approved types from 2023, all new cars from 2025)

In order to treat the inherent uncertainty in these voluntary uptake predictions, the input numbers were varied, along with other inputs, as part of the sensitivity analysis (see Annex 4.4.14). A lower estimate of the voluntary uptake was modelled to represent a scenario where voluntary uptake of the voluntary measures reaches only half the percentages quoted above.

Annex 4.4.6 Target population estimates

An accident data analysis was performed to estimate the size of the casualty target population, i.e. the number of fatal, serious and slight casualties that could potentially be affected by a safety measure based on suitable characteristics of the collision, for each of the proposed and existing safety measures.

Accident data was extracted from the Stats19 database¹⁵³ for the years 2011–2015 (last available year at the time of the study) and average numbers of this period were used to arrive at per annum estimates. Rollover collisions and collisions with more than two vehicles involved were excluded from the analysis because the police-reported data does not allow determination of which was the most severe event (injury causation) and therefore it is not clear which safety measures would apply to these collisions. Note that the calculation model corrects for the fact that the vehicle fleet was part-fitted with some of the measures under consideration at the time the accident data sample was drawn (e.g. ESC). The calculations approximate the accident data fleet fitment to be the average fleet dispersion calculated for the

¹⁵³ Stats19 is Great Britain’s database that records police reported traffic accidents that result in injury to at least one person. The database primarily records information on where the accident took place, when the accident occurred, the conditions at the time and location of the accident, details of the vehicles involved, the first point of impact, contributory factors to the accident, and information about the casualties. Approximately 50 pieces of information are collected for each accident.

years 2011–2015 using the model described in Annex 4.4.5. The casualty saving effects are calculated as a reduction resulting from the relative increase in fleet fitment starting from the 2011–2015 level rather than absolute fleet fitment rate.

The data extract queries for each measure were phrased to match descriptions from the effectiveness studies used (see Annex 4.4.7). Correction factors (multipliers) were applied to the target population estimates:

- Where the Stats19 data did not offer the necessary level of detail to arrive at a suitable target population. For example, for FFW-137, the police-reported data allowed to determine the number of casualties in all frontal impacts and a correction factor smaller than one from in-depth studies was applied to represent only the fraction that was in a large overlap (full-width) frontal collision. This reduced the target population for some measures.
- Where it was known that any relevant collision circumstances or contributory factors are systematically underreported in the police-reported statistics (e.g. ‘exceeding the speed limit’). This increased the target population for some measures.
- Where data from additional European countries regarding target populations for the specific measures considered was available, in order to represent the average situation in the countries available. This was, for example the case for measures HED-MGI, ISA-VOL, REV, VIS-DET and VIS-DIV. This increased or decreased the target populations for the relevant measures.

Refer to Annex 4.8.5 for an overview of target population descriptions and correction factors applied for each measure.

The target populations found were disaggregated by vehicle categories involved for (vehicle 1 and vehicle 2 or vulnerable road user), and first point of impact (e.g. N2N3 front to M1 off-side) to allow detailed modelling of the overlaps in target populations between measures (see Annex 4.4.8) and scaling to the European casualty population in the relevant vehicle combinations. This resulted in approximately 400 collision configurations and the target populations were converted into percentages of the total casualties in each of these configurations.

These target population percentages were scaled up to EU-28 to greatest level of detail possible from the data fields available within the pan-European CARE database¹⁵⁴. The scaling was based on the average European casualty distribution for fatal, serious and slight casualties in the years 2011 to 2015 in collisions where the relevant vehicle categories collided (see Table 43). This means, the scaling was carried out so that it is representative of the European proportions of casualties in M1-to-M1, M1-to-N1, N1-to-M2M3, etc. collisions. Information regarding the first point of impact (front, off-side, near-side, rear) is not available

¹⁵⁴ CARE is the community database on road accidents resulting in death or injury in the 28 European member states. https://ec.europa.eu/transport/road_safety/specialist/statistics_en#

at a pan-European level¹⁵⁵. Therefore, the UK was chosen to apportion the geometric configurations within the vehicle category combinations (based on Stats19 data).

The target populations for each year were scaled proportionally to match the total casualty population for fatal, serious and slight casualties in the given year according to the general road casualty trend (see Annex 4.4.3).

Table 43: Total casualty population and collision numbers across EU-28 per annum (average of period 2011 to 2015) in the relevant vehicle category combinations. Source: CARE database

Vehicle category		Collisions	Casualties (Vehicle 1)			Casualties (Vehicle 2)		
Vehicle 1	Vehicle 2		Fatal	Serious	Slight	Fatal	Serious	Slight
M1	<i>none</i>	127,635	5,405	33,198	129,912	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
M2M3	<i>none</i>	5,313	50	818	6,625	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
N1	<i>none</i>	7,475	338	1,687	7,305	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
N2N3	<i>none</i>	4,456	222	1,209	3,578	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
PTW	<i>none</i>	52,552	1,667	16,652	38,205	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
Cyclist	<i>none</i>	25,686	335	7,662	17,848	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
Other	<i>none</i>	4,301	317	1,560	3,239	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
M1	M1	252,173	2,900	37,283	367,874	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
M1	M2M3	8,986	194	808	5,254	13	580	8,823
M1	N1	32,931	552	3,720	30,590	111	1,320	13,459
M1	N2N3	23,967	1,456	4,583	22,809	35	483	3,522
M1	PTW	130,523	35	731	8,797	1,939	30,768	106,274
M1	Pedestrian	109,876	17	206	1,980	3,600	27,549	83,758
M1	Cyclist	103,824	7	123	1,581	1,005	16,833	86,001
M1	Other	13,203	331	1,469	9,247	114	1,246	5,628
M2M3	M2M3	117	2	605	9,317	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
M2M3	N1	755	6	75	1,005	12	55	325
M2M3	N2N3	488	27	121	1,077	3	27	101
M2M3	PTW	1,410	1	11	191	52	323	1,060
M2M3	Pedestrian	4,260	0	48	637	184	972	2,975
M2M3	Cyclist	1,654	0	26	332	49	288	1,173
M2M3	Other	472	4	56	500	7	43	150
N1	N1	2,313	57	413	2,997	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
N1	N2N3	2,112	139	492	1,684	13	75	430
N1	PTW	10,374	1	33	346	271	2,435	8,230
N1	Pedestrian	7,685	2	9	100	463	1,832	6,102
N1	Cyclist	7,051	1	6	82	164	1,321	5,572

¹⁵⁵ First point of impact in CARE is only reported by two member states (UK and Denmark) on a regular basis, as well as sporadically by Luxembourg (2013–2015) and France (2015 only).

Vehicle category		Collisions	Casualties (Vehicle 1)			Casualties (Vehicle 2)		
Vehicle 1	Vehicle 2		Fatal	Serious	Slight	Fatal	Serious	Slight
N1	Other	1,190	30	115	586	25	180	655
N2N3	N2N3	1,688	138	629	2,019	n/a	n/a	n/a
N2N3	PTW	3,422	1	12	90	188	901	1,923
N2N3	Pedestrian	3,188	2	7	73	438	812	1,486
N2N3	Cyclist	3,790	1	4	60	218	808	2,246
N2N3	Other	716	15	71	277	32	121	512
PTW	PTW	9,683	175	2,386	8,738	n/a	n/a	n/a
PTW	Pedestrian	8,953	25	452	3,211	202	1,559	5,769
PTW	Cyclist	4,550	14	425	2,125	52	777	2,919
PTW	Other	3,477	136	893	2,214	2	128	489
Pedestrian	Cyclist	7,628	24	966	4,772	8	577	3,018
Pedestrian	Other	5,846	291	1,377	4,193	5	50	245
Cyclist	Cyclist	6,799	71	1,896	7,776	n/a	n/a	n/a
Cyclist	Other	2,685	78	547	1,974	1	39	170
Multi vehicle (any)		109,959	3,865	26,459	159,204	n/a	n/a	n/a

Annex 4.4.7 Safety measure effectiveness

The casualty target populations are multiplied with effectiveness values for each safety measure, i.e. a percentage value indicating what proportion of the relevant collisions will be avoided or mitigated by the measure.

‘Avoidance’ describes a situation where casualties would remain entirely uninjured after application of the effective safety measure, for example, because the collision is prevented by an active safety system. ‘Mitigation’ describes a situation where casualties would sustain injuries of a lower severity level (fatal turned to serious casualty, or serious to slight casualty), for example, because an effective passive safety measure prevents the most severe injuries, or an active safety measure reduces the impact speed. Measures have been assigned separate values for effectiveness of avoidance and mitigation at all injury severity levels. It should be noted that effectiveness values for avoidance and mitigation are additive in this model. ‘Mitigated’ casualties are subsequently added to the target population of the next lower injury severity level for other measures.

Note that casualties prevented are attributed to the vehicle category equipped with the effective safety measure, which is not always identical with the vehicle category occupied by the casualty. To give an example, if a head-on collision involving a van (N1) and a car (M1) where the van drifted out of the lane and the drivers of both vehicles were fatally injured was prevented by LKA-ELK fitted to the van, then both fatalities prevented would be counted as benefit of LKA-ELK in the N1 category.

The effectiveness best estimates were based on the values determined by (Seidl *et al.*, 2017) in preparation of this study (extracted from research studies and stakeholder input). Where no

values could be identified during the course of this review and where no stakeholder input was provided, a road safety expert panel at TRL determined best estimates from the available evidence.

Refer to Annex 4.8.6 for the relevant effectiveness values, sources and rationale for expert panel estimates. Note that effectiveness values should always be interpreted in conjunction with the target population definition applied. Effectiveness can appear high when the target population definition is already very narrow and vice versa. For example, HED-MGI shows a high effectiveness percentage, however this applies only to the already narrow target population of *‘pedestrian and cyclist casualties in impacts with the vehicle front who suffered serious head injuries from impact with the glazed area of the windscreen more than 10 centimetres away from the scuttle, A-pillars, and header rail’*.

For the interval and scenario analysis (see Annex 4.4.14), effectiveness values were assigned a confidence level (high or low depending on the quality of the source) and the best estimates were varied as follows in order to determine the upper and lower estimates:

- Plus/minus 10% for high confidence estimates (for example, a value of 40% would be varied ± 4 percentage points, i.e. 36% to 44%)
- Plus/minus 20% for low confidence estimates.

Annex 4.4.8 Avoidance of double-counting of casualties prevented

When considering all proposed safety measures separately, the number of prevented casualties would be overestimated, because the target populations for different measures are partially overlapping, but each casualty can only be prevented once. To give an example, there will be collisions where a driver was exceeding the speed limit, left the lane and suffered a frontal impact. This collision will be in the target population for ISA, LKA-ELK and FFW-137/FFW-THO, but in reality can only be prevented once by either one of these systems. This is addressed in the model by removing casualties prevented by one measure from the subsequent target population of the other measures.

To achieve this, the proposed and existing safety measures were organised in groups that allow 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 general structure for modelling the interactions between measures in this study is visualised in Figure 33. The initial target population for the calculations includes all EU-28 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. The

reductions in target populations for subsequent layers are carried through for each of the over 400 collision configurations to realise a high level of accuracy. Note that ‘mitigated’ casualties (fatal turned to serious casualty, or serious to slight casualty) are added to the target population of the next lower injury severity level for other measures.

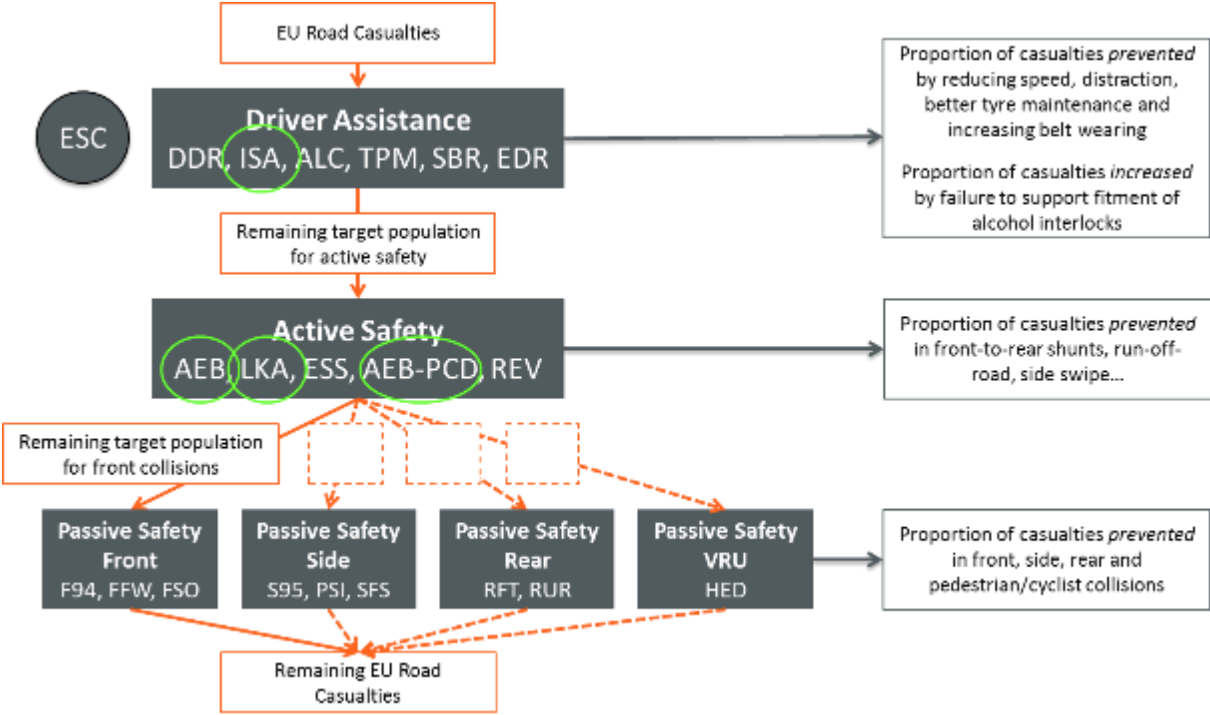


Figure 33: Modelling interactions of safety measures based on layers of protection (driver assistance, active safety, passive safety)

Refer to Annex 4.8.2 for the organisation of the proposed and existing safety measures in layers for M1, N1, M2&M3 and N2&N3 as applied in this study.

Annex 4.4.9 Monetisation of casualties prevented

The monetary values assigned for prevention of a fatal, serious and slight casualty, respectively, were based on the unit cost values suggested in the 2014 Update of the Handbook of External Costs of Transport, prepared on behalf of the European Commission, DG MOVE (Korzhenevych *et al.*, 2014), see Table 43¹⁵⁶. The values relate to market prices in the year 2010 and were adjusted for inflation to the relevant study year, using the inflation factors described in Annex 4.4.13.

¹⁵⁶ Note: ‘Mitigated’ casualties are monetised as full prevented casualties at the higher level, but subsequently added to the remaining population of the lower level and thereby reduce the monetary benefit in the lower severity group. The benefit of a fatality turned to a serious casualty, for instance, equates to €1,626,900 based on the above values.

Table 44: Monetary values applied for prevented casualties, at market prices (PPP) in year 2010 euros

Casualty severity	Social unit cost
Fatal	€1,870,000
Serious	€243,100
Slight	€18,700

Note that the value of €243,100 is assigned to ‘severe’ injuries in the study by (Korzhenevych *et al.*, 2014), which appears to implicate a definition based on injury level of MAIS4+ rather than police-defined ‘serious’ injuries. However:

- (Korzhenevych *et al.*, 2014) use the terms ‘serious’ and ‘severe’ interchangeably throughout the report.
- All values in the report are updates of the values determined during the course of the HEATCO project (Bickel *et al.*, 2006a), which, in turn, based the serious casualty valuation on a proportion of the fatality value that was derived for the ECMT 1998 or 2001 Round Table. This Round Table saw scientific contributions from Germany, Netherlands, UK and Sweden and the definition of a ‘Serious’ casualty was closely related to the national police record definition, rather than a MAIS-based definition.

Therefore, the value cited above for serious casualties is most appropriately applied to the conventional reported number of serious casualties in the CARE database, rather than the new MIAS-based definition of MAIS3+ injuries.

Annex 4.4.10 Safety measure costs

Costs for the proposed safety measures were estimated on a per vehicle basis for this study. The cost values are subjected to inflation using the inflation factors described in in Annex 4.4.13 and multiplied with the number of new vehicle registrations per vehicle category in the relevant study year.

The initial cost estimates presented are to be understood to reflect the costs to the vehicle manufacturers at time of mandatory introduction, that is,

- the price a vehicle manufacturer would pay a Tier 1 supplier for fully manufactured components (‘Tier 1 supplier costs’) with an additional mark-up to reflect costs for acquisition, storage and installation of the components; or
- the total cost to the vehicle manufacturer, including fixed and variable cost of manufacturing and assembly, and overheads for research and development, broken down per vehicle.

Table 45 presents the initial cost estimates per vehicle for each of the policy options assessed. Refer to Annex 4.8.7 for the relevant individual cost estimates, sources and rationale for expert panel estimates.

Table 45: Initial cost at mandatory introduction of policy options per vehicle (best estimate) inflated to year-2021 Euros

Initial cost per vehicle	PO1	PO2	PO3
Passenger cars (M1)	€201	€360	€516
Buses and coaches (M2&M3)	€6	€607	€970
Vans (N1)	€131	€206	€521
Trucks (N2&N3)	€6	€607	€1,013

The cost estimates in the study reflect the assumption of high-volume manufacturing of the required components due to mandatory introduction. Based on the practice applied by agencies such as NHTSA¹⁵⁷ and EPA¹⁵⁸ in past regulatory cost-effectiveness evaluations¹⁵⁹, cost reductions through learning by doing (accumulated production volume and small redesigns that reduce costs) are applied to the initial cost estimates after first mandatory introduction of the measures (Committee on the Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy; National Research Council, 2011). A two-step reduction of 20% and 10%, respectively, is applied to the initial cost-estimates in the first and second year, respectively, after introduction.

Where technology sharing of sensors between different measures was deemed possible, the relevant cost was distributed between the measures of interest. This was done for the measures AEB-VEH, AEB-PCD, ISA-VOL, and LKA-ELK, considering that these could likely be realised in a camera-based version (although radar might be necessary for more advanced systems, basic functionality could be realised using visual sensors).

The best estimates for costs were based on the values determined by (Seidl *et al.*, 2017) in preparation of this study (extracted from published tear-down studies and stakeholder input). Additional industry estimates from vehicle manufacturers were received and considered, where deemed appropriate, to justify upward or downward adjustments of the initial best estimates and to define the breadth of variation for the upper and lower estimate for the interval and scenario analysis. Where no values could be identified during the course of this review and where no stakeholder input was provided, a road safety expert panel at TRL determined best estimates from the available evidence. Note that most cost-estimates for N1 vehicles were derived from M1 costs, and most M2&M3 estimates from N2&N3 costs. This

¹⁵⁷ <https://www.nhtsa.gov/>

¹⁵⁸ <https://www.epa.gov/>

¹⁵⁹ https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/deis_appx_c.pdf

was necessary because the level of evidence for vans and buses and coaches was not as high as for the other vehicle categories.

Annex 4.4.11 Impact of additional safety measures on vehicle prices and sales numbers

This study makes predictions of future new vehicle sales numbers and fleet growth based on extrapolation of historic trends. It is important, in this context, to analyse whether the cost of the additional safety measures to the vehicle manufacturers would be likely to result in a substantial increase in end-user vehicle prices and thereby negatively affect new vehicle sales numbers. If this was the case, slower dispersion of the safety measures into the fleet might partially diminish the safety returns, which should be reflected in the model.

The costs calculated in this study for fitment of the proposed safety measures are to be understood to reflect the costs to the vehicle manufacturers. The full set of proposed safety measures (PO3) is estimated to create additional costs in the region of €520 per M1 and N1 vehicle, and in the region of €1,000 per M2&M3 and N2&N3 vehicle (refer to Annex 4.8.7 for details). These costs incurred by the vehicle manufacturers cannot directly be translated into a change in vehicle retail prices, because the markets for consumer, as well as commercial, vehicles are highly competitive which might not allow costs to be passed on directly; this can be observed in historic pricing data.

Up until 2011, the European Commission has published annually the ‘Report on car prices within the European Union’¹⁶⁰. These reports provide the most comprehensive and detailed guide to the historic development of car prices in Europe year-on-year by collating list prices for cars (i.e. before any dealership discounts) and determining the car price development in real terms, i.e. adjusted for inflation (European Commission, 2011). **Table 6** shows the price development during the last decade of available data (2002 to 2011).

¹⁶⁰ Available at: http://ec.europa.eu/competition/sectors/motor_vehicles/prices/report.html The car price reports were discontinued after 2011 because the Commission did not find any significant competition shortcomings in the new cars sector.

Table 46: Year-on-year change in real car prices for the last decade of available data. Source: Report on car prices within the European Union – Technical annex, Years: 2002 to 2011

Year	Year-on-year price change
2002	-0.2%
2003	-0.7%
2004	-1.9%
2005	-1.5%
2006	-1.6%
2007	-1.0%
2008	-3.2%
2009	-3.1%
2010	-0.6%
2011	-2.5%
2012 and beyond	EU car price reports discontinued; no published data

It can be seen that cars have become cheaper in real terms in every year of the last reported decade, despite this being a period in which technical development to meet new and more demanding environmental and safety standards increased, for example:

- Directive 98/69/EC and Regulation (EC) No 715/2007: Euro 4 and Euro 5 emissions standards applicable from 2005 and 2009, respectively.
- Mandatory average fleet CO₂ emissions limits: EU Regulation No 443/2009 was adopted in 2009 with mandatory compliance limits applying from 2012. The average CO₂ emissions of the new vehicle fleet sold by a manufacturer could not be reduced in a step change from one year to the next. Hence, manufacturers started around 2007, in preparation for the announced legislation, to introduce technologies that significantly reduced CO₂ emissions, in order to be able to meet the compliance limits in 2012. This can be concluded from the average rate of progress in CO₂ reduction, which accelerated considerably after 2007, compared to the long term trend before (Transport & Environment, 2011). Considerable investments in this regard therefore fall within the period of retail price decreases cited above.
- Directives 96/79/EC and 96/27/EC: Compliance with frontal and lateral crash tests for all new cars sold from October 2003.
- Regulation (EC) No 661/2009 (General Safety Regulation): Electronic stability control (ESC) applicable from 2011, mandatory gear shift indicators applicable from 2012.
- Regulation (EC) No 78/2009 (Pedestrian Safety Regulation): Emergency brake assist (EBA) applicable from 2011.

A 2011 study commissioned by the European Commission, DG Climate Action, analysed the effect of emissions and safety regulations and standards on vehicle prices (Varma *et al.*, 2011). The study concluded that historical vehicle price data and fitment status of certain features did not provide any definitive relationship between emissions standards and car prices. Overall, cars had become 12% to 22% cheaper (after inflation) in the study period of

2002 to 2010. The study found that, while there was certainly a cost associated for the vehicle manufacturers to comply with the environmental and safety legislation during that period, these costs were largely offset by cost reductions from economies of scale and improved productivity, because the competition in the market made it difficult to pass on cost increases to consumers. Stakeholders interviewed for the study argued that without the additional legislation, car prices would have fallen even further in that period. Nevertheless, it is evident that regulatory requirements have not stopped the trend of car retail prices decreasing, because compliance costs for emissions and safety standards are only one of the many complex factors influencing vehicle retail prices.

A report published by the European Federation for Transport and Environment (T&E) in 2011 also looked into the aspect of potential vehicle price increases specifically due to CO₂ emissions regulations and, looking back, compared the predicted influence on retail price with actual figures (Transport & Environment, 2011). The authors came to a similar conclusion as (Varma *et al.*, 2011): That car retail prices were influenced by a complex set of factors, with compliance costs being only one of them, and that concerns over cars becoming unaffordable due to CO₂ emissions regulations had been unfounded.

The past experience with CO₂ emissions legislation also allows comparing predicted additional costs with predicted and actual retail price increases: In a 2006 study prepared for the European Commission, the researchers from TNO had estimated the future costs to manufacturers of reaching the required average CO₂ targets to be an additional €832 per car in 2008, compared to a year-2002 baseline (Smokers *et al.*, 2006). This was expected by the authors to translate to an additional retail price of €1,200 per car in 2008, again compared to 2002. In reality however, cars have become approximately 10% cheaper (after inflation) between 2002 and 2008 (see **Table 6**), which equates to a price reduction of €2,000 for a €20,000 model. These figures show that, bearing in mind the scale of investment required to meet emissions requirements, coupled with the costs of the other aspects cited above, the costs to vehicle manufactures related to the fitment of new safety measures in the present study are not considered to be orders of magnitude different in scale than past predictions which did not translate to retail price increases.

Interpreting the general price trend and the conclusions from the cited studies on compliance costs, it can be concluded that vehicle manufacturers in the past have found strategies and practices to balance production costs and regulatory compliance. This has been, for example, via increases in production efficiency, or accepted temporarily reduced profit margins to at least partially offset any cost increase, because the competitive nature of the vehicle market did not allow substantial retail price increases. Past evidence therefore suggests that requiring additional equipment for CO₂ emission standards, which was estimated at a cost higher than the present estimates for the full set of proposed safety measures, did not cause an increase in retail prices. Substantial increases in vehicle prices due to the additional safety measures in the medium and long term are therefore not expected and consequently no extraordinary impact on vehicle sales numbers was modelled for the cost-benefit analysis.

Annex 4.4.12 Discounting of costs and benefits

A discounting rate is applied in the economic analysis for this study to relate the benefits and costs occurring in future years to the present. A ‘social discount rate’ r is applied to reflect the fact that benefits and costs further ahead in the future are valued lower than present benefits and costs.

The present value PV of costs C in the years $t=0$ to the end of the appraisal period $t=T$ is calculated as (Bickel *et al.*, 2006a):

$$PV = \sum_{t=0}^T C_t \times \frac{1}{(1+r)^t}$$

The present value of benefits is calculated in the same way.

Recommended social discount rates for EU transport projects in relevant guidelines range between 3% (recommended in the HEATCO project as lower bound for sensitivity analysis, (Bickel *et al.*, 2006b)) and up to 5.5% (recommended by DG Regional Policy for investments in Cohesion countries, (European Commission, DG Regional Policy, 2008)).

For the current CBA an average rate between these recommendations, i.e.

$$r = 4.25\%,$$

was chosen for the central estimate calculations. The interval analysis range was set as $r_{low} = 3.0\%$ to $r_{high} = 5.5\%$. A constant rate r was applied over time for the entire analysis period, which is in line with the HEATCO recommendations, which only call for a declining discount system if intergenerational impacts are concerned in very long appraisal periods (Bickel *et al.*, 2006b).

Annex 4.4.13 Inflation of monetary values

An inflation rate is applied to all monetary values in this study to adjust cost and benefit estimates from the past to current values and to factor in future devaluation. The inflation rate used is the year-on-year percentage change of the Harmonised Index of Consumer Prices published by Eurostat. For the past, historic data from Eurostat was used; for the future forecasts by the European Central Bank (Table 47).

Table 47: Year-on-year inflation rates applied in the study

Year	Inflation rate	Type	Source
2008	3.7%	actual	(Eurostat, 2017)
2009	1.0%	actual	(Eurostat, 2017)
2010	2.1%	actual	(Eurostat, 2017)
2011	3.1%	actual	(Eurostat, 2017)
2012	2.6%	actual	(Eurostat, 2017)
2013	1.5%	actual	(Eurostat, 2017)
2014	0.5%	actual	(Eurostat, 2017)

Year	Inflation rate	Type	Source
2015	0.0%	actual	(Eurostat, 2017)
2016	0.3%	actual	(Eurostat, 2017)
2017	1.5%	forecast	(European Central Bank, 2017a)
2018	1.4%	forecast	(European Central Bank, 2017a)
2019	1.6%	forecast	(European Central Bank, 2017a)
2020	1.8%	forecast	(European Central Bank, 2017a)
2021	1.8%	forecast	(European Central Bank, 2017a)
2022	1.8%	forecast	(European Central Bank, 2017a)
2023 and beyond	2.0%	forecast	(European Central Bank, 2017b)

Annex 4.4.14 Sensitivity analysis

To quantify the range uncertainty around the best estimate BCR values, two sensitivity analysis techniques common in cost-benefit evaluations were applied (Bickel *et al.*, 2006a):

- Interval analysis, and
- Scenario analysis.

Input parameters which have a strong influence on results and a relatively high associated uncertainty were identified as:

- Measure effectiveness (directly influencing the number of casualties saved),
- Measure cost (directly influencing the fitment cost),
- Discounting rate (influencing the weight of short-term and long-term effects),
- General road casualty trend (influencing the size of the target population for the safety measures), and
- Voluntary measure uptake (influencing the baseline to which the other policy options are compared).

The best estimate and upper/lower estimate values for these parameters were chosen as described in the previous sub-sections or in the appendices. Refer to Table 48 for an overview of the combination of input parameters used for each analysis. The other input parameters remained unchanged.

Table 48: Varied input parameter values for interval and scenario analysis

	Interval analysis (absolute lower BCR)	Scenario analysis (expected lower BCR)	Best estimate analysis	Scenario analysis (expected upper BCR)	Interval analysis (absolute upper BCR)
Measure effectiveness	Lower estimate	Upper estimate	Best estimate	Lower estimate	Upper estimate
Measure cost	Upper estimate	Upper estimate	Best estimate	Lower estimate	Lower estimate
Discounting rate	Upper estimate	Best estimate	Best estimate	Best estimate	Lower estimate
General road casualty trend	Lower estimate	Lower estimate	Best estimate	Best estimate	Best estimate
Voluntary measure uptake	Best estimate	Best estimate	Best estimate	Lower estimate	Lower estimate

The interval analysis was carried out to determine the absolute upper and lower bound of the BCR. The parameters mentioned above were varied in a direction that represents an absolute optimistic assumption (absolute upper BCR) and an absolute pessimistic assumption (absolute lower BCR). These are the outer bounds of variation that could be conceivable according to the model employed under extreme circumstances; however, these bounds would only be met in the improbable case that future reality diverges from the estimated input values in the same direction for each of the safety measures.

The scenario analysis was carried out to reflect the bounds of variation that could be expected in a scenario where the input value estimates applied had a tendency to systematically underestimate both effectiveness and costs (expected upper BCR), or to systematically overestimate both (expected lower BCR), and where the voluntary measure uptake (expected upper BCR) or the general road casualty trend (expected lower BCR) would be lower than expected.

The resulting absolute and expected upper/lower BCR results are reported alongside each best estimate BCR.

Annex 4.4.15 Data sources and stakeholder validation

In preparation of this cost-effectiveness study, the European Commission tasked TRL to collate the most up-to-date, high quality data available on effectiveness, cost, fleet penetration and target population of the safety measures. TRL selected the best sources for these parameters from the body of published evidence based on quality of research, quality of data, timeliness and relevance and extract suggested input values.

This was followed by a wide stakeholder consultation where stakeholders were asked to provide values for parameters (if no published evidence was available), to validate or contest TRL’s preliminary suggested values with additional evidence, and to comment on the proposed method for avoidance of double-counting of casualties prevented (three layers of protection). 72 representatives from 54 organisations (including 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) attended the two-day stakeholder meeting. In addition, 32 organisations provided written feedback.

All inputs, provided in writing or during the two-day face-to-face meeting, were documented and, where appropriate, used to update and refine the input values proposed for this cost-effectiveness study. The input values found in this process were collated in the report *In Depth Cost-Effectiveness Analysis of the Identified Measures and Features regarding the Way Forward for Vehicle Safety in the EU* ('GSR2') (Seidl *et al.*, 2017) and are referenced throughout Annex 4.8.1 to Annex 4.8.7 of this report. Where additional sources or expert panel assessments were required, this is explained in Annex 4.4.1 to Annex 4.4.15 and referenced alongside the numbers.

Annex 4.4.16 Limitations

In general, the model has used various input values (e.g. inflation rate, number of new registrations, measure effectiveness, etc.) to predict the effects of different policy options. Predictions of the future are by definition inherently subject to a degree of uncertainty. This study has used input values based on historical trends; the interval and scenario analysis provides assessment of the effect that deviations from the expected trend may have on the outcome, but cannot completely account for very extreme changes in circumstances. The following important limitations of the simulation model employed and the input value estimates should be taken into account when interpreting the results.

The accident data analysis to determine the target populations for the safety measures was based on GB national data rather than pan-European data. The EU-wide accident data available from CARE did not offer the level of detail necessary to perform this analysis because it does not contain contributory factors of collisions or data on the first point of impact on vehicles. Where data from additional European countries regarding target populations for the specific measures considered was available, this was incorporated by applying target population correction factors to represent the average situation in the countries available. This was the case for measures HED-MGI, ISA-VOL, REV, VIS-DET and VIS-DIV. To arrive at estimates valid for the European Union, the target population percentages found were scaled up to EU-28 to greatest level of detail possible from the data fields available within the CARE. The scaling was based on the average European casualty distribution for fatal, serious and slight casualties in collisions where the relevant vehicle categories collided. This means, the scaling was carried out so that it is representative of the European proportions of casualties in M1-to-M1, M1-to-N1, N1-to-M2M3, etc. collisions.

The effectiveness and cost estimates used are subject to a degree of uncertainty. The level of uncertainty varies between safety measures, with the level of evidence available for each measure from research. The level of evidence was good for some well-established measures (e.g. AEB and AEB-PCD) and less robust for some other measures (e.g. DDR-DAD and DDR-ADR). Both, effectiveness and cost estimates were established using a thorough review process during the GSR2 project which involved large-scale stakeholder consultations and are therefore considered to represent the highest level of evidence that could be acquired. To treat

the remaining uncertainty in these values, upper and lower estimates were employed for the interval and the scenario analysis.

The casualty simulations and cost calculations are based on a continuation of existing trends into the future (with expected variability in these trends captured in the scenario analysis). This approach cannot capture any potential disruptions that might occur in the mobility market in the future, such as autonomous driving radically changing the collision landscape, mobility as a service reducing private car ownership and potentially increasing overall miles driven, or a severe economic crisis reducing new vehicle uptake. Disruptions are highly uncertain and impossible to predict as to when, if, and to what extent they will happen and their impact could not be captured in the models other than in a highly speculative way, which would undermine the evidence-base for the analysis.

The results of the cost-benefit analysis should be interpreted with this context in mind and understood as an evidence-based, detailed prediction of the cost-effectiveness of the policy options if historic trends continue within a range of expected uncertainty.

Annex 4.5 **Results**

Annex 4.5.1 Cost-effectiveness of policy options

The main results of the cost-effectiveness evaluation are presented in the following tables and figures, separated by vehicle category cluster (M1, M2&M3, N1 and N2&N3, respectively). Further results for individual years of the evaluation period and ranges of uncertainty are given in Annex 4.9.2 and Annex 4.9.3, respectively.

The benefit-to-cost ratios (BCRs) reported allow a comparison of the different policy options based on the extent to which the benefits exceed (or fall short of) the costs created by a policy option over the entire evaluation period 2021–2037, compared to the baseline scenario (voluntary uptake). Values greater than 1 indicate that the benefits are greater than the costs incurred.

For passenger cars (M1), the results indicate that implementation of any of the policy options would be cost-effective, according to the best-estimate calculations and also within the expected lower and upper estimate band found in the scenario analysis. PO1 resulted in the highest BCR for passenger cars.

For buses and coaches (M2&M3), all policy options were found to be cost-effective according to best estimate calculations and also within the expected lower and upper estimate band. PO1 has the highest BCR; however note that this ratio is achieved, by this policy option consisting of only two measures, which has minimal impact on both costs and benefits as can be seen from the casualty prevention results (Annex 4.5.2).

For vans (N1), implementation of PO1 and PO2 were found to be cost-effective according to the best-estimate calculations. The band of expected uncertainty for PO2 just spans the threshold of cost-effectiveness. PO3 was found to be less cost-beneficial and did not exceed the threshold of cost-effectiveness.

For trucks (N2&N3), PO2 and PO3 exceeded the threshold of cost-effectiveness, according to best estimate calculations. PO2 presented the most favourable BCR with the expected lower BCR value falling short of cost-effectiveness by a small margin. For PO3, the expected lower and upper estimate band straddled the threshold of cost-effectiveness.

When interpreting the results it should also be considered that only safety benefits of the assessed measures have been considered in this study. Non-quantified benefits, such as, productivity gains due to the reduction in traffic congestion associated with road traffic collisions or reduced CO₂ emissions caused by TPM, will contribute to a greater benefit of the policy options.

Passenger cars (M1):

Table 49: Passenger cars (M1): Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario; uncertainty ranges from scenario and interval analysis

Passenger cars (M1)	PO1		PO2		PO3	
BCR (best estimate)	2.95		2.14		1.39	
BCR (expected lower/upper)	2.28	3.31	1.58	2.69	1.01	1.85
BCR (absolute lower/upper)	1.83	4.14	1.31	3.30	0.84	2.27

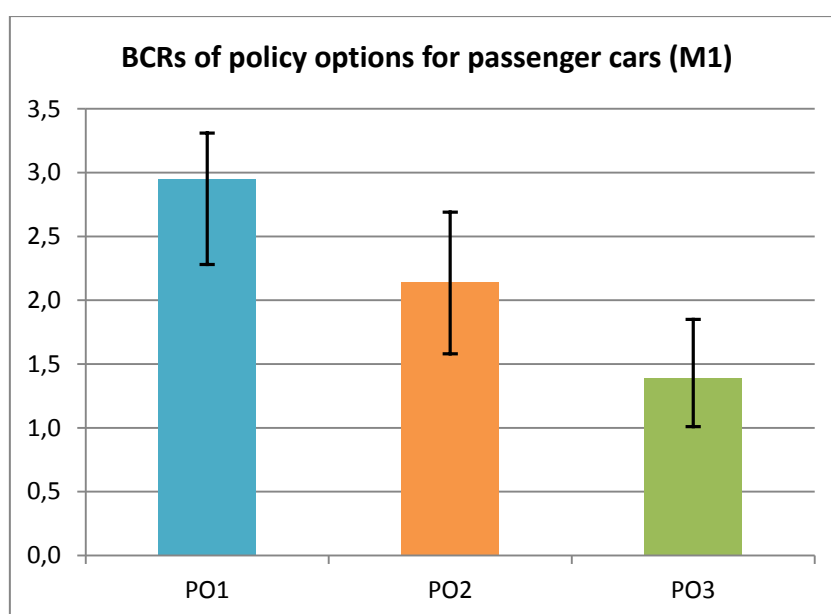


Figure 34: Passenger cars (M1): Comparison of best estimate benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3, with indication of uncertainty ranges from scenario analysis

Table 50: Passenger cars (M1): Present monetary value of benefits and costs of policy options PO1, PO2 and PO3 over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Passenger cars (M1)	PO1	PO2	PO3
Present value benefit	€37.5 bn	€57.4 bn	€64.1 bn
Present value cost	€12.7 bn	€26.9 bn	€46.0 bn

Buses and coaches (M2&M3):

Table 51: Buses and coaches (M2&M3): Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario; uncertainty ranges from scenario and interval analysis

Buses and coaches (M2&M3)	PO1		PO2		PO3	
BCR (best estimate)	4.64		3.11		2.11	
BCR (expected lower/upper)	3.17	14.32	1.91	4.42	1.46	2.56
BCR (absolute lower/upper)	2.11	21.72	1.37	6.26	1.03	3.65

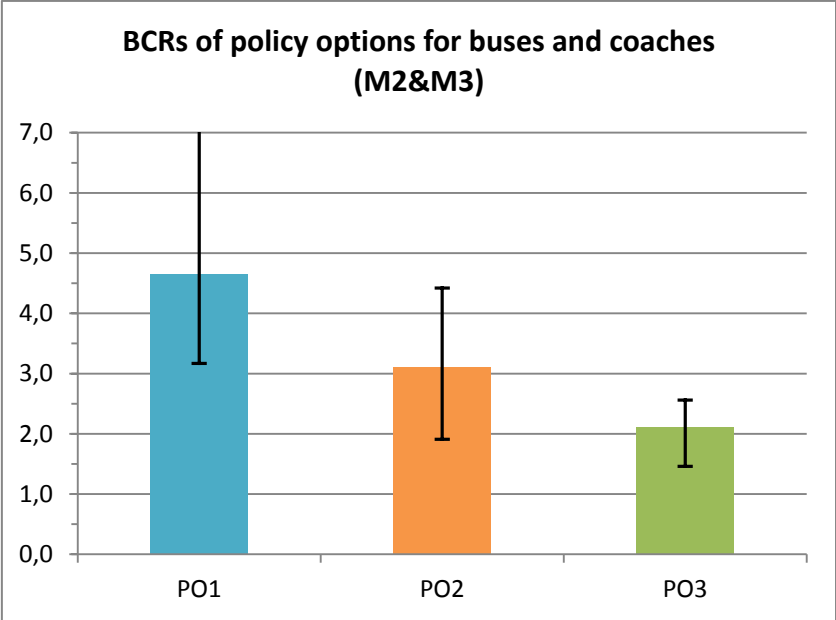


Figure 35: Buses and coaches (M2&M3): Comparison of best estimate benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3, with indication of uncertainty ranges from scenario analysis

Table 52: Buses and coaches (M2&M3): Present monetary value of benefits and costs of policy options PO1, PO2 and PO3 over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Buses and coaches (M2&M3)	PO1	PO2	PO3
Present value benefit	€11.2 mn	€813.7 mn	€937.0 mn
Present value cost	€2.4 mn	€262.0 mn	€444.5 mn

Vans (N1):

Table 53: Vans (N1): Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario; uncertainty ranges from scenario and interval analysis

Vans (N1)	PO1		PO2		PO3	
BCR (best estimate)	1.78		1.35		0.53	
BCR (expected lower/upper)	1.39	1.83	0.98	1.51	0.39	0.65
BCR (absolute lower/upper)	1.09	2.33	0.79	1.88	0.31	0.81

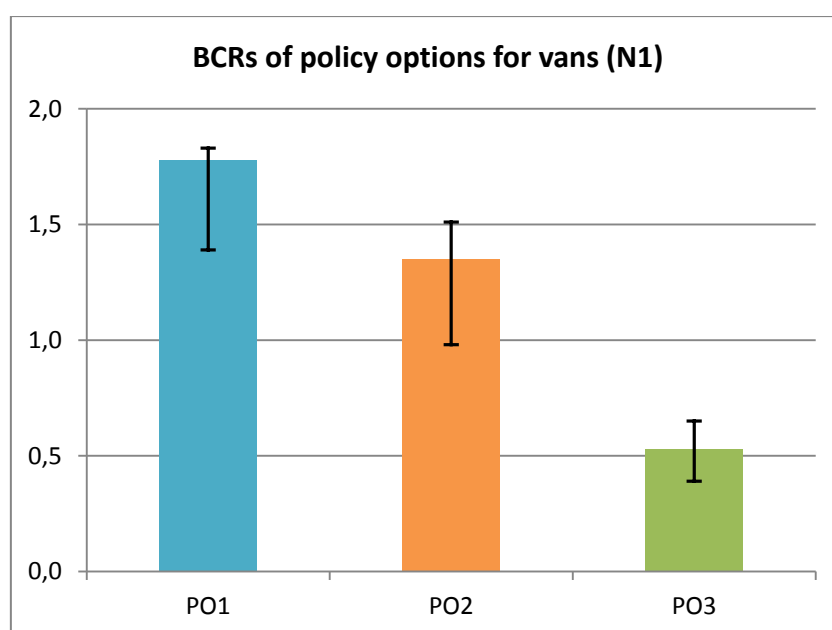


Figure 36: Vans (N1): Comparison of best estimate benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3, with indication of uncertainty ranges from scenario analysis

Table 54: Vans (N1): Present monetary value of benefits and costs of policy options PO1, PO2 and PO3 over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Vans (N1)	PO1	PO2	PO3
Present value benefit	€2.3 bn	€2.8 bn	€3.7 bn
Present value cost	€1.3 bn	€2.0 bn	€6.9 bn

Trucks (N2&N3):

Table 55: Trucks (N2&N3): Benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3 based on present values over entire evaluation period 2021–2037 compared to the baseline scenario; uncertainty ranges from scenario and interval analysis

Trucks (N2&N3)	PO1		PO2		PO3	
BCR (best estimate)	0.56		1.52		1.03	
BCR (expected lower/upper)	0.39	2.93	0.89	2.28	0.59	1.29
BCR (absolute lower/upper)	0.25	4.49	0.73	2.81	0.47	1.63

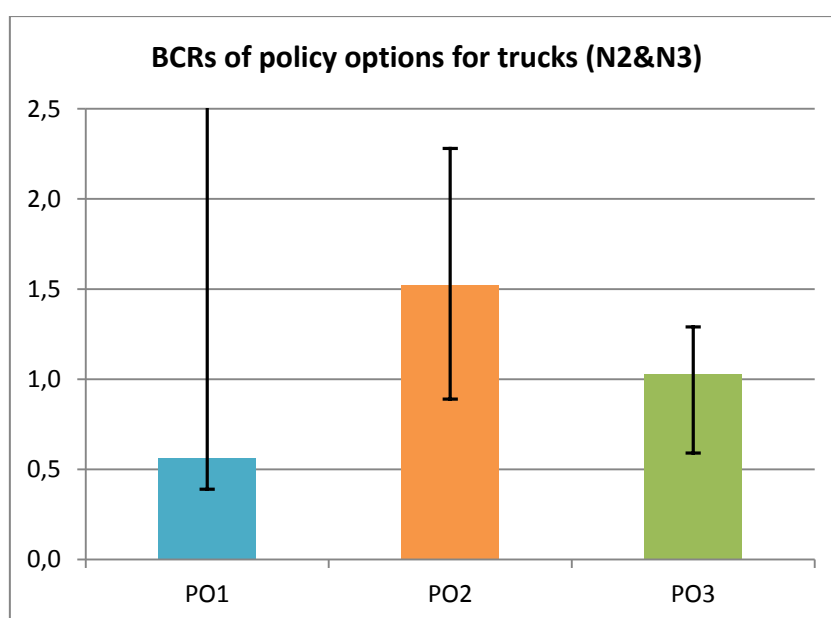


Figure 37: Trucks (N2&N3): Comparison of best estimate benefit-to-cost ratios (BCRs) of policy options PO1, PO2 and PO3, with indication of uncertainty ranges from scenario analysis

Table 56: Trucks (N2&N3): Present monetary value of benefits and costs of policy options PO1, PO2 and PO3 over entire evaluation period 2021–2037 compared to the baseline scenario (best estimate)

Trucks (N2&N3)	PO1	PO2	PO3
Present value benefit	€ 0.01 bn	€3.4 bn	€4.1 bn
Present value cost	€ 0.02 bn	€2.2 bn	€4.0 bn

Annex 4.5.2 Casualties prevented by policy options

The main results of the casualty prevention simulations are presented in the following tables and figures separated by vehicle category cluster (M1, M2&M3, N1 and N2&N3, respectively). Further results for individual years of the evaluation period are given in Annex 4.9.3.

Comparison of the results allows conclusions about which policy option prevents the highest number of casualties^{161,162} across EU-28 when compared with the baseline scenario. To estimate the casualty prevention totals, the best estimate numbers of all years of the evaluation period 2021–2037 are summed.

It can be observed for all vehicle categories that the number of casualties prevented by implementation of PO2 or PO3 exceeds the number prevented by PO1 by a considerable margin. Between all four vehicle categories, implementation of PO2 has the potential to prevent an additional 8,312 fatalities and 51,286 serious casualties compared to PO1 across EU-28 over the period 2021–2037. PO3 exceeds the potential of PO2 by further 1,843 fatalities and 21,807 serious casualties.

¹⁶¹ When interpreting the results, it should be noted that casualties prevented were attributed to the vehicle category equipped with the effective safety measure, which is not always identical with the vehicle category occupied by the casualty. To give an example, if a head-on collision involving a van (N1) and a car (M1) where the van drifted out of the lane and the drivers of both vehicles were fatally injured was prevented by LKA-ELK fitted to the van, then both fatalities prevented would be counted as benefit of LKA-ELK in the N1 category.

¹⁶² It should further be noted that ‘mitigated’ casualties were added to the remaining casualties at the next lower injury severity level.

All vehicle categories (total sum):

Table 57: Total sum of casualties prevented by safety measures across all vehicle categories over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

All categories	PO1	PO2	PO3
Fatalities prevented	14,639	22,951	24,794
Serious casualties prevented	67,647	118,933	140,740
Slight casualties prevented	288,293	421,562	515,681

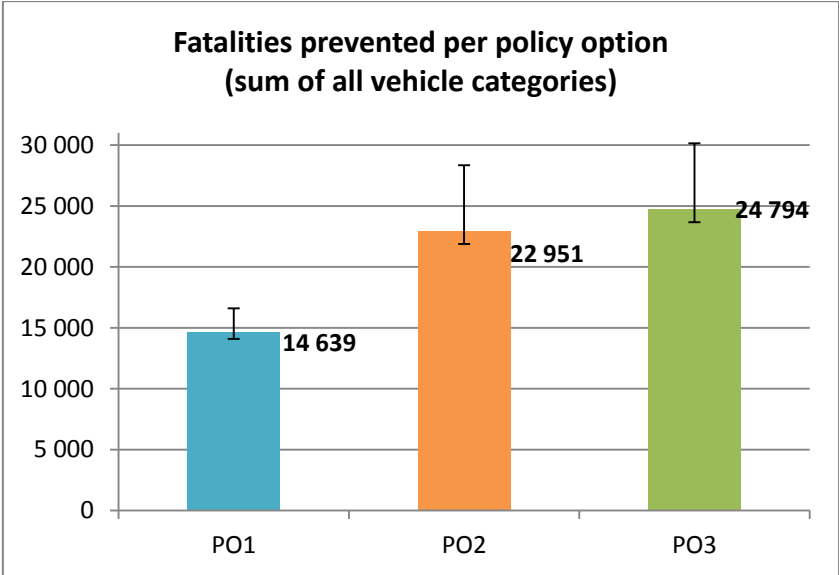


Figure 38: Total sum of fatal casualties prevented by safety measures across all vehicle categories over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate with indication of uncertainty ranges from scenario analysis)

Passenger cars (M1):

Table 58: Passenger cars (M1): Total number of casualties prevented by M1 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Passenger cars (M1)	PO1	PO2	PO3
Fatalities prevented	13,785	20,081	21,337
Serious casualties prevented	63,493	107,913	126,390
Slight casualties prevented	276,815	389,756	470,747

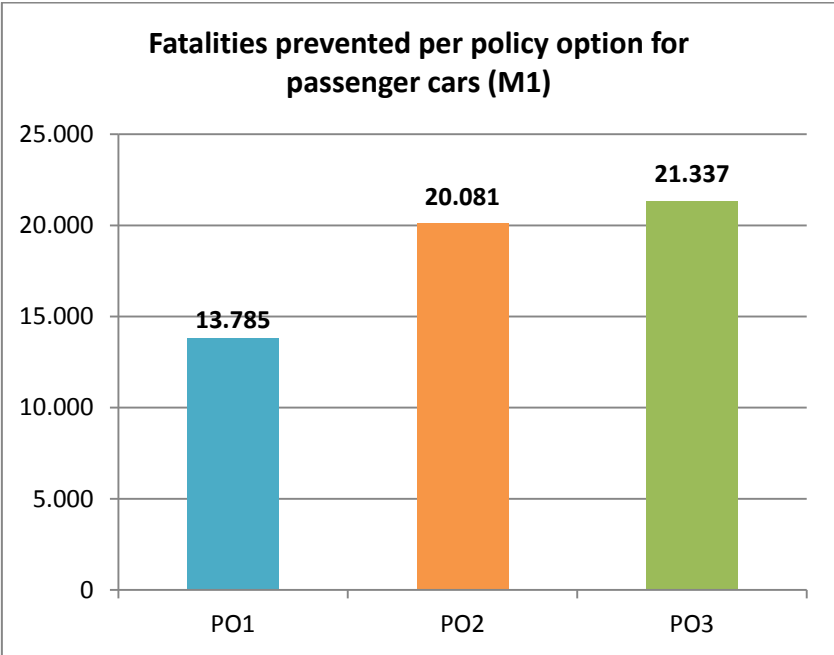


Figure 39: Passenger cars (M1): Total number of fatal casualties prevented by M1 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Buses and coaches (M2&M3):

Table 59: Buses and coaches (M2&M3): Total number of casualties prevented by M2&M3 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Buses and coaches (M2&M3)	PO1	PO2	PO3
Fatalities prevented	2	207	227
Serious casualties prevented	33	2,064	2,410
Slight casualties prevented	113	6,421	8,174

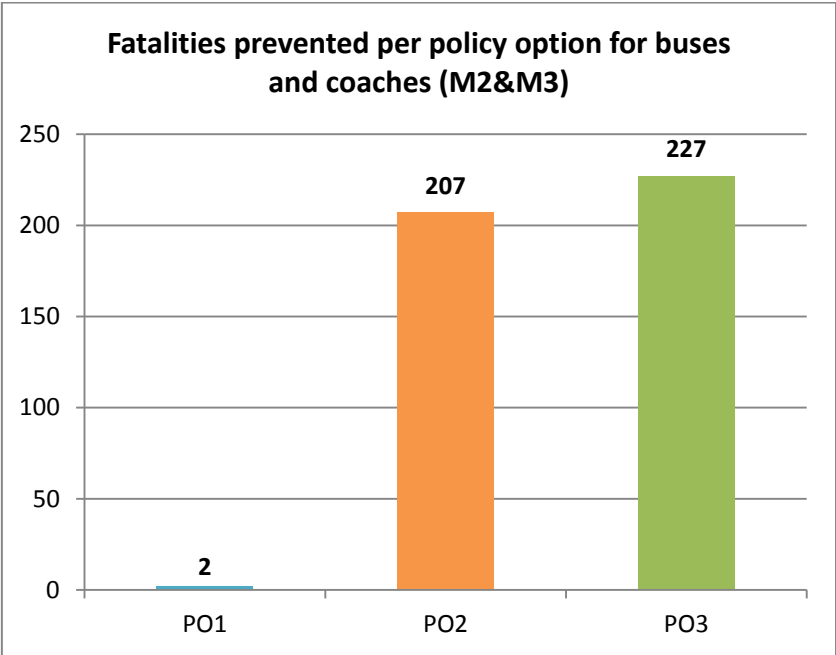


Figure 40: Buses and coaches (M2&M3): Total number of fatal casualties prevented by M2&M3 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Vans (N1):

Table 60: Vans (N1): Total number of casualties prevented by N1 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Vans (N1)	PO1	PO2	PO3
Fatalities prevented	852	1,005	1,283
Serious casualties prevented	4,074	5,068	6,917
Slight casualties prevented	11,208	15,536	23,486

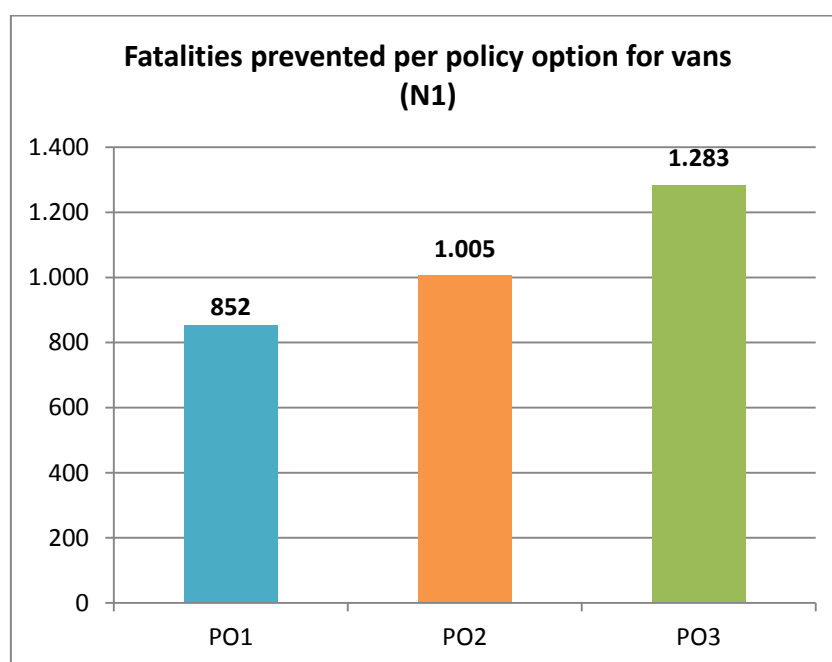


Figure 41: Vans (N1): Total number of fatal casualties prevented by N1 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Trucks (N2&N3):

Table 61: Trucks (N2&N3): Total number of casualties prevented by N2&N3 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Trucks (N2&N3)	PO1	PO2	PO3
Fatalities prevented	0	1,658	1,947
Serious casualties prevented	47	3,888	5,023
Slight casualties prevented	157	9,849	13,274

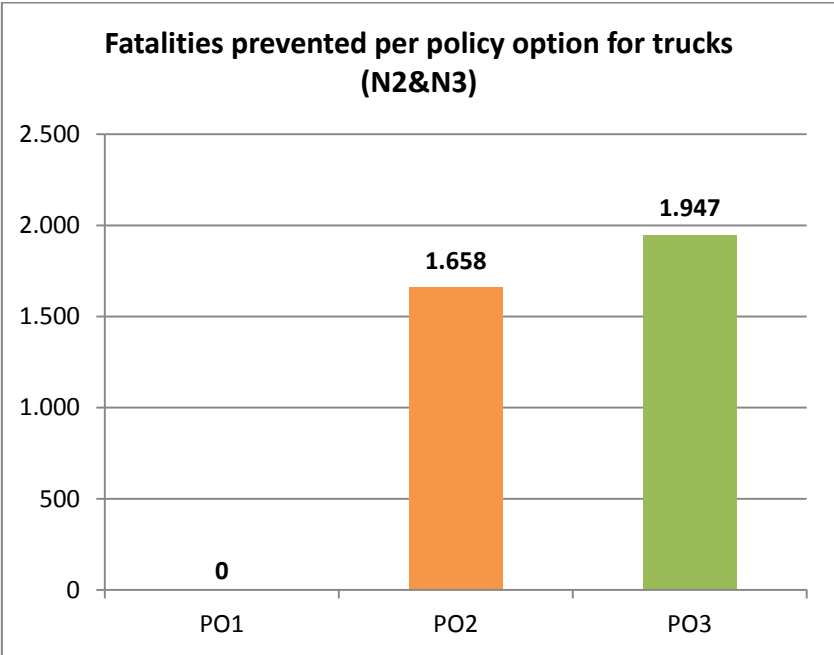


Figure 42: Trucks (N2&N3): Total number of fatal casualties prevented by N2&N3 safety measures over the evaluation period 2021–2037 across EU-28 compared to the baseline scenario (best estimate)

Annex 4.6 **Conclusions**

From the results found for passenger cars (M1) in this cost-effectiveness study, it can be concluded that PO1 offers the most favourable cost-benefit value, but falls short of the overall casualty savings that are expected for implementation of PO2 or PO3 by a considerable margin. PO2 has the potential to prevent approximately 6,296 fatalities more over the evaluation period (2021–2037) compared to PO1 and is cost-effective, with the benefits exceeding the costs by a factor of almost three. PO3 is expected to prevent an additional 1,249 fatalities compared to PO2.

The results for buses and coaches (M2&M3) lead to the following conclusions: PO1 is most cost-beneficial; however, with this policy option consisting of only two measures, the impact of implementation on both costs and benefits would be minimal. PO1 is expected to prevent almost no fatalities. PO2 has a favourable BCR of over 3 and has the potential to prevent 207 fatalities, which could be a reason to favour this policy option over PO1. PO3 would prevent an additional 20 fatalities and is still expected to be cost-beneficial compared to the baseline scenario at a factor of more than two.

For vans (N1), again PO1 is most cost-beneficial, but implementation of PO2, which is exceeding the threshold to cost-effectiveness, offers the potential to prevent an additional 153 fatalities and 994 serious casualties over the period 2021–2037, many of which are pedestrians and cyclists addressed by the measures AEB-PCD and HED-MGI. PO3 falls short of crossing the threshold to cost-effectiveness, with the costs exceeding the benefits with a factor of almost two, but would be expected to prevent another 278 fatalities and 1,849 serious casualties compared to PO2.

The conclusions for trucks (N2&N3) differ from those for buses and coaches, in that PO1 was found not to be cost-effective. However, it should be considered that PO1 has minimal costs associated with it (two measures) and therefore small differences in the target populations and resulting benefits cause large fluctuations in the ratio. PO2 is the most favourable option for trucks based on BCR and would prevent 1,658 fatalities. PO3 offers the potential to prevent an additional 289 fatalities, with the benefits exceeding the costs by only a small margin.

Overall it can be concluded that PO1 offers mostly favourable cost-effectiveness ratios; however, these are achieved with only a small impact on both the costs and the benefits compared to the baseline scenario of continued voluntary uptake. The impacts of PO2 and PO3 are larger, with numbers of fatalities prevented exceeding those of PO1 by a considerable margin; however this is accompanied by a greater cost. Where PO2 or PO3 exceed the threshold to cost-effectiveness ($BCR > 1$), the considerably greater number of casualties prevented compared to PO1 could be a reason to favour implementation of PO2 or PO3.

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Annex 4.8 Appendices of input values

Annex 4.8.1 General road casualty trend

Table 62: General road casualty trend, EU-28 casualties per annum; historic numbers for 2011–2016, future projections provided by European Commission for 2017–2037

Year	Best estimate			Lower estimate		
	Fatal casualties	Serious casualties	Slight casualties	Fatal casualties	Serious casualties	Slight casualties
2011	30,685	264,929	1,235,015	30,685	264,929	1,235,015
2012	28,243	247,661	1,193,873	28,243	247,661	1,193,873
2013	25,956	240,039	1,156,475	25,956	240,039	1,156,475
2014	25,977	250,051	1,173,515	25,977	250,051	1,173,515
2015	26,130	247,905	1,180,068	26,130	247,905	1,180,068
2016	25,619	246,127	1,207,268	25,619	246,127	1,207,268
2017	25,619	246,127	1,207,268	25,440	244,404	1,198,817
2018	25,619	246,127	1,207,268	25,262	242,693	1,190,426
2019	25,619	246,127	1,207,268	25,085	240,994	1,182,093
2020	25,619	246,127	1,207,268	24,909	239,307	1,173,818
2021	25,619	246,127	1,207,268	24,735	237,632	1,165,601
2022	25,619	246,127	1,207,268	24,562	235,969	1,157,442
2023	25,619	246,127	1,207,268	24,390	234,317	1,149,340
2024	25,619	246,127	1,207,268	24,219	232,677	1,141,295
2025	25,619	246,127	1,207,268	24,049	231,048	1,133,306
2026	25,619	246,127	1,207,268	23,881	229,431	1,125,373
2027	25,619	246,127	1,207,268	23,714	227,825	1,117,495
2028	25,619	246,127	1,207,268	23,548	226,230	1,109,672
2029	25,619	246,127	1,207,268	23,383	224,646	1,101,905
2030	25,619	246,127	1,207,268	23,219	223,074	1,094,191

Year	Best estimate			Lower estimate		
	Fatal casualties	Serious casualties	Slight casualties	Fatal casualties	Serious casualties	Slight casualties
2031	25,619	246,127	1,207,268	23,057	221,512	1,086,532
2032	25,619	246,127	1,207,268	22,896	219,962	1,078,926
2033	25,619	246,127	1,207,268	22,735	218,422	1,071,374
2034	25,619	246,127	1,207,268	22,576	216,893	1,063,874
2035	25,619	246,127	1,207,268	22,418	215,375	1,056,427
2036	25,619	246,127	1,207,268	22,261	213,867	1,049,032
2037	25,619	246,127	1,207,268	22,105	212,370	1,041,689

Annex 4.8.2 Layers of proposed and existing safety measures

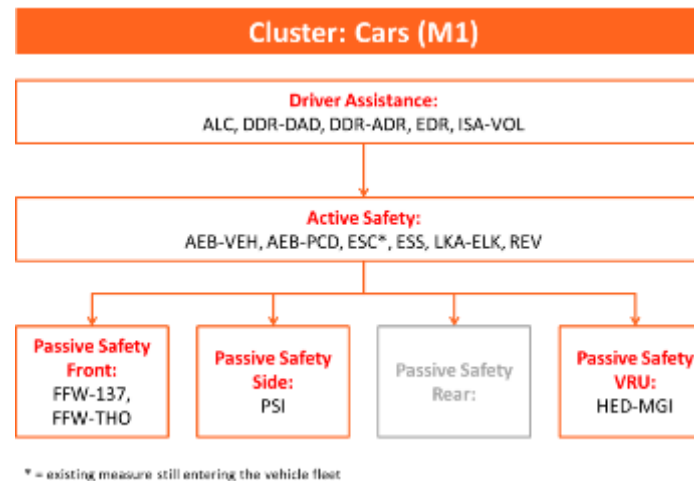


Figure 43: Measure layers for cluster cars (M1)

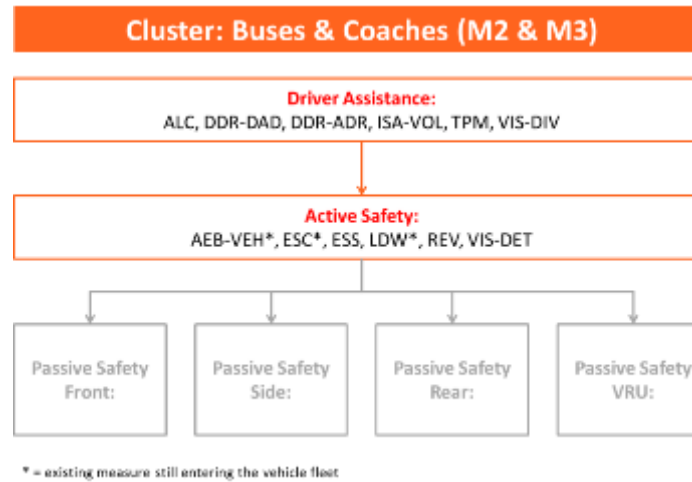


Figure 44: Measure layers for cluster buses and coaches (M2&M3)

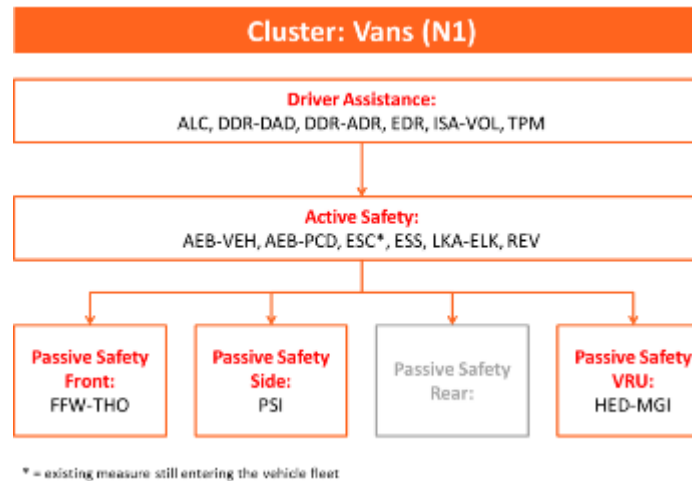


Figure 45: Measure layers for cluster vans (N1)

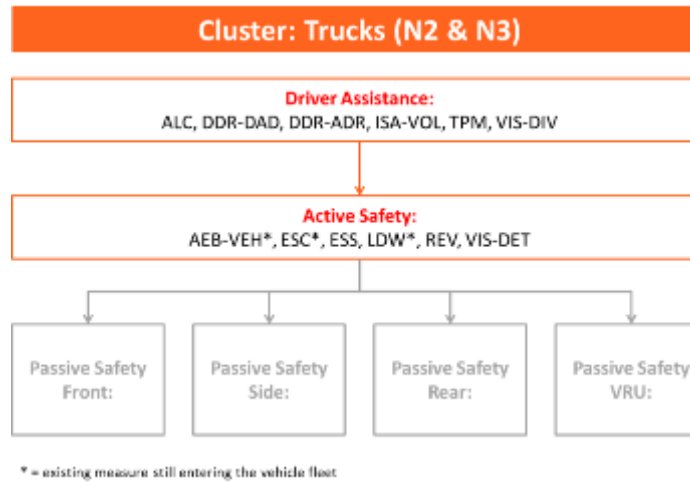


Figure 46: Measure layers for cluster trucks (N2&N3)

Annex 4.8.3 Vehicle fleet size

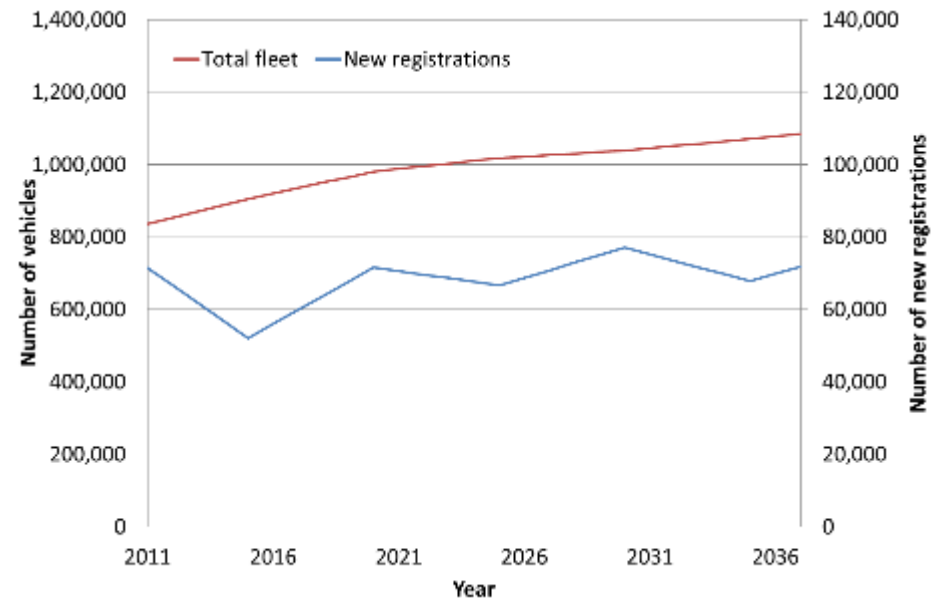


Figure 47: Bus and coach (M2 and M3) fleet and new registrations 2011 to 2037

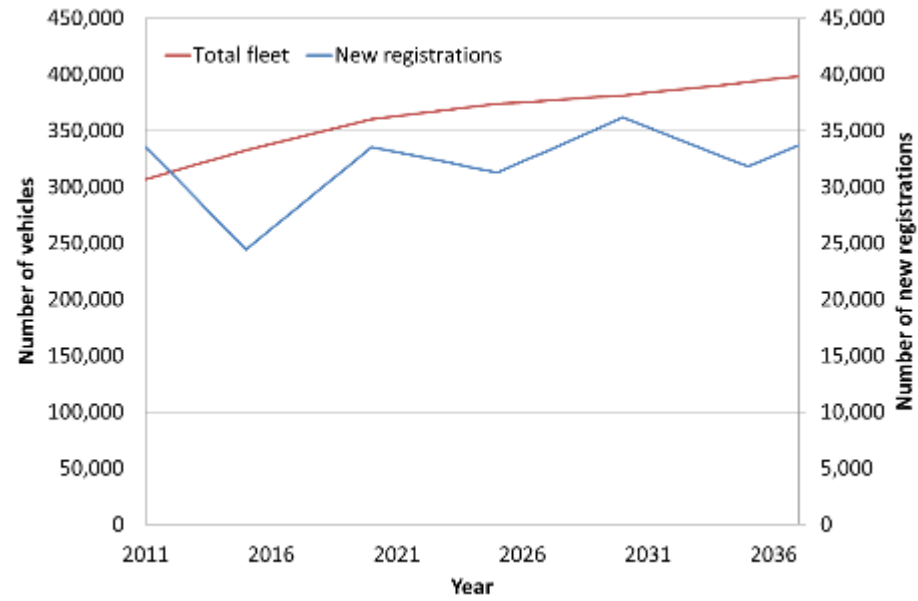


Figure 48: Extra-urban bus and coach fleet and new registrations 2011 to 2037

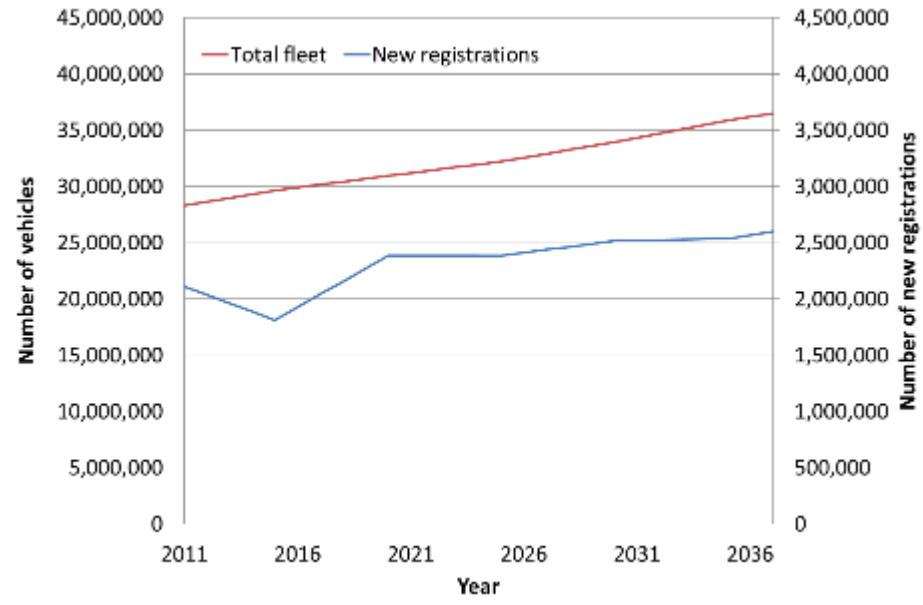


Figure 49: Van (N1) fleet and new registrations 2011 to 2037

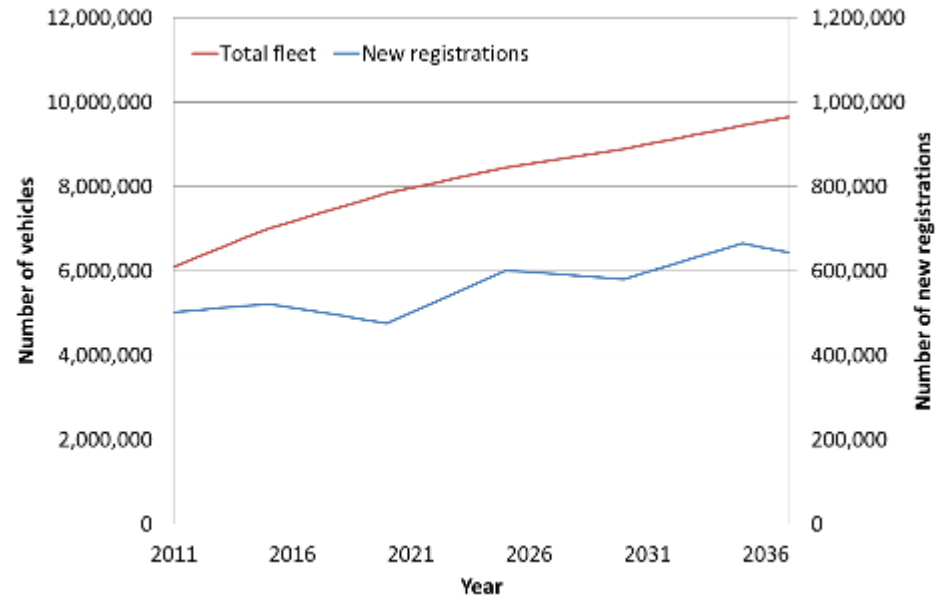


Figure 50: Truck (N2 and N3) fleet and new registrations 2011 to 2037

Annex 4.8.4 Fleet dispersion of safety measures

Table 63: Technology launch date

	M1	M2&M3	N1	N2&N3	Source / justification

	M1	M2&M3	N1	N2&N3	Source / justification
AEB-VEH	2009	2009	2009	2009	Introduced before 2011 (Seidl <i>et al.</i> , 2017), 2009 provides the closest link to third-party observations on fleet fitment rates in 2015 (i.e. 32% of newly registered cars in the Netherlands, 30% in Belgium, 16% in Spain and 21% in the United Kingdom).
AEB-PCD (pedestrian)	2012	n/a	2012	n/a	Launch date in first motor cars (e.g. Volvo).
AEB-PCD (cyclist)	2015	n/a	2015	n/a	Launch date in first motor cars (e.g. Volvo).
ALC	2019	2019	2019	2019	Time needed to develop the installation document and to see alcohol interlocks developed to match the specifications.
DDR-DAD	2011	2011	2011	2011	Systems recognised by Euro NCAP (e.g. Ford Driver Alert).
DDR-ADR	2018	2018	2018	2018	Close to market, but no evidence of launch, yet (Seidl <i>et al.</i> , 2017).
EDR	2006	n/a	2006	n/a	Initial cost/benefit study date.
ESC	1996	1996	1996	1996	1996 is probably too early for trucks and buses but is intended to reflect the launch date of the first example, and predominantly relating to the car fleet uptake.
ESS	2010	2010	2010	2010	System evaluation cited by (Seidl <i>et al.</i> , 2017).
FFW-137	2008	n/a	2008	n/a	
FFW-THO	2012	n/a	2012	n/a	
HED-MGI	2009	n/a	2009	n/a	Monitoring phase for headform-to-windscreen tests in Pedestrian Safety Regulation (EC) No 78/2009.
ISA-VOL	2015	2015	2015	2015	This matches the release date for vehicles such as the Ford S-Max with its voluntary ISA system.
LDW	n/a	2011	n/a	2011	NHTSA and TRL studies suggest launch dates about 2011.
LKA-ELK	2018	n/a	2018	n/a	Suggested launch date according to GSR2 stakeholder input (Seidl <i>et al.</i> , 2017).
PSI	2001	n/a	2001	n/a	
REV	2010	2010	2010	2010	(NHTSA, 2010)
TPM	n/a	2005	2005	2005	(Seidl <i>et al.</i> , 2017)
VIS-DET	n/a	2016	n/a	2016	Mercedes-Benz Active Brake Assist 4 was introduced in December 2016 and it offers functionality including (and exceeding) that required for this measure (Seidl <i>et al.</i> , 2017).
VIS-DIV	n/a	2017	n/a	2017	The topic of heavy vehicle direct vision starting to gain momentum amongst operators and vehicle manufacturers (e.g. announcement of direct vision standard for London).

Table 64: Full voluntary implementation year for new registrations

	M1	M2&M3	N1	N2&N3
AEB-VEH	2023	2023	2023	2023
AEB-PCD (pedestrian)	2026	n/a	2026	n/a

	M1	M2&M3	N1	N2&N3
AEB-PCD (cyclist)	2029	n/a	2029	n/a
ALC	2033	2033	2033	2033
DDR-DAD	2025	2025	2025	2025
DDR-ADR	2032	2032	2032	2032
EDR	2012	n/a	2016	n/a
ESC	2006	2006	2006	2006
ESS	2024	2024	2024	2024
FFW-137	2014	n/a	2014	n/a
FFW-THO	2026	n/a	2026	n/a
HED-MGI	2023	n/a	2023	n/a
ISA-VOL	2029	2029	2029	2029
LDW	n/a	2025	n/a	2025
LKA-ELK	2032	n/a	2032	n/a
PSI	2015	n/a	2015	n/a
REV	2024	2024	2024	2024
TPM	n/a	2019	2019	2019
VIS-DET	n/a	2030	n/a	2030
VIS-DIV	n/a	2031	n/a	2031

Table 65: Voluntary implementation uptake for new registrations

	M1	M2&M3	N1	N2&N3
AEB-VEH	High	High	High	High
AEB-PCD (pedestrian)	High	n/a	Medium	n/a
AEB-PCD (cyclist)	High	n/a	Medium	n/a

	M1	M2&M3	N1	N2&N3
ALC	None	None	None	None
DDR-DAD	Medium	Medium	Medium	Medium
DDR-ADR	None	None	None	None
EDR	Medium	n/a	Medium	n/a
ESC	High	High	High	High
ESS	High	High	High	High
FFW-137	High	n/a	Medium	n/a
FFW-THO	High	n/a	Medium	n/a
HED-MGI	None	n/a	None	n/a
ISA-VOL	None	None	None	None
LDW	n/a	High	n/a	High
LKA-ELK	Medium	n/a	Medium	n/a
PSI	High	n/a	None	n/a
REV	Medium	None	Medium	None
TPM	n/a	None	None	None
VIS-DET	n/a	None	n/a	None
VIS-DIV	n/a	Medium	n/a	Medium

Annex 4.8.5 Target population descriptions for accident data extracts

Table 66: Target population descriptions for proposed measures for all vehicle categories

Measure	Target population description for extract from police reported data	Correction factors subsequently applied in order to ...	Correction factor fatal	Correction factor serious	Correction factor slight
AEB-VEH	Casualties in two-motor-vehicle (excluding powered two-wheelers) front-to-rear collisions.	None.	1	1	1
AEB-PCD	Pedestrian and cyclist casualties in impacts with vehicle front.	None.	1	1	1
ALC	Casualties where the driver being impaired by alcohol contributed to the collision.	... narrow the target population down to only those alcohol-related collisions which were caused by hard-core drink drivers (repeat offenders) (Seidl <i>et al.</i> , 2017).	0.75	0.75	0.75
DDR-DAD	Casualties in collisions, where drowsiness or long lasting inattention/distraction contributed to the collision.	... account for underreporting of relevant contributory factors (TRL expert panel estimate).	2.00	4.00	4.00
DDR-ADR	Casualties in collisions, where drowsiness or long lasting or short-term inattention/distraction contributed to the collision.	... account for underreporting of relevant contributory factors (TRL expert panel estimate).	2.00	4.00	4.00
EDR	Car and van occupant casualties in all motor vehicle collisions.	None.	1	1	1
ESS	Casualties in two-motor-vehicle (excluding powered two-wheelers) front-to-rear collisions on roads with a speed limit exceeding 30 mph, where sudden braking of the vehicle in front contributed to the collision.	... account for underreporting of relevant contributory factors (TRL expert panel estimate).	4.50	4.50	4.50
FFW-137	Front seat casualties in frontal impacts.	... narrow the target population down to only full-width impacts with thorax injuries (Seidl <i>et al.</i> , 2017).	0.0825	0.0825	0.0825
FFW-THO	Front seat casualties in frontal impacts.	... narrow the target population down to only full-width impacts with thorax injuries (Seidl <i>et al.</i> , 2017).	0.0825	0.0825	0.0825
HED-MGI	Pedestrian and cyclist casualties in impacts with vehicle front.	... narrow target population down to those casualties who suffered serious head injuries from impact with the glazed area of the windscreen more than 10 centimetres away from the scuttle, A-pillars, and header rail; TRL calculations based on GIDAS data (ACEA TF-ACC, 2017e).	0.025875	0.020493	0
ISA-VOL	Casualties in collisions where the driver exceeding the speed limit contributed to the collision and there were no other contributory factors that indicated poor compliance of the driver with the law (e.g. impaired by alcohol/drugs, uncorrected eyesight, using mobile phone, stolen vehicle, etc.).	... (account for underreporting of contributory factor 'exceeding the speed limit' in Stats19) x (adjust to average population in Germany and UK (ACEA TF-ACC, 2017a), (ACEA TF-ACC, 2017b)).	M1/N1: 4.50x0.99 M2&M3/N2&N3: 4.50x1.64	M1/N1: 4.50x1.18 M2&M3/N2&N3: 4.50x5.50	M1/N1: 4.50x1.12 M2&M3/N2&N3: 4.50x4.50
LKA-ELK	Casualties in head-on and single-vehicle crashes on roads with speed limits between 70 km/h and 120 km/h (40 mph and 70 mph) and dry or wet road surfaces (i.e. not covered by ice or snow).	None.	1	1	1
PSI	Front seat casualties in lateral impacts against narrow objects (e.g. trees, lampposts, traffic signals, etc.).	None.	1	1	1

Measure	Target population description for extract from police reported data	Correction factors subsequently applied in order to ...	Correction factor fatal	Correction factor serious	Correction factor slight
REV	Pedestrian and cyclist casualties caused by a reversing motor vehicle.	... (account for collisions that happen away from public roads and are therefore not included in official road casualty statistics (Seidl <i>et al.</i> , 2017)) x (adjust to average population in France, Germany and UK (ACEA TF-ACC, 2017c)).	M1/N1: 2.00 M2&M3/N2&N3: 2.00x1.25	M1/N1: 2.00 M2&M3/N2&N3: 2.00x1.08	M1/N1: 2.00 M2&M3/N2&N3: 2.00x1.00
TPM	Casualties where illegal, defective or under-inflated tyres contributed to the collision.	... narrow the target population down to only those collisions where under-inflated tyres contributed (TRL expert panel estimate).	0.25	0.25	0.25
VIS-DET	For N2&N3: Pedestrian and cyclist casualties in impacts with vehicle front or side. For M2&M3: Pedestrian and cyclist casualties in impacts with vehicle front or side where a vehicle blind spot contributed to the collision. Note: The narrower target population definition for buses and coaches is necessary to make meaningful effectiveness estimates, because the current direct vision of these vehicles is considerably better than that of trucks.	... adjust to average population in France, Germany and UK (ACEA TF-ACC, 2017d).	0.80	1.21	1.33
VIS-DIV	For N2&N3: Pedestrian and cyclist casualties in impacts with vehicle front or side. For M2&M3: Pedestrian and cyclist casualties in impacts with vehicle front or side where a vehicle blind spot contributed to the collision. Note: The narrower target population definition for buses and coaches is necessary to make meaningful effectiveness estimates, because the current direct vision of these vehicles is considerably better than that of trucks.	... adjust to average population in France, Germany and UK (ACEA TF-ACC, 2017d).	0.80	1.21	1.33

Table 67: Target population descriptions for existing measures for all vehicle categories

Measure	Target population description for extract from police reported data	Correction factors subsequently applied in order to ...	Correction factor fatal	Correction factor serious	Correction factor slight
AEB-VEH	Casualties in two-motor-vehicle (excluding powered two-wheelers) front-to-rear collisions. Note: This is an existing measure for M2&M3 and N2&N3 only.	None.	1	1	1
ESC	Loss of control crashes.	None.	1	1	1
LDW	Casualties in collisions on a dual-carriageway or motorway where the vehicle left the carriageway, or rear-impacted a vehicle on the hard shoulder, or side-swiped vehicle. Note: This is an existing measure for M2&M3 and N2&N3 only.	None.	1	1	1

Annex 4.8.6 Effectiveness

Table 68: Effectiveness of proposed measures for M1 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
AEB-VEH	19.0%	19.0%	19.0%	19.0%	42.0%	High	(Seidl <i>et al.</i> , 2017). Note: Powered-two wheelers were excluded from the target population, i.e. car/van-to-motorcycle collisions were considered not affected. Recent preliminary research showed that in reality a positive effect is to be expected (Lenkeit and Smith, 2016). The benefit estimates applied are therefore conservative.
AEB-PCD	24.4%	24.4%	21.0%	21.0%	42.1%	High	Effectiveness for pedestrians. (Seidl <i>et al.</i> , 2017) for fatal and serious, expert panel estimate for slight.
AEB-PCD	27.5%	27.5%	16.4%	16.4%	32.8%	High	Effectiveness for cyclists. (Seidl <i>et al.</i> , 2017) for fatal and serious, expert panel estimate for slight.
ALC	4.2%	0.0%	4.2%	0.0%	4.2%	Low	TRL expert panel estimate. Assumption that this measure allows the continuation of alcohol interlock installation programmes for hard core drink drivers. 32.0% percent of the EU-28 population live in countries where such programmes exist; (Elder <i>et al.</i> , 2011) report that around 13% of relevant individuals take part in programmes, with programmes being highly effective while interlocks are installed.
DDR-DAD	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017)
DDR-ADR	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017). Same effectiveness assumed as for basic DDR-DAD systems, but applied to the extended target population for advanced distraction recognition.
EDR	1.0%	1.0%	1.0%	1.0%	1.0%	Low	TRL expert panel estimate. Nominal number to reflect that there will be anon-zero positive effect for road safety from the possibility to learn from detailed collision records.
ESS	5.0%	20.0%	10.0%	20.0%	20.0%	Low	TRL expert panel estimate. Based on the brake reaction time reductions, referenced in (Seidl <i>et al.</i> , 2017), and resulting reductions in stopping distance and impact speed.
FFW-137	0.0%	5.0%	0.0%	5.0%	0.0%	High	(Seidl <i>et al.</i> , 2017). Effectiveness of making vehicles that would comply with UN Regulation No. 94 (but not with UN Regulation No. 137) compliant with FFW-137. Note: Applied only to a small proportion of the vehicle fleet, which would not meet this requirement yet.
FFW-THO	0.0%	6.0%	0.0%	6.0%	0.0%	High	(Seidl <i>et al.</i> , 2017). Additional effectiveness of making vehicles that would comply with FFW-137 compliant with FFW-THO.
HED-MGI	0.0%	77.0%	0.0%	48.0%	0.0%	High	Based on data collected during the course of the monitoring phase for headform-to-windscreen tests in Pedestrian Safety Regulation (EC) No 78/2009. The value represents a head-to-glass impact test with a mandatory limit of HIC=1,000, which would reduce the mean result from HIC=727 (current monitoring data) to HIC=550 and result in a relative reduction in injury risk as indicated by the effectiveness values given. Note: Applied only to the narrow corrected target population representing casualties who suffered serious head injuries from impact with the glazed area of the windscreen more than 10 centimetres away from the scuttle, A-pillars, and header rail.
ISA-VOL	19.0%	6.7%	19.0%	8.4%	19.0%	High	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017a).

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
LKA-ELK	53.0%	0.0%	38.5%	0.0%	38.5%	High	(Sternlund <i>et al.</i> , 2017) and (Cicchino, 2017). For serious and slight casualties, an average value between the effectiveness values found by the two studies was used. For fatal casualties, the Sternlund value was used as a conservative estimate because the value found by Cicchino for fatalities (86%) was based on a very small sample of vehicles and therefore considered unreliable. Assumption that emergency-type LKA systems could not or would not be deactivated frequently by drivers.
PSI	0.0%	54.0%	0.0%	54.0%	0.0%	High	(Seidl <i>et al.</i> , 2017) and (Billot <i>et al.</i> , 2013) Note: Applied only to a small proportion of the vehicle fleet, which would not meet this requirement yet.
REV	41.0%	0.0%	41.0%	0.0%	41.0%	High	(Seidl <i>et al.</i> , 2017). Effectiveness for camera-based system.

Table 69: Effectiveness of existing measures for M1 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
ESC	38.0%	0.0%	21.0%	0.0%	21.0%	High	(Høye, 2011)

Table 70: Effectiveness of proposed measures for M2&M3 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
ALC	4.2%	0.0%	4.2%	0.0%	4.2%	Low	TRL expert panel estimate. Assumption that this measure allows the continuation of alcohol interlock installation programmes for hard core drink drivers. 32.0% percent of the EU-28 population live in countries where such programmes exist; (Elder <i>et al.</i> , 2011) report that around 13% of relevant individuals take part in programmes, with programmes being highly effective while interlocks are installed.
DDR-DAD	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017)
DDR-ADR	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017). Same effectiveness assumed as for basic DDR-DAD systems, but applied to the extended target population for advanced distraction recognition.
ESS	5.0%	20.0%	10.0%	20.0%	20.0%	Low	TRL expert panel estimate. Based on the brake reaction time reductions, referenced in (Seidl <i>et al.</i> , 2017), and resulting reductions in stopping distance and impact speed.
ISA-VOL	8.9%	9.1%	1.3%	16.8%	19.9%	High	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017b)
REV	33.3%	0.0%	33.3%	0.0%	33.3%	Low	TRL calculations based on (ACEA TF-ACC, 2017c). Effectiveness for camera-based system.
TPM	33.3%	0.0%	33.3%	0.0%	33.3%	Low	TRL expert panel estimate. Note: Applied to narrow target population.
VIS-DET	39.7%	0.0%	40.0%	0.0%	40.0%	Low	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017d). Effectiveness for front and side vulnerable road user detection and warning (no auto braking). Note: Applied to a considerably more narrowly defined target population than that for N2/N3.
VIS-DIV	24.0%	0.0%	24.0%	0.0%	24.0%	Low	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017d). Effectiveness for best-in-class direct vision approach. Note: Applied to a considerably more narrowly defined target population than that for N2/N3. Note 2: The estimated balance between the effects of detection-warning systems and improved direct vision might shift in reality between the two measures. Human factors research indicates that drivers need visual confirmation of the reason for a warning to respond fully effectively to it (see US research for reversing camera rulemaking, (NHTSA, 2010)). Improvements in direct vision are therefore needed to realise the full benefits modelled for detection-warning systems.

Table 71: Effectiveness of existing measures for M2&M3 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
AEB-VEH	0.0%	25.0%	0.0%	25.0%	5.0%	Low	(Robinson <i>et al.</i> , 2010)
ESC	28.5%	0.0%	28.5%	0.0%	28.5%	High	(NHTSA, 2015)
LDW	20.0%	0.0%	20%	0.0%	20.0%	Low	(Robinson <i>et al.</i> , 2010). Lower end of the prospective effectiveness estimates used to reflect the fact that LDW systems, as defined in UN Regulation No. 130, can be deactivated by drivers.

Table 72: Effectiveness of proposed measures for N1 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
AEB-VEH	19.0%	19.0%	19.0%	19.0%	42.0%	High	(Seidl <i>et al.</i> , 2017)
AEB-PCD	24.4%	24.4%	21.0%	21.0%	42.1%	High	Effectiveness for pedestrians. (Seidl <i>et al.</i> , 2017) for fatal and serious, expert panel estimate for slight.
AEB-PCD	27.5%	27.5%	16.4%	16.4%	32.8%	High	Effectiveness for cyclists. (Seidl <i>et al.</i> , 2017) for fatal and serious, expert panel estimate for slight.
ALC	4.2%	0.0%	4.2%	0.0%	4.2%	Low	TRL expert panel estimate. Assumption that this measure allows the continuation of alcohol interlock installation programmes for hard core drink drivers. 32.0% percent of the EU-28 population live in countries where such programmes exist; (Elder <i>et al.</i> , 2011) report that around 13% of relevant individuals take part in programmes, with programmes being highly effective while interlocks are installed.
DDR-DAD	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017)
DDR-ADR	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017). Same effectiveness assumed as for basic DDR-DAD systems, but applied to the extended target population for advanced distraction recognition.
EDR	1.0%	1.0%	1.0%	1.0%	1.0%	Low	TRL expert panel estimate. Nominal number to reflect that there will be non-zero positive effect for road safety from the possibility to learn from detailed collision records.
ESS	5.0%	20.0%	10.0%	20.0%	20.0%	Low	TRL expert panel estimate. Based on the brake reaction time reductions, referenced in (Seidl <i>et al.</i> , 2017), and resulting reductions in stopping distance and impact speed.
FFW-137	0.0%	5.0%	0.0%	5.0%	0.0%	High	(Seidl <i>et al.</i> , 2017). Effectiveness of making vehicles that would comply with UN Regulation No. 94 (but not with UN Regulation No. 137) compliant with FFW-137. Note: Applied only to a small proportion of the vehicle fleet, which would not meet this requirement yet.
FFW-THO	0.0%	6.0%	0.0%	6.0%	0.0%	High	(Seidl <i>et al.</i> , 2017). Additional effectiveness of making vehicles that would comply with FFW-137 compliant with FFW-THO.
HED-MGI	0.0%	77.0%	0.0%	48.0%	0.0%	Low	Based on data collected during the course of the monitoring phase for headform-to-windscreen tests on cars in Pedestrian Safety Regulation (EC) No 78/2009 (therefore reduced confidence for vans). The value represents a head-to-glass impact test with a mandatory limit of HIC=1,000, which would reduce the mean result from HIC=727 (current monitoring data) to HIC=550 and result in a relative reduction in injury risk as indicated by the effectiveness values given. Note: Applied only to the narrow corrected target population representing casualties who suffered serious head injuries from impact with the glazed area of the windscreen more than 10 centimetres away from the scuttle, A-pillars, and header rail.
ISA-VOL	19.0%	6.7%	19.0%	8.4%	19.0%	High	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017a).

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
LKA-ELK	53.0%	0.0%	38.5%	0.0%	38.5%	High	(Sternlund <i>et al.</i> , 2017) and (Cicchino, 2017) (studies for M1 vehicles, best available evidence). For serious and slight casualties, an average value between the effectiveness values found by the two studies was used. For fatal casualties, the Sternlund value was used as a conservative estimate because the value found by Cicchino for fatalities (86%) was based on a very small sample of vehicles and therefore considered unreliable. Assumption that emergency-type LKA systems could not or would not be deactivated frequently by drivers.
PSI	0.0%	54.0%	0.0%	54.0%	0.0%	High	(Seidl <i>et al.</i> , 2017) and (Billot <i>et al.</i> , 2013) Note: Applied only to a small proportion of the vehicle fleet, which would not meet this requirement yet.
REV	41.0%	0.0%	41.0%	0.0%	41.0%	High	(Seidl <i>et al.</i> , 2017). Effectiveness for camera-based system.
TPM	33.3%	0.0%	33.3%	0.0%	33.3%	Low	TRL expert panel estimate. Note: Applied to narrow target population.

Table 73: Effectiveness of existing measures for N1 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
ESC	38.0%	0.0%	21.0%	0.0%	21.0%	High	(Høye, 2011)

Table 74: Effectiveness of proposed measures for N2&N3 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
ALC	4.2%	0.0%	4.2%	0.0%	4.2%	Low	TRL expert panel estimate. Assumption that this measure allows the continuation of alcohol interlock installation programmes for hard core drink drivers. 32.0% percent of the EU-28 population live in countries where such programmes exist; (Elder <i>et al.</i> , 2011) report that around 13% of relevant individuals take part in programmes, with programmes being highly effective while interlocks are installed.
DDR-DAD	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017)
DDR-ADR	16.7%	0.0%	16.7%	0.0%	16.7%	Low	(Seidl <i>et al.</i> , 2017). Same effectiveness assumed as for basic DDR-DAD systems, but applied to the extended target population for advanced distraction recognition.
ESS	5.0%	20.0%	10.0%	20.0%	20.0%	Low	TRL expert panel estimate. Based on the brake reaction time reductions, referenced in (Seidl <i>et al.</i> , 2017), and resulting reductions in stopping distance and impact speed.
ISA-VOL	8.9%	9.1%	1.3%	16.8%	19.9%	High	TRL calculations based on (Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017b)
REV	33.3%	0.0%	33.3%	0.0%	33.3%	Low	TRL calculations based on (ACEA TF-ACC, 2017c). Effectiveness for camera-based system.
TPM	33.3%	0.0%	33.3%	0.0%	33.3%	Low	TRL expert panel estimate. Note: Applied to narrow target population.
VIS-DET	39.7%	0.0%	40.0%	0.0%	40.0%	High	(Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017d). Effectiveness for front and side vulnerable road user detection and warning (no auto braking).
VIS-DIV	2.9%	0.0%	2.9%	0.0%	3.0%	High	(Barrow <i>et al.</i> , 2017) and (ACEA TF-ACC, 2017d). Effectiveness for best-in-class direct vision approach. Note: The estimated balance between the effects of detection-warning systems and improved direct vision might shift in reality between the two measures. Human factors research indicates that drivers need visual confirmation of the reason for a warning to respond fully effectively to it (see US research for reversing camera rulemaking, (NHTSA, 2010)). Improvements in direct vision are therefore needed to realise the full benefits modelled for detection-warning systems.

Table 75: Effectiveness of existing measures for N2&N3 vehicles equipped

Measure	Fatal (avoid)	Fatal (mitigate)	Serious (avoid)	Serious (mitigate)	Slight (avoid)	Confidence	Source / justification
AEB-VEH	0.0%	25.0%	0.0%	25.0%	5.0%	Low	(Robinson <i>et al.</i> , 2010)
ESC	28.5%	0.0%	28.5%	0.0%	28.5%	High	(NHTSA, 2015)
LDW	20.0%	0.0%	20%	0.0%	20.0%	Low	(Robinson <i>et al.</i> , 2010). Lower end of the prospective effectiveness estimates used to reflect the fact that LDW systems, as defined in UN Regulation No. 130, can be deactivated by drivers.

Annex 4.8.7 Costs

Table 76: Initial cost at mandatory introduction of proposed measures for M1 vehicles. Cost estimate in € per vehicle equipped for the given year (subject to inflation). Estimated development and fixed production costs are included and spread equally across vehicles.

Measure	Cost (best estimate)	Cost (lower estimate)	Cost (upper estimate)	in year	Source / justification
AEB-VEH	€44	€35	€53	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK.
AEB-PCD	€54	€43	€65	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK.
ALC	€2	€1	€5	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of an alcohol interlock installation sheet. The cost for equipping any vehicles with alcohol interlocks, made possible by this measure would be carried by the drivers affected.
DDR-DAD	€9	€8	€10	2020	(Seidl <i>et al.</i> , 2017). Cost of a system based on existing sensors, such as steering wheel input.
DDR-ADR	€110	€98	€150	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of a system based on driver-facing sensor hardware, such as camera.
EDR	€2	€1	€5	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost for a Part-563-type EDR. Equivalent hardware already available on most vehicles, but recordings are not readable.
ESS	€1	€0	€2	2020	(Seidl <i>et al.</i> , 2017). Nominal cost for software-based system (validation and testing).
FFW-137	€32	€26	€38	2008	(Seidl <i>et al.</i> , 2017). Cost for vehicles that comply with UN Regulation No. 94 but not with UN Regulation No. 137.
FFW-THO	€16	€13	€19	2008	(Seidl <i>et al.</i> , 2017). Additional cost for vehicles that comply with UN Regulation No. 137 with Hybrid III ATDs but not with THOR-M ATDs.
HED-MGI	€5	€2	€20	2020	TRL expert panel estimate for cost of adapting the glazed area of windshields to comply with a mandatory HIC limit in head-to-glass impact tests. Assumption that this cost is mostly made up of research and development efforts by glass suppliers, with only a small increase in ongoing production costs.
ISA-VOL	€59	€47	€71	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK. Additional cost added for actuators required.
LKA-ELK	€70	€56	€84	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK. Additional cost added for actuators required.
PSI	€30	€20	€40	2020	TRL expert panel estimate under consideration of industry input for cost of making vehicle compliant with UN Regulation No. 135, which do not meet the requirements yet.

Measure	Cost (best estimate)	Cost (lower estimate)	Cost (upper estimate)	in year	Source / justification
REV	€40	€25	€55	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of a camera-based system using an existing display.

Table 77: Initial cost at mandatory introduction of proposed measures for M2&M3 vehicles. Cost estimate in € per vehicle equipped for the given year (subject to inflation). Estimated development and fixed production costs are included and spread equally across vehicles.

Measure	Cost (best estimate)	Cost (lower estimate)	Cost (upper estimate)	in year	Source / justification
ALC	€4	€2	€6	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other heavy vehicles (N2&N3). Cost of an alcohol interlock installation sheet. The cost for equipping any vehicles with alcohol interlocks, made possible by this measure would be carried by the drivers affected.
DDR-DAD	€20	€10	€50	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other heavy vehicles (N2&N3). Cost of a system based on existing sensors, such as steering wheel input.
DDR-ADR	€165	€147	€225	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other heavy vehicles (N2&N3). Cost of a system based on driver-facing sensor hardware, such as camera.
ESS	€2	€0	€4	2020	(Seidl <i>et al.</i> , 2017). Nominal cost for software-based system (validation and testing).
ISA-VOL	€110	€92	€124	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other heavy vehicles (N2&N3).
REV	€125	€106	€144	2012	(Seidl <i>et al.</i> , 2017). Cost of full system including camera and display.
TPM	€52	€44	€60	2013	(van Zyl <i>et al.</i> , 2013) and (Seidl <i>et al.</i> , 2017). Cost of a direct TPM solution.
VIS-DET	€300	€150	€500	2020	TRL expert panel estimate under consideration of industry input provided for other heavy vehicles (N2&N3) and (Martin <i>et al.</i> , 2017). Cost of front and side vulnerable road user detection and warning (no auto braking)
VIS-DIV	€150	€100	€450	2020	TRL expert panel estimate under consideration of industry input provided for other heavy vehicles (N2&N3). Cost for best-in-class approach, i.e. adjustments of existing cabs. Requirement only applies to new types of vehicles, i.e. any cost incurred will partially be absorbed in cab re-design for new vehicle generation (no redesign cost for existing models). This is reflected in a cost estimate reflecting the lower end of estimates from industry input.

Table 78: Initial cost at mandatory introduction of proposed measures for N1 vehicles. Cost estimate in € per vehicle equipped for the given year (subject to inflation). Estimated development and fixed production costs are included and spread equally across vehicles.

Measure	Cost (best estimate)	Cost (lower estimate)	Cost (upper estimate)	in year	Source / justification
AEB-VEH	€44	€35	€53	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK.
AEB-PCD	€54	€43	€65	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK.
ALC	€2	€1	€5	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). Cost of an alcohol interlock installation sheet. The cost for equipping any vehicles with alcohol interlocks, made possible by this measure would be carried by the drivers affected.
DDR-DAD	€9	€8	€10	2020	(Seidl <i>et al.</i> , 2017). Cost of a system based on existing sensors, such as steering wheel input.
DDR-ADR	€110	€98	€150	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). Cost of a system based on driver-facing sensor hardware, such as camera.
EDR	€2	€1	€5	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). Cost for a Part-563-type EDR. Equivalent hardware already available on most vehicles, but recordings are not readable.
ESS	€1	€0	€2	2020	(Seidl <i>et al.</i> , 2017). Nominal cost for software-based system (validation and testing).
FFW-137	€32	€26	38	2008	(Seidl <i>et al.</i> , 2017). Cost for vehicles that comply with UN Regulation No. 94 but not with UN Regulation No. 137.
FFW-THO	€16	€13	€19	2008	(Seidl <i>et al.</i> , 2017). Cost for vehicles that comply with UN Regulation No. 137 with Hybrid III ATDs but not with THOR-M ATDs.
HED-MGI	€5	€2	€20	2020	TRL expert panel estimate for cost of adapting the glazed area of windscreens to comply with a mandatory HIC limit in head-to-glass impact tests. Assumption that this cost is mostly made up of research and development efforts by glass suppliers, with only a small increase in ongoing production costs.
ISA-VOL	€59	€47	€71	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK. Additional cost added for actuators required.
LKA-ELK	€70	€56	€84	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). The cost reflects the apportioned share of the total cost for a system that shares sensor technology to deliver four measures: AEB-VEH, AEB-PCD, ISA-VOL and LKA-ELK. Additional cost added for actuators required.
PSI	€30	€20	€40	2020	TRL expert panel estimate under consideration of industry input, provided for other light vehicles (M1), for cost of making vehicle compliant with UN Regulation No. 135, which do not meet the requirements yet.
REV	€40	€25	€55	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input provided for other light vehicles (M1). Cost of a camera-based system using an existing display.
TPM	€5	€4	€10	2013	(van Zyl <i>et al.</i> , 2013) and (Seidl <i>et al.</i> , 2017). Cost of an indirect TPM solution fitted to vehicles with four wheels (no twin-wheels).

Table 79: Initial cost at mandatory introduction of proposed measures for N2&N3 vehicles. Cost estimate in € per vehicle equipped for the given year (subject to inflation). Estimated development and fixed production costs are included and spread equally across vehicles.

Measure	Cost (best estimate)	Cost (lower estimate)	Cost (upper estimate)	in year	Source / justification
ALC	€4	€2	€6	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of an alcohol interlock installation sheet. The cost for equipping any vehicles with alcohol interlocks, made possible by this measure would be carried by the drivers affected.
DDR-DAD	€20	€10	€50	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of a system based on existing sensors, such as steering wheel input.
DDR-ADR	€165	€147	€225	2020	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of a system based on driver-facing sensor hardware, such as camera.
ESS	€2	€0	€4	2020	(Seidl <i>et al.</i> , 2017). Nominal cost for software-based system (validation and testing).
ISA-VOL	€110	€92	€124	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input.
REV	€150	€130	€250	2012	(Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of full system including camera and display.
TPM	€66	€56	€200	2013	(van Zyl <i>et al.</i> , 2013) and (Seidl <i>et al.</i> , 2017) under consideration of industry input. Cost of a direct TPM solution fitted to the towing vehicle only (no trailers).
VIS-DET	€300	€150	€500	2020	TRL expert panel estimate under consideration of industry input and (Martin <i>et al.</i> , 2017). Cost of front and side vulnerable road user detection and warning (no auto braking)
VIS-DIV	€150	€100	€450	2020	TRL expert panel estimate under consideration of industry input. Cost for best-in-class approach, i.e. adjustments of existing cabs. Requirement only applies to new types of vehicles, i.e. any cost incurred will partially be absorbed in cab re-design for new vehicle generation (no redesign cost for existing models). This is reflected in a cost estimate reflecting the lower end of estimates from industry input.

Annex 4.9 **Appendices of results**

Annex 4.9.1 Casualty baseline

Table 80: Casualty baseline (PO0, reflecting continued dispersion of existing mandatory safety measures and voluntary uptake of safety measures), EU-28 casualties per annum

Year	Best estimate		
	Fatal casualties	Serious casualties	Slight casualties
2017	25,245	244,674	1,200,609
2018	25,123	244,081	1,197,141
2019	25,012	243,387	1,192,776
2020	24,895	242,524	1,187,341
2021	24,759	241,495	1,181,155
2022	24,613	240,377	1,174,802
2023	24,459	239,198	1,168,456
2024	24,301	237,992	1,162,231
2025	24,141	236,787	1,156,208
2026	23,971	235,549	1,150,094
2027	23,788	234,239	1,143,662
2028	23,598	232,874	1,137,101
2029	23,408	231,496	1,130,854
2030	23,222	230,197	1,125,625
2031	23,044	229,002	1,121,229
2032	22,876	227,873	1,117,078
2033	22,721	226,850	1,113,449
2034	22,579	225,930	1,110,322
2035	22,451	225,114	1,107,619
2036	22,340	224,434	1,105,474
2037	22,243	223,865	1,103,725

Annex 4.9.2 Monetary benefits and costs

Table 81: Benefits of policy option PO1 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Benefits PO1	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 3,652,196	€ 854	€ 210,718	€ 966
2023	€ 151,296,385	€ 35,500	€ 9,203,539	€ 37,192
2024	€ 545,168,688	€ 133,426	€ 34,170,855	€ 145,379
2025	€ 1,000,898,311	€ 255,849	€ 64,560,479	€ 285,993
2026	€ 1,400,107,873	€ 371,047	€ 91,097,341	€ 415,470
2027	€ 1,771,664,008	€ 483,150	€ 114,072,703	€ 533,452
2028	€ 2,118,023,710	€ 592,081	€ 134,088,757	€ 641,286
2029	€ 2,445,305,073	€ 697,999	€ 151,755,745	€ 740,125
2030	€ 2,757,870,573	€ 801,080	€ 167,505,333	€ 830,859
2031	€ 3,037,253,906	€ 897,348	€ 181,520,552	€ 914,852
2032	€ 3,273,637,576	€ 983,998	€ 194,450,377	€ 994,352
2033	€ 3,480,530,155	€ 1,062,392	€ 206,230,741	€ 1,070,533
2034	€ 3,661,231,359	€ 1,132,949	€ 216,896,377	€ 1,143,570
2035	€ 3,818,311,956	€ 1,196,280	€ 226,553,732	€ 1,213,646
2036	€ 3,964,331,864	€ 1,254,962	€ 235,592,427	€ 1,279,173
2037	€ 4,104,957,655	€ 1,311,279	€ 239,408,474	€ 1,338,221

Table 82: Costs of policy option PO1 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Costs PO1	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 20,851,089	€ 3,029	€ 2,052,932	€ 22,887
2023	€ 666,628,005	€ 103,749	€ 69,015,529	€ 832,924
2024	€ 1,096,450,305	€ 181,071	€ 120,557,163	€ 1,541,724
2025	€ 962,402,461	€ 174,006	€ 112,143,632	€ 1,568,627
2026	€ 950,204,101	€ 175,225	€ 104,096,560	€ 1,521,154
2027	€ 932,402,875	€ 176,448	€ 96,273,637	€ 1,476,343
2028	€ 918,897,205	€ 177,609	€ 89,786,569	€ 1,433,454
2029	€ 914,885,110	€ 178,677	€ 85,032,330	€ 1,392,087
2030	€ 920,097,355	€ 179,638	€ 81,758,624	€ 1,352,020
2031	€ 866,858,578	€ 171,522	€ 78,805,841	€ 1,361,456
2032	€ 821,028,128	€ 163,679	€ 76,508,761	€ 1,369,900
2033	€ 779,785,286	€ 156,099	€ 74,590,851	€ 1,377,368
2034	€ 741,519,077	€ 148,771	€ 72,890,548	€ 1,383,888
2035	€ 705,351,992	€ 141,687	€ 71,318,764	€ 1,389,492
2036	€ 706,705,939	€ 142,780	€ 70,636,578	€ 1,337,121
2037	€ 707,857,856	€ 143,761	€ 69,974,289	€ 1,286,365

Table 83: Benefits of policy option PO2 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Benefits PO2	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 5,043,429	€ 58,327	€ 236,837	€ 241,474
2023	€ 210,270,736	€ 2,634,930	€ 10,319,870	€ 11,365,243
2024	€ 754,955,557	€ 9,825,649	€ 38,416,358	€ 43,208,350
2025	€ 1,406,209,021	€ 18,777,585	€ 74,799,102	€ 84,051,066
2026	€ 2,033,698,335	€ 27,228,953	€ 109,948,213	€ 122,090,314
2027	€ 2,648,095,042	€ 35,336,633	€ 140,958,380	€ 156,508,065
2028	€ 3,219,130,259	€ 43,067,457	€ 166,751,229	€ 187,606,327
2029	€ 3,753,286,844	€ 50,597,095	€ 188,508,110	€ 215,851,332
2030	€ 4,259,317,555	€ 58,111,280	€ 207,158,331	€ 243,081,828
2031	€ 4,706,545,364	€ 65,333,713	€ 223,294,324	€ 268,235,450
2032	€ 5,078,380,771	€ 71,876,058	€ 238,184,903	€ 292,288,513
2033	€ 5,396,376,447	€ 77,630,018	€ 251,521,779	€ 315,504,968
2034	€ 5,667,224,301	€ 82,575,411	€ 263,388,500	€ 337,632,315
2035	€ 5,896,416,783	€ 86,758,175	€ 274,092,181	€ 358,724,627
2036	€ 6,103,661,312	€ 90,376,170	€ 284,143,468	€ 378,248,366
2037	€ 6,297,613,219	€ 93,562,470	€ 288,550,553	€ 395,547,577

Table 84: Costs of policy option PO2 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Costs PO2	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 36,608,027	€ 294,132	€ 2,187,630	€ 2,222,375
2023	€ 1,173,837,465	€ 10,287,194	€ 73,476,170	€ 82,588,682
2024	€ 1,946,885,861	€ 17,869,262	€ 129,257,128	€ 152,147,319
2025	€ 1,831,696,972	€ 17,226,074	€ 149,251,181	€ 155,289,935
2026	€ 1,968,686,605	€ 17,424,317	€ 170,685,530	€ 151,263,075
2027	€ 1,970,382,148	€ 17,351,814	€ 161,024,412	€ 145,183,480
2028	€ 1,981,486,293	€ 17,535,211	€ 153,190,295	€ 141,524,065
2029	€ 2,004,601,027	€ 18,181,667	€ 147,380,027	€ 141,654,506
2030	€ 2,037,673,215	€ 19,354,195	€ 143,213,366	€ 145,666,632
2031	€ 1,932,164,962	€ 19,538,819	€ 138,927,979	€ 155,089,405
2032	€ 1,836,698,195	€ 19,240,903	€ 135,370,212	€ 161,035,027
2033	€ 1,747,920,951	€ 18,583,567	€ 132,240,431	€ 163,975,882
2034	€ 1,663,929,128	€ 17,829,579	€ 129,364,756	€ 165,853,663
2035	€ 1,583,675,055	€ 16,977,921	€ 126,647,479	€ 166,498,652
2036	€ 1,587,193,701	€ 17,107,512	€ 125,473,959	€ 160,209,742
2037	€ 1,590,033,775	€ 17,224,227	€ 124,317,325	€ 154,121,562

Table 85: Benefits of policy option PO3 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Benefits PO3	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 5,296,049	€ 64,080	€ 267,361	€ 262,633
2023	€ 220,849,893	€ 2,896,213	€ 11,704,789	€ 12,375,282
2024	€ 794,090,313	€ 10,806,181	€ 43,611,477	€ 47,111,746
2025	€ 1,496,571,707	€ 20,826,921	€ 87,490,526	€ 93,633,844
2026	€ 2,204,354,042	€ 30,619,015	€ 134,640,508	€ 140,563,460
2027	€ 2,910,930,151	€ 40,181,364	€ 178,777,729	€ 184,717,893
2028	€ 3,568,592,789	€ 49,310,690	€ 216,127,851	€ 224,526,483
2029	€ 4,183,755,428	€ 58,182,496	€ 248,035,142	€ 260,548,408
2030	€ 4,765,255,593	€ 66,984,433	€ 275,546,462	€ 294,681,257
2031	€ 5,277,941,509	€ 75,393,916	€ 299,305,818	€ 326,140,295
2032	€ 5,703,014,983	€ 82,991,402	€ 320,661,884	€ 355,962,675
2033	€ 6,064,831,386	€ 89,687,075	€ 339,457,416	€ 384,478,601
2034	€ 6,371,420,680	€ 95,468,181	€ 355,889,709	€ 411,581,971
2035	€ 6,629,391,751	€ 100,391,933	€ 370,396,600	€ 437,312,718
2036	€ 6,861,170,981	€ 104,689,595	€ 383,714,462	€ 461,074,546
2037	€ 7,076,868,299	€ 108,522,074	€ 390,972,196	€ 482,050,865

Table 86: Costs of policy option PO3 compared to the baseline scenario per vehicle category per year (future monetary value, best estimate)

Costs PO3	M1	M2&M3	N1	N2&N3
2021	€ 0	€ 0	€ 0	€ 0
2022	€ 42,192,710	€ 423,552	€ 5,964,756	€ 3,415,339
2023	€ 1,353,540,595	€ 14,823,967	€ 205,725,210	€ 127,023,221
2024	€ 2,261,052,623	€ 25,820,055	€ 364,708,363	€ 234,596,848
2025	€ 2,672,896,381	€ 28,071,684	€ 454,925,311	€ 268,124,075
2026	€ 3,435,357,794	€ 31,645,012	€ 549,369,467	€ 289,349,543
2027	€ 3,492,303,600	€ 31,685,993	€ 535,330,457	€ 279,335,838
2028	€ 3,555,792,162	€ 31,971,352	€ 523,206,307	€ 271,847,808
2029	€ 3,628,433,359	€ 32,708,691	€ 513,156,649	€ 268,252,408
2030	€ 3,708,222,578	€ 33,961,455	€ 504,782,127	€ 268,638,814
2031	€ 3,527,235,174	€ 33,487,203	€ 493,196,216	€ 278,929,380
2032	€ 3,358,790,944	€ 32,552,048	€ 482,490,434	€ 285,648,055
2033	€ 3,199,454,280	€ 31,278,482	€ 472,359,156	€ 289,270,906
2034	€ 3,047,245,254	€ 29,928,662	€ 462,624,055	€ 291,743,199
2035	€ 2,901,045,223	€ 28,500,980	€ 453,185,807	€ 292,898,673
2036	€ 2,907,900,432	€ 28,719,539	€ 449,132,708	€ 281,846,047
2037	€ 2,913,320,014	€ 28,916,012	€ 445,068,893	€ 271,140,899

Annex 4.9.3 Casualties prevented

Table 87: Fatal casualties prevented across EU-28 by safety measures of policy option PO1 compared to the baseline scenario per vehicle category per year (best estimate)

Fatal casualties PO1	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	1	0	0	0
2023	47	0	3	0
2024	172	0	11	0
2025	321	0	21	0
2026	457	0	30	0
2027	589	0	38	0
2028	717	0	47	0
2029	843	0	53	0
2030	969	0	61	0
2031	1,087	0	67	0
2032	1,195	0	73	0
2033	1,295	1	79	0
2034	1,390	0	84	0
2035	1,479	0	90	0
2036	1,567	1	96	0
2037	1,656	0	99	0

Table 88: Serious casualties prevented across EU-28 by safety measures of policy option PO1 compared to the baseline scenario per vehicle category per year (best estimate)

Serious casualties PO1	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	5	0	0	0
2023	205	1	13	0
2024	757	0	51	1
2025	1,423	0	98	1
2026	2,041	1	141	2
2027	2,648	2	180	2
2028	3,245	2	217	2
2029	3,837	1	251	3
2030	4,431	2	285	3
2031	4,995	3	315	4
2032	5,509	3	348	4
2033	5,995	3	379	4
2034	6,454	3	408	4
2035	6,886	4	437	5
2036	7,314	4	466	6
2037	7,748	4	485	6

Table 89: Slight casualties prevented across EU-28 by safety measures of policy option PO1 compared to the baseline scenario per vehicle category per year (best estimate)

Slight casualties PO1	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	20	0	1	0
2023	836	0	36	0
2024	3,107	1	138	2
2025	5,883	2	267	4
2026	8,491	4	386	5
2027	11,103	4	498	7
2028	13,718	5	601	8
2029	16,359	7	697	9
2030	19,051	8	790	10
2031	21,650	8	878	12
2032	24,051	10	961	13
2033	26,323	11	1,042	15
2034	28,482	12	1,120	16
2035	30,533	13	1,196	18
2036	32,569	14	1,273	18
2037	34,639	14	1,324	20

Table 90: Fatal casualties prevented across EU-28 by safety measures of policy option PO2 compared to the baseline scenario per vehicle category per year (best estimate)

Fatal casualties PO2	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	1	0	0	0
2023	65	0	4	5
2024	237	2	12	17
2025	446	4	24	34
2026	651	5	35	51
2027	855	8	46	67
2028	1,054	10	56	82
2029	1,245	11	64	98
2030	1,434	14	72	112
2031	1,608	16	80	127
2032	1,762	18	86	141
2033	1,903	20	94	155
2034	2,032	22	99	171
2035	2,150	24	105	185
2036	2,263	26	112	199
2037	2,375	27	116	214

Table 91: Serious casualties prevented across EU-28 by safety measures of policy option PO2 compared to the baseline scenario per vehicle category per year (best estimate)

Serious casualties PO2	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	7	1	0	0
2023	294	6	14	11
2024	1,084	21	57	45
2025	2,089	41	115	87
2026	3,149	61	175	128
2027	4,260	81	231	165
2028	5,355	101	280	197
2029	6,441	120	323	229
2030	7,530	141	362	264
2031	8,562	162	397	298
2032	9,497	181	435	330
2033	10,371	199	471	362
2034	11,186	215	505	395
2035	11,948	231	538	428
2036	12,695	245	571	460
2037	13,445	258	594	489

Table 92: Slight casualties prevented across EU-28 by safety measures of policy option PO2 compared to the baseline scenario per vehicle category per year (best estimate)

Slight casualties PO2	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	25	0	1	0
2023	1,064	18	43	26
2024	3,946	67	165	101
2025	7,580	131	332	202
2026	11,275	195	509	301
2027	15,125	257	682	398
2028	18,971	319	837	490
2029	22,849	382	979	580
2030	26,801	446	1,111	667
2031	30,610	509	1,235	753
2032	34,120	568	1,350	839
2033	37,430	620	1,459	927
2034	40,561	668	1,563	1,013
2035	43,525	710	1,664	1,100
2036	46,454	748	1,766	1,185
2037	49,420	783	1,840	1,267

Table 93: Fatal casualties prevented across EU-28 by safety measures of policy option PO3 compared to the baseline scenario per vehicle category per year (best estimate)

Fatal casualties PO3	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	1	0	0	0
2023	66	0	4	5
2024	242	2	13	18
2025	460	4	27	37
2026	680	6	42	58
2027	902	9	56	78
2028	1,118	11	70	96
2029	1,325	13	81	115
2030	1,529	15	93	132
2031	1,716	17	103	149
2032	1,880	20	112	166
2033	2,030	22	121	184
2034	2,166	24	129	202
2035	2,290	26	137	219
2036	2,408	28	145	236
2037	2,524	30	150	252

Table 94: Serious casualties prevented across EU-28 by safety measures of policy option PO3 compared to the baseline scenario per vehicle category per year (best estimate)

Serious casualties PO3	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	8	1	1	0
2023	320	7	17	13
2024	1,180	23	67	50
2025	2,306	46	138	100
2026	3,553	70	221	153
2027	4,887	93	301	205
2028	6,204	117	373	250
2029	7,513	140	436	295
2030	8,822	165	495	342
2031	10,061	189	548	387
2032	11,182	212	602	431
2033	12,225	233	653	474
2034	13,195	252	701	517
2035	14,097	270	746	561
2036	14,978	288	792	603
2037	15,859	304	826	642

Table 95: Slight casualties prevented across EU-28 by safety measures of policy option PO3 compared to the baseline scenario per vehicle category per year (best estimate)

Slight casualties PO3	M1	M2&M3	N1	N2&N3
2021	0	0	0	0
2022	28	0	2	1
2023	1,173	19	52	28
2024	4,360	73	201	111
2025	8,514	146	420	231
2026	13,002	227	682	367
2027	17,798	310	953	507
2028	22,597	393	1,203	641
2029	27,435	478	1,436	771
2030	32,359	563	1,657	897
2031	37,099	647	1,866	1,020
2032	41,454	726	2,061	1,143
2033	45,548	798	2,248	1,267
2034	49,410	863	2,426	1,390
2035	53,053	923	2,599	1,514
2036	56,645	978	2,771	1,635
2037	60,272	1,030	2,909	1,751

Annex 4.9.4 Sensitivity analysis

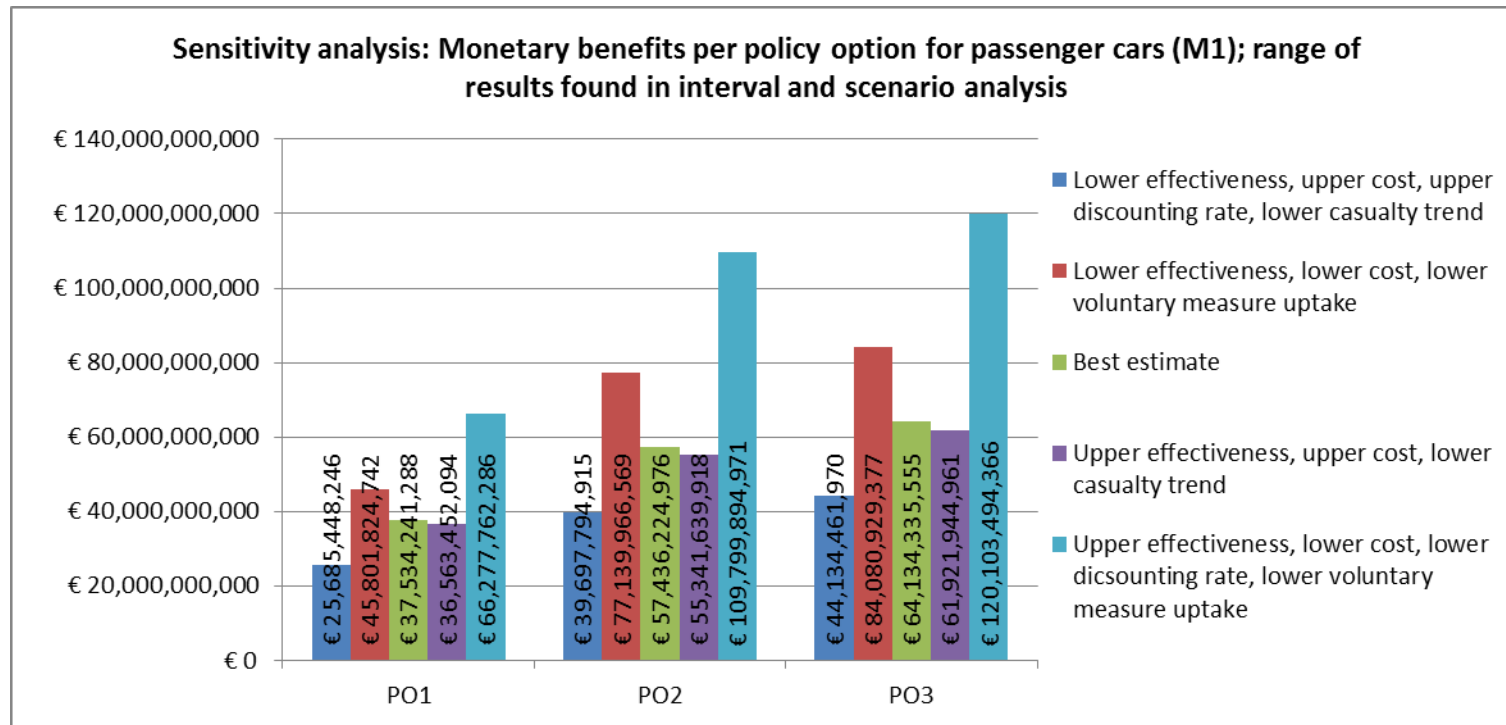


Figure 51: Passenger cars (M1): Present monetary value of benefits of M1 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

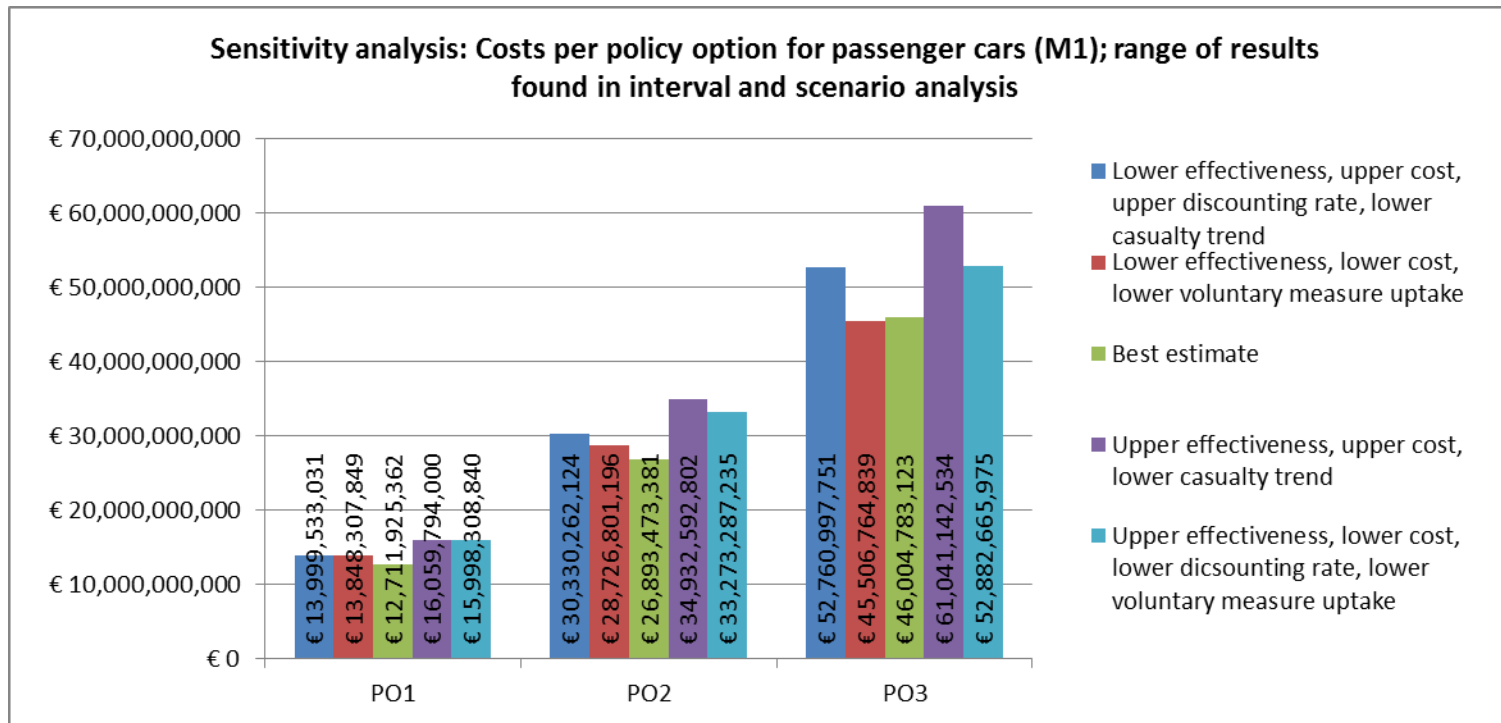


Figure 52: Passenger cars (M1): Present value of costs of M1 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

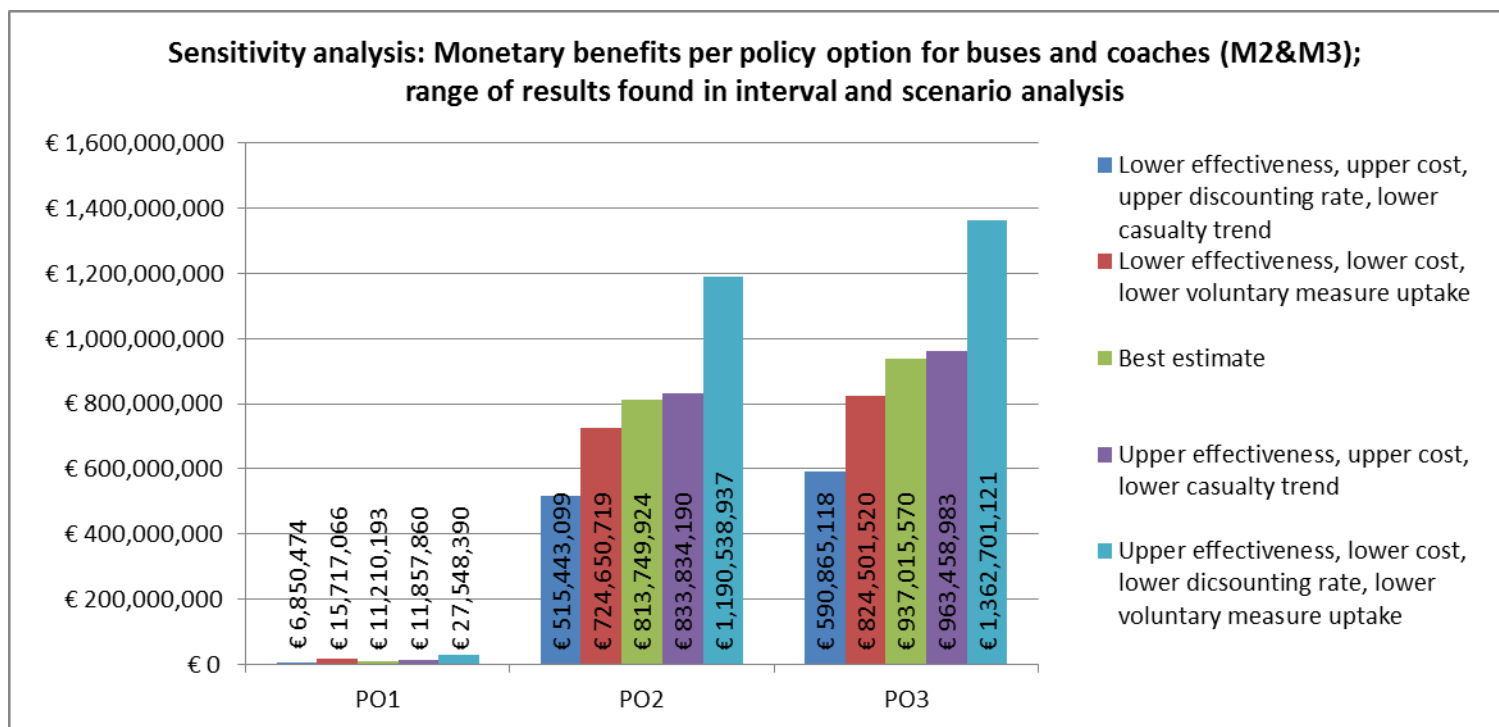


Figure 53: Buses and coaches (M2&M3): Present monetary value of benefits of M2&M3 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

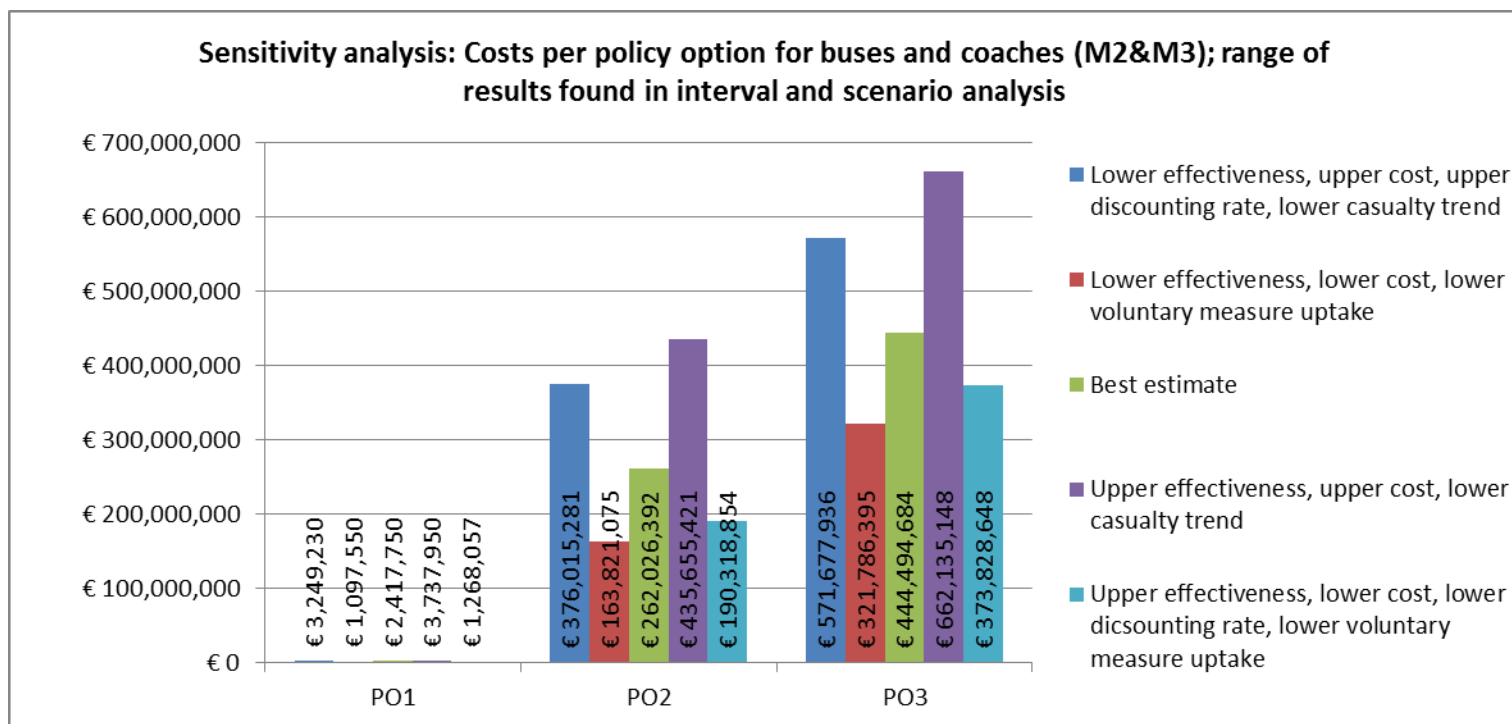


Figure 54: Buses and coaches (M2&M3): Present value of costs of M2&M3 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

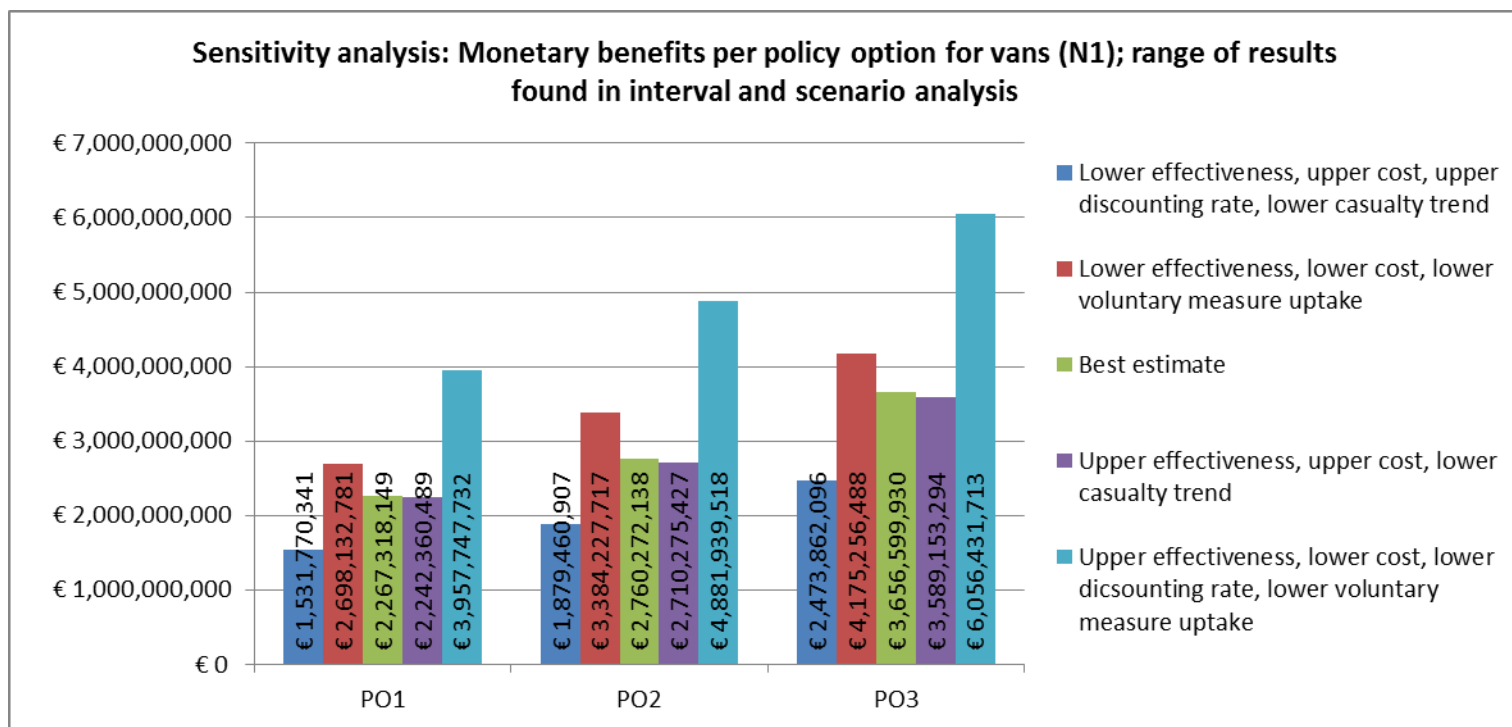


Figure 55: Vans (N1): Present monetary value of benefits of N1 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

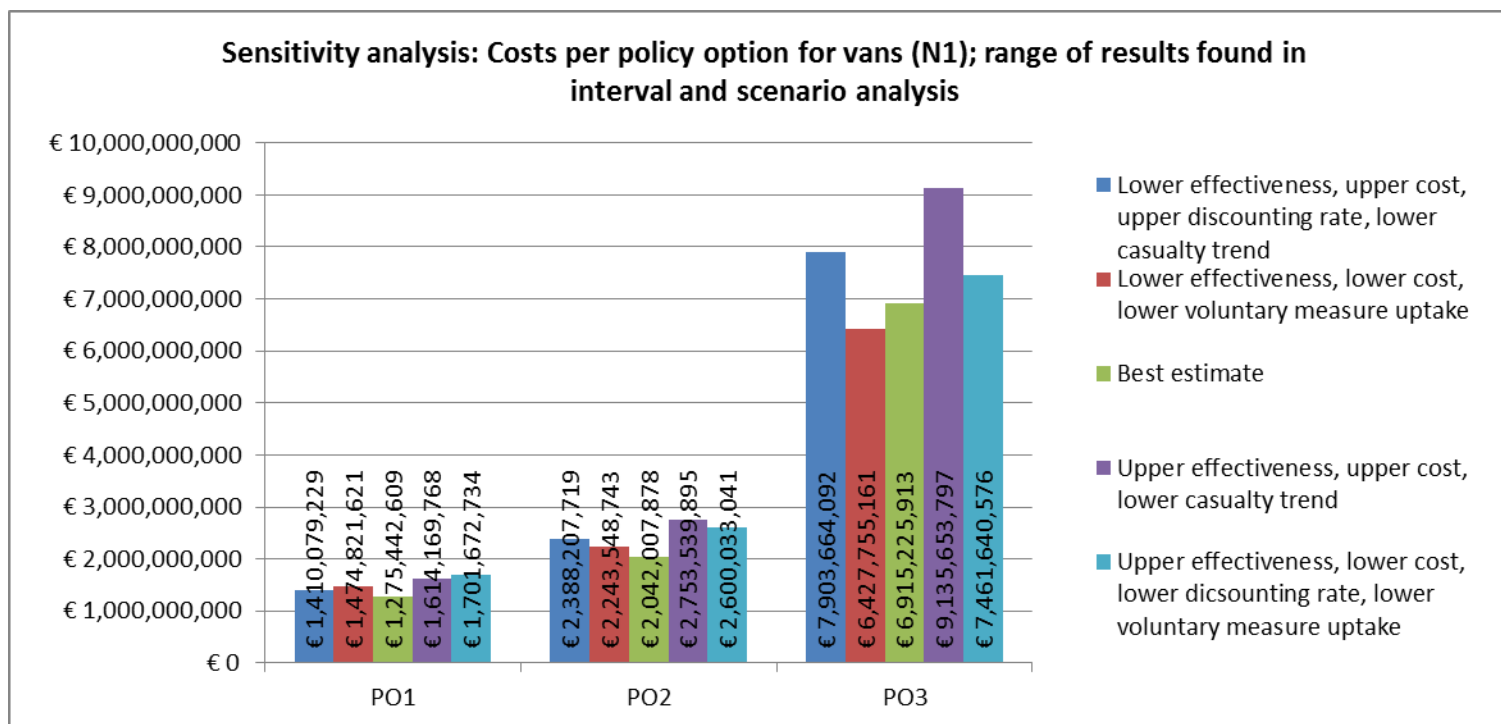


Figure 56: Vans (N1): Present value of costs of N1 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

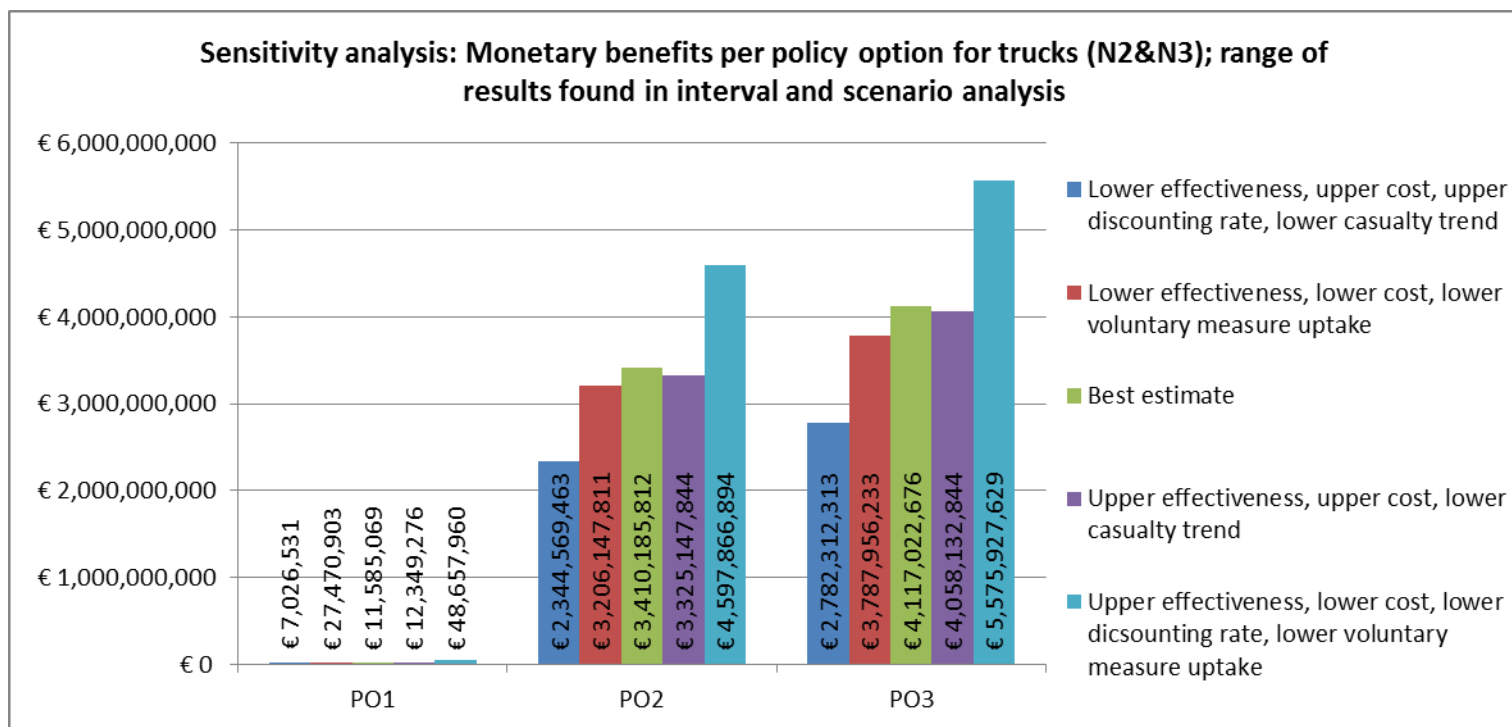


Figure 57: Trucks (N2&N3): Present monetary value of benefits of N2&N3 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

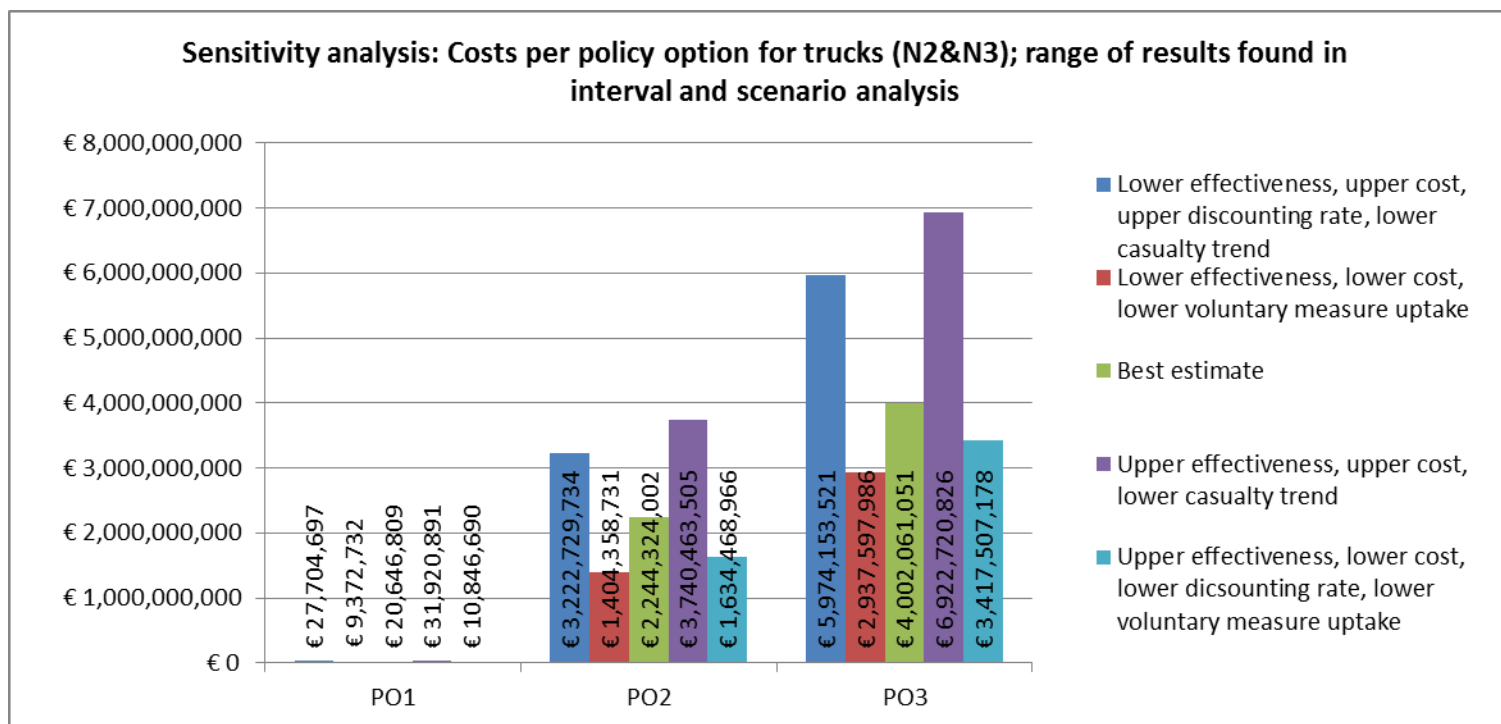


Figure 58: Trucks (N2&N3): Present value of costs of N2&N3 safety measures over entire evaluation period 2021–2037 compared to the baseline scenario (range of results found in interval and scenario analysis)

ANNEX 5 – FLOW CHART FOR VEHICLE GROUPS WITH FOCUS ON THE ROAD ACCIDENT VICTIM’S PERSPECTIVE

LDV = Light Duty Vehicle

HDV = Heavy Duty Vehicle

Accident scenario = in which the occupants of or persons around the respective LDVs and HDVs are involved

Occurance = accidents occurring in the real-world

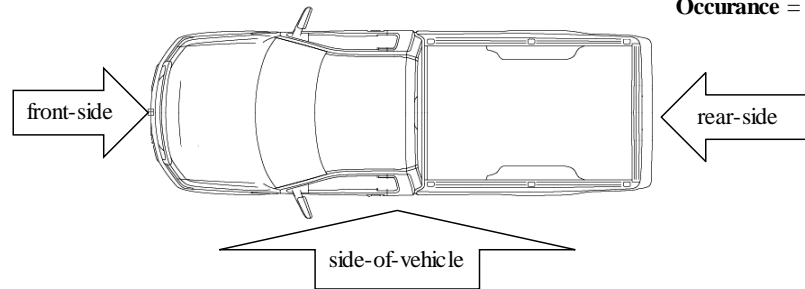
Accident type = FI Frontal Impact, RI Rear Impact, SI Side Impact, F-LVRU Front impact LDV with VRU,

R-LVRU Rear Impact LDV with VRU, F-HVRU Front impact HDV with VRU,

S-HVRU Side impact HDV with VRU, R-HVRU Rear Impact HDV with VRU

Highest risk = for persons in and around the accident vehicle or N/S if Not Significant

Additional risk = of fire and/or electrocution of occupants, bystanders and rescue workers



LDV	Accident scenario	Occurance	Accident type	Highest risk	Additional risk	Remaining focus areas
	<i>While driving forward:</i>					
	Collision front-side with approaching vehicle	common -----	FI	LDV	Yes →	FI-LDV including Post crash fire and electric safety
	Collision front-side with vehicle moving away	common -----	FI	LDV	Yes ↘	
	Collision front-side with still-standing vehicle or obstacle	common -----	FI	LDV	Yes ↘	
	Collision front-side with vulnerable road user	common -----	F-LVRU	VRU	→	F-LVRU
	Collision rear-side with approaching vehicle	common -----	RI	LDV	Yes →	RI-LDV including Post crash fire and electric safety
	Collision rear-side with vehicle moving away	impossible				
	Collision rear-side with still-standing vehicle or obstacle	impossible				
	Collision rear-side with vulnerable road user	impossible				
	Collision side-of-vehicle with approaching vehicle	common -----	SI	LDV	Yes →	SI-LDV including Post crash fire and electric safety
	Collision side-of-vehicle with vehicle moving away	impossible				
	Collision side-of-vehicle with still-standing vehicle or obstacle	common -----	SI	LDV	Yes ↘	
	Collision side-of-vehicle with vulnerable road user	not common				
	<i>While driving rearward:</i>					
	Collision front-side with approaching vehicle	not common				
	Collision front-side with vehicle moving away	impossible				
	Collision front-side with still-standing vehicle or obstacle	impossible				
	Collision front-side with vulnerable road user	impossible				
	Collision rear-side with approaching vehicle	not common				
	Collision rear-side with vehicle moving away	impossible				
	Collision rear-side with still-standing vehicle or obstacle	common -----	RI	LDV	Yes ↘	
	Collision rear-side with vulnerable road user	common -----	R-LVRU	VRU	→	R-LVRU
	Collision side-of-vehicle with approaching vehicle	common -----	RI	LDV	Yes ↘	
	Collision side-of-vehicle with vehicle moving away	impossible				
	Collision side-of-vehicle with still-standing vehicle or obstacle	not common				
	Collision side-of-vehicle with vulnerable road user	not common				

While turning:

Collision front-side with approaching vehicle	common ----- FI	LDV	Yes ↘
Collision front-side with vehicle moving away	not common		
Collision front-side with still-standing vehicle or obstacle	common ----- FI	LDV	Yes ↘
Collision front-side with vulnerable road user	common ----- F-LVRU	VRU	Yes →
Collision rear-side with approaching vehicle	common ----- - RI	LDV	Yes ↘
Collision rear-side with vehicle moving away	impossible		
Collision rear-side with still-standing vehicle or obstacle	impossible		
Collision rear-side with vulnerable road user	impossible		
Collision side-of-vehicle with approaching vehicle	common ----- -- SI	LDV	Yes ↘
Collision side-of-vehicle with vehicle moving away	impossible		
Collision side-of-vehicle with still-standing vehicle or obstacle	not common		
Collision side-of-vehicle with vulnerable road user	not common		

While at a standstill:

Collision front-side with approaching vehicle	common ----- FI	LDV	Yes ↘
Collision front-side with vehicle moving away	impossible		
Collision front-side with still-standing vehicle or obstacle	impossible		
Collision front-side with vulnerable road user	impossible		
Collision rear-side with approaching vehicle	common ----- - RI	LDV	Yes ↘
Collision rear-side with vehicle moving away	impossible		
Collision rear-side with still-standing vehicle or obstacle	impossible		
Collision rear-side with vulnerable road user	not common		
Collision side-of-vehicle with approaching vehicle	common ----- -- SI	LDV	Yes ↘
Collision side-of-vehicle with vehicle moving away	impossible		
Collision side-of-vehicle with still-standing vehicle or obstacle	impossible		
Collision side-of-vehicle with vulnerable road user	not common		

HDV

While driving forward:

Collision front-side with approaching vehicle	common ----- FI	HDV	Yes →	FI-HDV including Post crash fire and electric safety
Collision front-side with vehicle moving away	common ----- FI	HDV	Yes ↘	
Collision front-side with still-standing vehicle or obstacle	common ----- FI	HDV	Yes ↘	
Collision front-side with vulnerable road user	common ----- F-HVRU	VRU	Yes →	F-HVRU
Collision rear-side with approaching vehicle	common ----- - RI	HDV	Yes →	RI-HDV including Post crash fire and electric safety
Collision rear-side with vehicle moving away	impossible			
Collision rear-side with still-standing vehicle or obstacle	impossible			
Collision rear-side with vulnerable road user	impossible			
Collision side-of-vehicle with approaching vehicle	common ----- -- SI	N/S		
Collision side-of-vehicle with vehicle moving away	impossible			
Collision side-of-vehicle with still-standing vehicle or obstacle	not common			
Collision side-of-vehicle with vulnerable road user	not common			

While driving rearward:

Collision front-side with approaching vehicle	not common			
Collision front-side with vehicle moving away	impossible			
Collision front-side with still-standing vehicle or obstacle	impossible			
Collision front-side with vulnerable road user	impossible			
Collision rear-side with approaching vehicle	not common			
Collision rear-side with vehicle moving away	impossible			
Collision rear-side with still-standing vehicle or obstacle	common ----- RI	N/S		
Collision rear-side with vulnerable road user	common ----- R-HVRU	VRU	—————→	R-HVRU
Collision side-of-vehicle with approaching vehicle	common ----- SI	N/S		
Collision side-of-vehicle with vehicle moving away	impossible			
Collision side-of-vehicle with still-standing vehicle or obstacle	not common			
Collision side-of-vehicle with vulnerable road user	not common			

While turning:

Collision front-side with approaching vehicle	common ----- FI	HDV	Yes ↘	
Collision front-side with vehicle moving away	not common			
Collision front-side with still-standing vehicle or obstacle	common ----- FI	N/S		
Collision front-side with vulnerable road user	common ----- F-HVRU	VRU	—————→	
Collision rear-side with approaching vehicle	common ----- RI	HDV	Yes ↘	
Collision rear-side with vehicle moving away	impossible			
Collision rear-side with still-standing vehicle or obstacle	impossible			
Collision rear-side with vulnerable road user	impossible			
Collision side-of-vehicle with approaching vehicle	common ----- SI	N/S		
Collision side-of-vehicle with vehicle moving away	impossible			
Collision side-of-vehicle with still-standing vehicle or obstacle	not common			
Collision side-of-vehicle with vulnerable road user	common ----- S-HVRU	VRU	—————→	S-HVRU

While at a standstill:

Collision front-side with approaching vehicle	common ----- FI	N/S		
Collision front-side with vehicle moving away	impossible			
Collision front-side with still-standing vehicle or obstacle	impossible			
Collision front-side with vulnerable road user	impossible			
Collision rear-side with approaching vehicle	common ----- RI	HDV	Yes ↘	
Collision rear-side with vehicle moving away	impossible			
Collision rear-side with still-standing vehicle or obstacle	impossible			
Collision rear-side with vulnerable road user	not common			
Collision side-of-vehicle with approaching vehicle	common ----- SI	N/S		
Collision side-of-vehicle with vehicle moving away	impossible			
Collision side-of-vehicle with still-standing vehicle or obstacle	impossible			
Collision side-of-vehicle with vulnerable road user	not common			

The following main accident types are derived from the flow chart above:

- FI-LDV – Frontal Impact Light Duty Vehicle
 - This means either passenger cars, SUVs, pick-ups, vans or other light commercial vehicles that are involved in a crash where the front-side of the vehicle is crushed. Although there are numerous crash configurations possible, the persons at risk here are in principle the vehicle's occupants that are generally subjected to very similar dynamics among the different crash configurations, where high deceleration forces and high external forces are exerted on the occupants, leading to internal and external trauma.
 - Victims are the occupants of the light duty motor-vehicle.
 - Scope for improvement of mitigation through crash testing representing real-world crash scenarios with injury measuring dummies. [*Remove exemptions, introduce full-width crash test*]
 - Scope for introduction of frontal crash avoidance technologies. [*AEBS and LKA*]
 - Scope for introduction of further crash injury mitigation technologies. [*Catch all*]
 - As a result of a crash, the vehicle in question could catch fire due to ruptured fuel system or compromised propulsion battery integrity in case of an electric or hybrid-electric vehicle. Additionally, such accidented vehicles can further have exposed high-voltage components that may electrocute persons coming into direct or indirect contact with them.
 - Victims are the occupants of the light duty motor-vehicle, bystanders and rescue workers.
 - Scope for improvement of mitigation through crash testing representing real-world crash scenarios with post-crash fire risk and/or electrical risk checking. [*Remove exemptions, introduce full-width crash test*]
- SI-LDV – Side Impact Light Duty Vehicle
 - This means light duty motor-vehicles as above, involved in a crash where the side of the vehicle is crushed. There are a few crash configurations possible and in each case the principle persons at risk are the occupants that are generally subjected to high deceleration forces and high external forces, leading to internal and external trauma.
 - Victims are the occupants of the light duty motor-vehicle.
 - Scope for improvement of mitigation through crash testing representing real-world crash scenarios with injury measuring dummies. [*Remove exemptions, introduce pole side-impact test*]
 - No scope for improvement of side crash avoidance technologies. [*ESC, already rolled out*]
 - As a result of a crash, the vehicle in question could catch fire due to ruptured fuel system or compromised propulsion battery integrity in case of an electric or hybrid-electric vehicle. Additionally, such accidented vehicles can further have exposed high-voltage components that may electrocute persons coming into direct or indirect contact with them.
 - Victims are the occupants of the light duty motor-vehicle, bystanders and rescue workers.
 - Scope for improvement of mitigation through crash testing representing real-world crash scenarios with post-crash fire risk and/or electrical risk checking. [*Remove exemptions, introduce pole side-impact test*]

- RI-LDV – Rear Impact Light Duty Vehicle
 - This means light duty motor-vehicles as above, involved in a crash where the rear-side of the vehicle is crushed. There are a few crash configurations possible and in each case the principle persons at risk are the occupants. However, the issue is rarely a matter of high deceleration forces or high external forces, but notably the risk of whiplash in low-speed accidents and the risk of fire due to the traditional and conventional placement of the fuel tank at the rear of the vehicle.
 - Victims are the occupants of the light duty motor-vehicle.
 - No scope for improvement of mitigation though crash testing representing real-world crash scenarios with injury measuring dummies. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulation 17 on seat and head restraint testing in process of being updated]*
 - No scope for introduction of rear crash avoidance technologies. *[Does not make sense / does not exist]*
 - As a result of a crash, the vehicle in question could catch fire due to ruptured fuel system or compromised propulsion battery integrity in case of an electric or hybrid-electric vehicle. Additionally, such accidented vehicles can further have exposed high-voltage components that may electrocute persons coming into direct or indirect contact with them.
 - Victims are the occupants of the light duty motor-vehicle, bystanders and rescue workers.
 - Scope for improvement of mitigation through crash testing representing real-world crash scenarios with post-crash fire risk and/or electrical risk checking. *[Introduce rear impact crash test]*

- F-LVRU – Front-side of Light duty vehicle impacting Vulnerable Road User
 - This means light duty motor-vehicles as above, involved in a collision with a pedestrian or cyclists onto the front of the vehicle. In the initial phase the pedestrian or cyclist is struck by the front of the vehicle, generally leading to leg and hip injuries, and subsequently the head of the person strikes the bonnet, wiper scuttle panel, windscreen or windscreen frame, by which head trauma is sustained.
 - Victims are pedestrians and cyclists outside the light duty motor-vehicle.
 - Scope for improvement of mitigation though crash testing representing real-world crash scenarios with injury measuring devices for the two distinct injury modes. *[Extension of the front-of-vehicle testing zone for head impacts]*
 - Scope for introduction of pedestrian and cyclist frontal crash avoidance technologies. *[AEBS]*
 - Scope for introduction of further crash injury mitigation technologies. *[Catch all]*

- R-LVRU – Rear-side of Light duty vehicle impacting Vulnerable Road User
 - This means light duty motor-vehicles as above, involved in a collision with a person onto the rear of the vehicle, most commonly when the motor-vehicle in question is reversing out of the parked position. The person is struck by the rear of the vehicle that generally leads to the person to fall, either being partly or fully run-over by the motor-vehicle or sustaining injuries through impact with head or other body parts onto the ground.
 - Victims are pedestrians and cyclists outside the light duty motor-vehicle.

- No scope for introduction of mitigation though crash testing representing real-world crash scenarios with injury measuring dummies or devices. *[Does not make sense / does not exist]*
 - Scope for introduction of pedestrian and cyclist rearward crash avoidance technologies. *[Introduce rear view camera or detection]*
- FI-HDV – Front Impact Heavy Duty Vehicle
 - This means either trucks, with or without their trailers, or buses that are involved in a crash where the front-side of the vehicle is crushed. Although there are numerous crash configurations possible, the occupants are subjected to similar dynamics among the different crash configurations, subject to deceleration forces and external forces being exerted on the occupants. If the collision occurs with a light duty vehicle, an occurrence that is generally more common than with another heavy duty vehicle, the occupants in the light duty vehicle will have a much higher risk of injuries than those in the heavy duty vehicle. These instances are however covered by the relevant main accident type FI-LDV above.
 - Victims are the occupants of the heavy duty motor-vehicle.
 - No scope for improvement of mitigation though crash testing representing real-world crash scenarios with injury measuring dummies. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulation 29 on cab strength has recently been introduced in GSR].*
 - Scope for improvement of mitigating effects intended for the common collision partner, light duty vehicles. *[This will fall under the Self-Regulation option, as Directive 2015/719/EU promotes fuel efficient elongated cabs voluntary uptake that needs modified and improved Front Underrun Protection device]*
 - No scope for improvement of frontal crash avoidance technologies. *[AEBS and LDWS have recently been introduced in GSR]*
 - Scope for introduction of further crash injury mitigation technologies. *[Catch all]*
 - As a result of a crash, generally speaking when it concerns a bus rather than a truck as according to available accident statistics there is a much lower risk for the latter, the vehicle could catch fire due to ruptured fuel system or compromised propulsion battery integrity in case of an electric or hybrid-electric vehicle. Additionally, such accidented vehicles can further have exposed high-voltage components that may electrocute persons coming into direct or indirect contact with them.
 - Victims are the occupants of the heavy duty motor-vehicle, bystanders and rescue workers.
 - Scope for improvement of mitigation through fire risks measures. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulations 107 and 118 are improved or in process of being updated]*
 - No scope for improvement of mitigation through electrical risk checking. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulation 100 is in process of being updated]*
- RI-HDV – Rear Impact Heavy Duty Vehicle
 - This means heavy duty motor-vehicles as above, involved in a crash where the rear-side of the vehicle is crushed. There are a few crash configurations possible, but it is not likely there is a major injury risk for the occupants of the heavy duty vehicle. In principle, occupants of a light duty motor-vehicle being the other party involved in

the accident, as already covered by the relevant main accident type FI-LDV above, would bear nearly the full risk of sustaining injuries when they occur.

- No victims in the heavy duty motor-vehicle.
- Scope for improvement of mitigating effects intended for the common collision partner, light duty vehicles. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulation 58 is improved or in process of being updated]*
- No scope for improvement of rear crash avoidance technologies. *[Does not make sense / does not exist]*
- As a result of a crash, generally speaking a bus in question could catch fire due to ruptured fuel system or compromised propulsion battery integrity in case of an electric or hybrid-electric vehicle, as such systems are in principle not found on the rear of truck or trailers. Where applicable, such accidented vehicles can further have exposed high-voltage components that may electrocute persons coming into direct or indirect contact with them.
 - Victims are the occupants of the heavy duty motor-vehicle, bystanders and rescue workers.
 - Scope for improvement of mitigation through fire risks measures. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulations 107 and 118 are improved or in process of being updated]*
 - No scope for improvement of mitigation through electrical risk checking. *[This will fall under the Baseline Scenario option, as the relevant UNECE regulation 100 is in process of being updated]*
- F-HVRU – Front-side of Heavy duty vehicle impacting Vulnerable Road User
 - This means heavy duty motor-vehicles as above, involved in a collision with a pedestrian or cyclists with the front of the vehicle. In the initial phase the pedestrian or cyclist is struck by the front of the vehicle that can lead to overall injuries, but subsequently there is a risk of the person of being run over.
 - Victims are pedestrians and cyclists outside the heavy duty motor-vehicle or vehicle combination.
 - No scope for introduction of mitigation though crash testing representing real-world crash scenarios with injury measuring devices. *[Does not make sense / does not exist]*
 - Scope for introduction of pedestrian and cyclist frontal crash avoidance technologies. *[Introduction of detection systems and introduction of direct visibility requirements. No scope for updating AEBS for trucks/buses as this measure has just been introduced by GSR]*
- S-HVRU – Side-of-vehicle of Heavy duty vehicle impacting Vulnerable Road User
 - This means heavy duty motor-vehicles as above, involved in a collision with a pedestrian or cyclists with the side of the vehicle, notably when the vehicle or vehicle combination is turning. In the initial phase the pedestrian or cyclist is struck by the front or side corner of the vehicle, that can lead to overall injuries, but subsequently there is a risk of the person of being run over, even to the extent of the rear wheels of the vehicle, given the relatively high ground clearance in relation to a person that is knocked down onto the road.
 - Victims are pedestrians and cyclists outside the heavy duty motor-vehicle or vehicle combination.

- No scope for introduction of mitigation though crash testing representing real-world crash scenarios with injury measuring devices. *[Does not make sense / does not exist]*
 - Scope for introduction of pedestrian and cyclist side or frontal-towards-side crash avoidance technologies. *[Introduction of detection systems and introduction of direct visibility requirements. No scope for updating AEBS for trucks/buses as this measure has just been introduced by GSR]*
- R-HVRU – Rear-side of Heavy duty vehicle impacting Vulnerable Road User
 - This means heavy duty motor-vehicles as above, involved in a collision with a person onto the rear of the vehicle, most commonly when the motor-vehicle in question is reversing out of the parked position. The person is struck by the rear of the vehicle that generally leads to the person to fall, either being partly or fully run-over by the vehicle or vehicle combination or sustaining injuries through impact with head or other body parts onto the ground.
 - Victims are pedestrians and cyclists outside the heavy duty motor-vehicle.
 - No scope for introduction of mitigation though crash testing representing real-world crash scenarios with injury measuring dummies or devices. *[Does not make sense / does not exist]*
 - Scope for introduction of pedestrian and cyclist rearward crash avoidance technologies. *[Introduce rear view camera or detection]*

1. Vehicle safety legislation – General Safety Regulation

As part of the vehicle type-approval framework, general vehicle safety in the EU is in turn covered by a *de facto* sub-framework within the main framework. General vehicle safety is regulated through a single act, namely Regulation (EC) No 661/2009¹⁶³ as adopted by the co-legislator, covering a large number of safety measures. The main objectives of the GSR were adding new technologies and safety features to vehicles as standard equipment, simplification by repealing old Directives and to primarily replace them by UNECE¹⁶⁴ regulations. For other political reasons at the time, the GSR also achieved environmental benefits in that vehicle tyres became more energy efficient and quieter and it also introduced gear-shift indicators to help drivers save fuel and cut vehicle emissions by optimising the engine speed under specific driving conditions. Apart from the last mentioned (minor) items, the GSR covers all vehicle safety aspects such as stability control systems, braking performance, crashworthiness, safety belts, child seat safety, electric powertrain protection, lighting installation, electro-magnetic resistance, fuel system fire safety, head restraints, tyre safety and numerous additional items.

Upon the introduction of the GSR new vehicle types, that were granted a new whole vehicle type-approval, have been required to be fitted with stability control systems since 1 November 2011. Mandatory compliance followed for nearly the full package of measures covered by the GSR and for all new vehicle types, as per 1 November 2012. The suite of requirements had to be applied for all vehicles sold in the EU to the general public (not just new ‘types’ of vehicle) from 1 November 2014, save for the mandatory fitment of advanced emergency braking and lane departure warning systems on all trucks and buses which came into force one year later. Also, the protection of occupants in truck cabs in case of a crash was introduced on a mandatory basis for new types of trucks from 30 January 2017 and will be required for all new trucks sold in the EU as from 30 January 2021. Finally, several specific requirements covering tyre safety, noise and rolling resistance are still being phased-in until 1 May 2023.

This can be best explained by for instance the introduction of stability control systems, as regulated in the original GSR, for which our estimates of technology adoption in the past time have been based on data and other information provided by the vehicle industry and supplier industry, as validated through several wide and transparent stakeholder consultation sessions from 2014 onwards. In this case, manufactures had to make this safety feature available by November 2011 on all new vehicle types introduced on the market with all new vehicles sold having to comply before 2014. This had the effect of first boosting the up-to-then voluntary fitment from a plateau at around 80% in 2008 and 2009 up to 100% by 2014. However, even with full fitment in new vehicles, it still takes time for those vehicles to replace existing vehicles on the road. This explains the lag in the vehicle fleet dispersion where an effective near 100% fitment will be reached at a much later stage.

Even though the current time-lapse does not allow carrying out a full *ex post* evaluation, the effectiveness and fleet penetration of the previous measures is taken into account for the in depth analysis the effectiveness of the new vehicle safety measures proposed in this Impact

¹⁶³ Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor (Text with EEA relevance), OJ L 200, 31.7.2009, p. 1

¹⁶⁴ United Nations Economic Commission for Europe – World Forum for the harmonization of vehicle regulations (WP.29)

Assessment. This is based on the initial information on effectiveness¹⁶⁵ with further data taken from other available and referenced sources (e.g. international studies) as part of the preparatory work for this Impact Assessment in which this approach was requested and validated by the stakeholders. In reality a casualty can only be prevented once and therefore this was addressed in the analysis model by removing casualties prevented by a given existing measure, such as stability control, from the subsequent target population of the other measures. This approach was also fully endorsed through extensive stakeholder consultations on this matter.

2. Vehicle safety legislation – Pedestrian Safety Regulation

Regulation (EC) No 78/2009¹⁶⁶ aims to protect pedestrians and other vulnerable road users involved in a collision with a vehicle. It requires cars, vans and other light commercial vehicles to be fitted with energy absorbing bonnets and front bumpers, to cushion the head and legs of a pedestrian. These features are also expected to protect cyclists when an accident occurs between a motor-vehicle and such vulnerable road user. It further requires manufacturers to fit so-called ‘brake assist systems’ into their vehicles. These systems anticipate in a matter of milliseconds whether a driver is going to perform an emergency stop instead of normal gradual braking, and in those emergency circumstances apply the brakes beyond the level called for by the driver. This intervention can shave-off valuable fractions of the final impact speed as well as centimetres of the stopping distance, all helping to reduce the severity of the vulnerable road user’s injuries¹⁶⁷.

Although moped and motorcycle riders are also often referred to as vulnerable road users, they are not included as such for the purpose of this Impact Assessment. There is a considerable variation in the Member States in the distribution of moped and motorcycle fatalities by area and road type and the most frequently recorded specific critical event for riders is surplus speed, described as speed that is too high for the conditions or manoeuvre being carried out, very much in contrast to pedestrians and cyclists¹⁶⁸. Although this group should be taken into account wherever practicable, specific measures to address their safety¹⁶⁹ are deemed more appropriate outside of the regulatory framework impacted by this initiative.

The energy absorbing capability of bonnets and front bumpers already existed in European vehicles since mandatory vulnerable road user protection requirements were introduced in Directive 2003/102/EC¹⁷⁰. This legislation followed a failed attempt to self-regulate through the negotiated voluntary agreement in 2001 between the European Commission and the

¹⁶⁵ COM(2008) 316

¹⁶⁶ Regulation (EC) No 78/2009 of the European Parliament and of the Council of 14 January 2009 on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users, amending Directive 2007/46/EC and repealing Directives 2003/102/EC and 2005/66/EC (Text with EEA relevance), OJ L 35, 4.2.2009, p. 1

¹⁶⁷ COM(2007)560 final

¹⁶⁸ https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/bfs2016_motomoped.pdf

¹⁶⁹ Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles (OJ L 60, 2.3.2013, p. 52) and Commission Delegated Regulation (EU) No 3/2014 of 24 October 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to vehicle functional safety requirements for the approval of two- or three-wheel vehicles and quadricycles (OJ L 7, 10.1.2014, p. 1)

¹⁷⁰ Directive 2003/102/EC of the European Parliament and of the Council of 17 November 2003 relating to the protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle and amending Council Directive 70/156/EEC, OJ L 321, 6.12.2003, p. 15

European Automobile Manufacturers' Association (ACEA)¹⁷¹. Over the course of many following years, the relevant mandatory safety provisions have been implemented on most passenger cars, vans and light commercial vehicles, and will be fully implemented on 24 August 2019, when the full set of requirements become mandatory on all new cars sold in the EU, notably by finally including heavy passenger cars such as SUVs that were exempted from pedestrian protection structural design requirements before this time.

In this case, there is also the matter of time it will still take before vehicles compliant with this safety aspect are completely dispersed within the EU fleet, meaning no *ex post* effectiveness analysis could yet be carried out.

3. Impact of additional safety measures on vehicle prices and sales prices

Analysis has shown that cars have become cheaper in real terms in every year of the last reported decade, see Table 6 in section 6.3.3, despite this being a period in which technical development to meet new and more demanding environmental and safety standards increased, for example:

- **Directive 98/69/EC and Regulation (EC) No 715/2007**
Euro 4 and Euro 5 emissions standards applicable from 2005 and 2009, respectively.
- **Regulation (EC) No 443/2009**
Mandatory average fleet CO₂ emissions limits with mandatory compliance limits applying from 2012. The average CO₂ emissions of the new vehicle fleet sold by a manufacturer could not be reduced in a step change from one year to the next. Hence, manufacturers confirmed to have started around 2007, in preparation for the announced legislation, to introduce technologies that significantly reduced CO₂ emissions, in order to be able to meet the compliance limits in 2012. This can be concluded from the average rate of progress in CO₂ reduction, which accelerated considerably after 2007, compared to the long term trend before¹⁷². Considerable investments in this regard therefore fall within the period of retail price decreases cited above.
- **Directives 96/79/EC and 96/27/EC**
Compliance with frontal impact and side impact crash tests for all new cars sold from October 2003.
- **Regulation (EC) No 661/2009 (General Safety Regulation)**
Mandatory electronic stability control (ESC) applicable from November 2011, tyre pressure monitoring systems (TPMS), safety belt reminder (SBR), ISOFIX child seat connectors, gear shift indicators, *et cetera*, applicable from November 2012 for all new passenger car EU market introductions.
- **Directive 2003/102/EC**
Compliance with pedestrian protection provisions, energy absorbing bumper and bonnet from October 2005 for new passenger car EU market introductions.
- **Regulation (EC) No 78/2009 (Pedestrian Safety Regulation)**
Anti-lock braking system (ABS) with brake assist system (BAS) applicable from October 2009 for all new passenger car EU market introductions.

¹⁷¹ Commission Communication (COM(2001) 389 final) regarding the voluntary agreement on safer car fronts with the European car industry (ACEA)

¹⁷² https://www.transportenvironment.org/sites/te/files/media/2011_09_car_company_co2_report_final.pdf

A 2011 study commissioned by Directorate-General for Climate Action, analysed the effect of emissions and safety regulations and standards on vehicle prices¹⁷³. The study concluded that historical vehicle price data and fitment status of certain features did not provide any definitive relationship between emissions standards and car prices. Overall, cars had become 12% to 22% cheaper (after inflation) in the study period of 2002 to 2010. The study found that, while there was certainly costs associated for the vehicle manufacturers to comply with the environmental and safety legislation during that period, these costs were largely offset by cost reductions from economies of scale and improved productivity, because the competition in the market made it difficult to pass on cost increases to consumers. Stakeholders interviewed for the study argued that without the additional legislation, car prices would have fallen even further in that period. Nevertheless, it is evident that regulatory requirements have not stopped the trend of car retail prices decreasing, because compliance costs for emissions and safety standards are only one of the many complex factors influencing vehicle retail prices.

A report published by the European Federation for Transport and Environment (T&E) in 2011 also looked into the aspect of potential vehicle price increases specifically due to CO₂ emissions regulations and, looking back, compared the predicted influence on retail price with actual figures¹⁷⁴. The authors came to a similar conclusion as the DG CLIMA study: that car retail prices were influenced by a complex set of factors, with compliance costs being only one of them, and that concerns over cars becoming unaffordable due to CO₂ emissions regulations had been unfounded.

The past experience with CO₂ emissions legislation also allows comparing predicted additional costs with predicted and actual retail price increases: In a 2006 study prepared for the European Commission, the researchers from TNO had estimated the future costs to manufacturers of reaching the required average CO₂ targets to be an additional € 832 per car in 2008, compared to a year-2002 baseline. This was expected by the authors to translate to an additional retail price of € 1 200 per car in 2008, again compared to 2002. In reality however, cars have become approximately 10% cheaper (after inflation) between 2002 and 2008, which equates to a price reduction of € 2 000 for a € 20 000 model.

These figures show that, bearing in mind the scale of investment required to meet emissions requirements, coupled with the costs of the other aspects cited above, the costs to vehicle manufacturers related to the fitment of new safety measures in the present Impact Assessment are not considered to be orders of magnitude different in scale than past predictions which did not translate to retail price increases.

Interpreting the general price trend and the conclusions from the cited studies on compliance costs, it may be concluded that vehicle manufacturers in the past have found strategies and practices to balance production costs and regulatory compliance. This has been for example, via increases in production efficiency, or accepted temporarily reduced profit margins to at least partially offset any cost increase, because the competitive nature of the vehicle market did not allow substantial retail price increases.

Past evidence suggests that requiring additional equipment for CO₂ emission standards, which was estimated at a cost higher than the present estimates for the full set of proposed vehicle safety measures, did not cause an increase in retail prices. Substantial increases in vehicle prices due to the proposed new vehicle safety measures in the medium and long term are

¹⁷³ https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/cars/docs/report_effect_2011_en.pdf

¹⁷⁴ https://www.transportenvironment.org/sites/te/files/media/2011_09_car_company_co2_report_final.pdf

therefore not expected and consequently no extraordinary impact on vehicle sales numbers was modelled for the cost-benefit analysis.

In order to understand how new safety measures could affect demand for vehicles it is important to observe on one side, how consumers perceive safety measures in vehicles, and on the other side, to which extent the additional cost of safety measures affects the final price of vehicles.

Academic literature has developed a large literature based on hedonic techniques: differentiated goods are valued by consumers for their utility-bearing attributes.

Berry et al (1995) pioneered in this field, assuming demand in the automobile sector is not homogenous and differs according to the product characteristics.¹⁷⁵ The authors find different demand elasticities (how demand changes facing a variation in another variable i.e.: price, safety level) for different measures and different vehicle models. In other words, all consumers do not value vehicle (safety) measures equally. This depends, on one side, on consumer's characteristics (such as income or family size) and on the other side on vehicle characteristics (Berry et al.2004).

The results of the research help to characterise demand elasticity. Literature shows that increase in safety measures reduces considerably elasticity. In other words, for a given vehicle price, it is likely that consumers can tolerate better larger price changes if car's safety equipment is higher¹⁷⁶ (alternatively, for a given price, consumers' demand would react further to a price variation when safety equipment is lower).

Other stylised facts from research show that demand differs depending on vehicle models. Research conducted by Berry et al. seems to indicate that, increasing safety measures by 10% while keeping the same price in case of low safety level vehicles models¹⁷⁷ increases the demand by 13%, the corresponding increase in vehicles models with already high safety level produces only 1.7% increase in demand.

What these results seem to indicate is that probably, consumers value safety differently, valuing it more (larger marginal utility) when vehicles have lower safety standards.

On the other hand, price elasticity seem to be higher for consumers of popular vehicle segments, while consumers of less crowded vehicle segments seem to cope better with a price increase.

The final drop in vehicle sales volumes will depend on the net effect. Lower decreases in sales volumes could result from increased perceived value of safety features by consumers which offsets any price increases. What literature seems to point is that, depending on the safety standards of the vehicle and the vehicle segment, these effects will be different.

References

Andersson, H. "The value of safety as revealed in the Swedish car market: an application of the hedonic pricing approach", *The journal of Risk Uncertainty*, 2005, 211-239.

¹⁷⁵ The empirical analysis is done using data for the American automobile market.

¹⁷⁶ Interestingly enough, the paper also analyses elasticity of other vehicle's characteristics. For instance, we observe that sport cars have lower elasticities than other vehicles. This means that for a given vehicle price, consumers wanting to buy sport cars will tend to react to a lower extent to a price change, due in large part to the "sport" characteristic of the vehicle.

¹⁷⁷ Authors considered Vehicle size as a proxy for safety.

Berry, S., and Levinsohn, J., and Pakes, A. “Automobile Prices in Market Equilibrium”, *Econometrica*, Vol.63, No.4 (Jul., 1995), 841-890

Berry, S., and Levinsohn, J., and Pakes, A. Differentiated Products Demand Systems from a combination of Micro and Macri Data: The New Car Market”, *Journal of Political Economy*, 2004, 112, no.1

Ehrlich, I., and Becker, G.S. “Market Insurance, Self-Insurance, and Self-Protection“, *Journal of Political Economy*, 1972, 80, 623-648

Peltzman, S. “The effects of automobile safety regulation”, *Journal of Political Economy*, 1975, 83(4), 677-725.

4. Impact of advanced safety measures on driver perception and behaviour

Research has studied how governmental intervention influences valuation of safety features on the car market. Ehrlich and Becker (1972) discuss in their theoretical paper the influence of different safety measures such as: market accident insurance, “self-insurance” (i.e. wearing seat-belt), and “self-protection” (e.g.: reduction by the driver of the probability of an accident through cautious, slower driving). Interaction of these measures seems to be different. While market insurance and self-insurance act as substitutes, self-insurance seems to discourage self-protection (i.e. drivers wearing seat belts are likely to drive faster and careless). Therefore, policies aiming to increase traffic safety through self-insurance (i.e.: new safety measures) could discourage self-protection (i.e.: driver behaviour).

Peltzman (1975) also analysed the response to safety regulation in the American automobile market. His hypothesis complements those of Ehrlich and Becker. If government introduces higher safety levels than the ones perceived optimal by consumers, drivers might respond by reducing their self-protection, i.e.: driving faster.

While optimality is a subjective perception (as discussed above in section 3 of this Annex – utility of safety measures depends on consumer’s characteristics and vehicle characteristics), one could discuss to which extent optimality is partly influenced by a “crowd effect” and how familiar the driver is with the safety measures. Safety measures which are not yet mature in the market could be perceived as not optimal by consumers, who could then not use them if they do not perceive them as optimal.

References

Ehrlich, I., and Becker, G.S. “Market Insurance, Self-Insurance, and Self-Protection“, *Journal of Political Economy*, 1972, 80, 623-648

Peltzman, S. “The effects of automobile safety regulation”, *Journal of Political Economy*, 1975, 83(4), 677-725.

European Parliament

2014-2019



TEXTS ADOPTED

Provisional edition

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Saving lives: Boosting car safety in the EU

European Parliament resolution of 14 November 2017 on saving lives: boosting car safety in the EU (2017/2085(INI))

The European Parliament,

- having regard to the Commission report entitled ‘Saving Lives: Boosting Car Safety in the EU – Reporting on the monitoring and assessment of advanced vehicle safety features, their cost effectiveness and feasibility for the review of the regulations on general vehicle safety and on the protection of pedestrians and other vulnerable road users’ (COM(2016)0787) and to the accompanying Commission staff working document (SWD(2016)0431),
- having regard to Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor¹⁷⁸,
- having regard to Regulation (EC) No 78/2009 of the European Parliament and of the Council of 14 January 2009 on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users, amending Directive 2007/46/EC and repealing Directives 2003/102/EC and 2005/66/EC¹⁷⁹,
- having regard to Directive 2014/47/EU of the European Parliament and of the Council of 3 April 2014 on the technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Union and repealing Directive 2000/30/EC¹⁸⁰,
- having regard to Directive (EU) 2015/413 of the European Parliament and of the Council of 11 March 2015 facilitating cross-border exchange of information on road-safety-related

¹⁷⁸ OJ L 200, 31.7.2009, p. 1.

¹⁷⁹ OJ L 35, 4.2.2009, p. 1.

¹⁸⁰ OJ L 127, 29.4.2014, p. 134.

traffic offences¹⁸¹,

- having regard to Directive (EU) 2015/719 of the European Parliament and of the Council of 29 April 2015 amending Council Directive 96/53/EC laying down for certain road vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic¹⁸²,
- having regard to Regulation (EU) 2015/758 of the European Parliament and of the Council of 29 April 2015 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC,
- having regard to its resolution of 9 September 2015 on ‘The implementation of the 2011 White Paper on Transport: taking stock and the way forward towards sustainable mobility’¹⁸³,
- having regard to its resolution of 18 May 2017 on road transport in the European Union¹⁸⁴,
- having regard to its resolution of 3 July 2013 on ‘Road safety 2011-2020 – First milestones towards an injury strategy’¹⁸⁵,
- having regard to its resolution of 27 September 2011 on European road safety 2011-2020¹⁸⁶,
- having regard to its resolution of 15 December 2011 on ‘The Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system’¹⁸⁷,
- having regard to the Commission communication entitled ‘A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility’ (COM(2016)0766),
- having regard to the Commission communication entitled ‘Towards a European road safety area: policy orientations on road safety 2011-2020’ (COM(2010)0389),
- having regard to the Commission communication entitled ‘CARS 2020: Action Plan for a competitive and sustainable automotive industry in Europe’ (COM(2012)0636),
- having regard to the Commission White Paper entitled ‘Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system’ (COM(2011)0144),
- having regard to the Commission report entitled ‘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’, drawn up by the Transport Research Laboratory and published on 31 March 2015,

¹⁸¹ OJ L 68, 13.3.2015, p. 9.

¹⁸² OJ L 115, 6.5.2015, p. 1.

¹⁸³ Texts adopted, P8_TA(2015)0310.

¹⁸⁴ Texts adopted, P8_TA(2017)0228.

¹⁸⁵ OJ C 75, 26.2.2016, p. 49.

¹⁸⁶ OJ C 56E, 26.2.2013, p. 54.

¹⁸⁷ OJ C 168E, 14.6.2013, p. 72.

- having regard to the Commission staff working document entitled ‘On the implementation of objective 6 of the European Commission’s policy orientations on road safety 2011-2020 – First milestone towards an injury strategy’ (SWD(2013)0094),
 - having regard to the Council conclusions of 8 June 2017 on road safety in support of the Valletta Declaration of March 2017,
 - having regard to the package ‘Europe on the Move’, released by the Commission on 31 May 2017, which includes a set of eight legislative initiatives with a special focus on road transport,
 - having regard to the United Nations General Assembly resolution 70/260 of 15 April 2016 entitled ‘Improving Global Road Safety’,
 - having regard to Rule 52 of its Rules of Procedure,
 - having regard to the report of the Committee on Transport and Tourism and the opinion of the Committee on the Internal Market and Consumer Protection (A8-0330/2017),
- A. whereas every year on Europe’s roads around 25 500 people die and some 135 000 are seriously injured, so that more – and more effective – measures need to be taken, in consultation with Member States, if the vision zero goal of ‘no fatalities’ is to be achieved;
 - B. whereas road safety depends on three factors: vehicle, infrastructure and drivers’ behaviour, and, therefore, measures in all three areas are necessary in order to enhance road safety and effective measures should be taken in the area of active and passive vehicle safety;
 - C. whereas the average age of passenger cars, light-duty vehicles and heavy-duty vehicles in the EU is constantly increasing and is now over 10 years; whereas the age of a vehicle has a direct bearing on the consequences of and the injuries sustained in a road accident;
 - D. whereas driver assistance systems make the vehicles safer and also enable the safe and active participation of persons with reduced mobility and the elderly in road traffic;
 - E. whereas intelligent driving systems reduce congestion, warn drivers of hazards on their route, and consequently help to lower the risk of causing an accident;
 - F. whereas the move towards driver-free vehicles is progressing rapidly and road safety generally is an urgent issue, so that a review of the General Safety Regulation must be submitted by the Commission no later than first quarter of 2018; whereas in any event any further delay would be unacceptable;
 - G. whereas since 38 % of all fatalities occur in urban areas, often involving vulnerable road users, Member States should take vulnerable road users into consideration in urban traffic planning, improving their treatment in relation to modes of transport such as cars and buses; whereas the Commission should present its review of the pedestrian protection regulation;
 - H. whereas there is a clear link between road safety and the working conditions of professional road users;

General requests

1. Stresses that Member States should conduct efficient and regular road checks on drivers, as the main causes of accidents, at present as in the past, are speed levels that are inappropriate and excessive speed for the driving conditions concerned, distraction, driving under the influence of alcohol or drugs, and excessive fatigue, and therefore:
 - (a) calls on the Commission to set a percentage for the numbers of vehicles in classes M1 and N1 to be checked;
 - (b) calls on the Commission to introduce stricter controls for the proper enforcement of compulsory working-time limits and rest periods for drivers who are professional road users;
 - (c) calls on the Member States to step up exchanges of best practices, particularly regarding smart enforcement strategies, and to introduce penalties which will act as a deterrent to offenders;
2. Notes that around 25 % of all annual traffic fatalities in the EU are caused by alcohol consumption; invites the Commission, therefore, to assess the possible added value of harmonising the EU blood alcohol concentration limit at 0.0% for new drivers in their first two years and for professional drivers, and welcomes some Member States' zero tolerance policy for drunk driving;
3. Urges the Commission, bearing in mind the Valletta Declaration on improving road safety issued by the Maltese presidency on 29 March 2017, to include new targets for halving the number of serious injuries on the roads in the EU in its new road safety strategy for the decade 2020-2030;
4. Calls on the Member States to significantly improve the state of their road infrastructure by means of regular and effective maintenance, including of traffic signs and signalling systems, and appropriate upgrades to cope with traffic volumes, and to introduce innovative measures providing full functionality and enhancing the interoperability of driver assistance systems, resulting in so-called intelligent infrastructure; calls on the Commission to set up a mechanism to ensure that the European road infrastructure remains in an adequate condition;
5. Points out that infrastructural alterations (for example certain types of crash barrier or traffic-calming devices) can sometimes cause accidents or make them worse, especially when motorised two-wheelers are involved; calls on the Commission, therefore, to propose any standardisation measure likely to remedy the drawbacks;
6. Observes that many drivers are not aware of the necessity of or how to form a corridor for emergency vehicle access on motorways, and therefore calls on the Commission to set common standards for the creation of such corridors and to launch a European awareness campaign;
7. Observes that for pedestrians and cyclists nearly half of all fatalities resulting from traffic accidents are of persons aged over 65, and that road accidents are the biggest cause of death among young people; calls on the Member States, therefore, to make it possible for older people and young drivers to use the roads safely by developing well-publicised programmes to avert age-specific accident risks;
8. Observes that in 51 % of cases the victims of fatal road accidents in urban areas are pedestrians and cyclists, and therefore encourages cities to include targets in their mobility

plans for reducing the number of road and traffic accidents; also calls on the Member States to take greater account of more vulnerable road users, by addressing critical accident hotspots and by building and maintaining more safe pedestrian and cycling infrastructure or expanding and modernising existing infrastructure while also ensuring better indications; calls on the Commission also to take further action at EU level over and above the availability of existing funding schemes, in order to facilitate widespread improvements to cycling infrastructure and to mandate new active and passive vehicle safety technologies that protect in particular vulnerable road users;

9. Notes that because some cyclists are ignorant of traffic regulations and/or fail to observe them, situations sometimes arise in which their own safety and that of other road users can be endangered; calls on the Commission to consider what kind of proposal it might make to promote safer cycling, thereby enabling bicycles to be dovetailed smoothly with the other modes of urban mobility;
10. Encourages intelligent transport system (ITS) and public transport operators to further develop technologies for vehicles that encourage drivers to switch to safer modes of transport when entering urban areas;
11. Observes that new means of transport, such as e-bikes and other electric mobility devices, are becoming increasingly popular; calls on the Commission, therefore, to examine the safety requirements for such vehicles without delay, and to make proposals for their safe integration into road transport, while taking due account of subsidiarity;
12. Notes that the development and implementation of safety systems ought to make for road safety, and that this process will accordingly require some kind of adaptation period; calls on the Commission, therefore, to allow for the time necessary to develop such systems before specific technical legislation is put into effect;
13. Recalls that odometer fraud remains an untackled problem, especially in the second-hand car market, as noted by the Commission in its study on the functioning of the market for second-hand cars from a consumer perspective; urges the Commission and the Member States to address the issue of manipulation of or tampering with odometers through effective measures and legislation;
14. Notes that the more vehicles there are on the road, the more likely it is accidents might occur; calls, therefore, on the Member States and the Commission to promote collective and shared mobility, especially in urban areas, in order to reduce the circulating fleet, as well as measures to increase the proportion of bicycles and of professionally driven vehicles;
15. Points out that the equipment that must compulsorily be carried in a vehicle differs from one Member State to another, and calls on the Commission, therefore, to draw up an EU-wide binding list of objects that should fall under the carrying requirement;
16. Maintains that the EU and its research centres should play a leading role in the development of autonomous vehicles, since these will revolutionise the automobile sector, especially in terms of road safety, in which respect they are expected to save thousands of lives every year, as well as contributing to the digitalisation of the internal market;

Driver assistance systems to increase road safety

17. Stresses that approximately 92 % of all accidents are due to human error or interaction of

human error with vehicles and/or infrastructure, and that it should therefore be compulsory to incorporate only those driver assistance systems which improve road safety significantly as demonstrated by scientific evidence, have a favourable cost-benefit ratio, and have attained market maturity; considers that additionally, the resulting purchase price increases should not be so inordinate that the intended customers for such vehicles cannot afford to buy them, and that driver assistance systems, which are of relevance for road safety, should be checked regularly;

18. Calls on the Commission to test the above-mentioned safety devices when performing vehicle market surveillance;
19. Considers that the benefits of improved safety standards and equipment can be realised only if existing and future provisions are implemented and enforced effectively; calls, in this regard, for increased European-level oversight of type-approval authorities and technical services in the Union; calls, in addition, for greater and more independent post-market surveillance of vehicles on roads across the Union to ensure that they continue to conform to safety criteria;
20. Stresses that, when non-conformities are identified, European consumers should be able to count on rapid, appropriate and coordinated corrective measures, including Union-wide vehicle recall where necessary; considers that economic operators should be liable for any damage caused to owners of affected vehicles as a result of non-compliance or following a recall;
21. Calls on the Commission and the Member States to improve the safety level of existing vehicles in use and to support developments and innovations which will increase the safety of cars already in use by incentivising and promoting the retrofitting of vehicles with cost-effective road safety systems that help drivers react better in a dangerous situation;
22. Calls on manufacturers and operators:
 - (a) to make it clear to drivers what the activation status of each driver assistance system is;
 - (b) where systems can be switched off, to introduce two-stage deactivation systems, such that the driver can initially merely switch off the warning signal and can only deactivate the system itself by means of a second procedure;
 - (c) to ensure that each time a vehicle is started afresh the driver assistance system is restored to active status; and
 - (d) to introduce a pricing policy which will encourage consumers to choose vehicles equipped with safety and driver assistance systems;
23. Stresses that evident warnings should be sufficiently differentiated to ensure that it is intuitively clear to which system the assistance pertains, and that warnings should also be easy to perceive for elderly persons, persons with a disability, such as hearing and/or sight impairment, and persons with reduced mobility; calls, therefore, on the parties concerned to adopt appropriate uniform standards allowing the possibility of operator-specific solutions;
24. Welcomes the fact that almost all cars tested under the European New Car Assessment Programme for consumers (Euro NCAP) are awarded five stars and that the majority of car

manufacturers have successfully responded to the challenge of meeting the new Euro NCAP requirements; notes, however, that not all car models sold in Europe are tested by Euro NCAP, and not all of the same type are sold with the same specification, which may create lack of clarity for consumers and thus offer a false level of confidence in the vehicle in relation to the actual performance of the model purchased; recalls the importance, therefore, of a strong underlying standard of mandatory safety requirements which ensure that all necessary safety equipment is present across the fleet used and sold in the EU;

25. Is of the opinion that the Euro NCAP should always reflect the actual car safety of a specific model, and encourages it to be more ambitious in assessing the safety of new vehicles than the statutory minimum requirements compel it to, and to take into consideration the updated statutory minimum requirements, in order to further promote the development of vehicles that ensure high road safety standards and so that Europe remains ambitious and acts as a global leader in car safety;
26. Calls on the Commission to coordinate the adoption of standards with the United Nations Economic Commission for Europe (UNECE) so as to achieve international consistency and at the same time limit to a minimum exemptions from the requirement to install driver assistance systems, in order to improve road safety across the board; stresses, in addition, that manufacturers should create clear information materials to help drivers better understand the various driver assistance systems and their functionalities;
27. Calls for a harmonised European approach which takes into account all existing international and national legislation and ensures its complementarity;
28. Calls on the Commission to investigate the involvement of special-purpose vehicles in urban accidents and, if necessary, to abolish the existing exemptions from the requirement to install driver assistance systems;
29. Stresses that drivers' instruction should include periodical and additional training in using obligatory driver assistance mechanisms, paying special attention to the elderly and persons with reduced mobility; urges driving schools, on the one hand, to incorporate issues relating to the operation of these systems into their learner training, and, on the other hand, to couple acquiring a driving licence with having received professional, on-road practical training;
30. Notes that financial incentives, for example tax-based or insurance-based, for measures such as the installation of additional safety-relevant driver assistance systems in new and used cars or their inclusion in driver training, can facilitate the market uptake of vehicles with advanced safety features; invites Member States to consider introducing such mechanisms;
31. Calls on the Commission to require market operators to arrange for the use of open standards and interfaces which will further improve interoperability, so that independent tests can be carried out by accessing the relevant vehicle and system data, including their updates, and can be performed by any qualified professional, while respecting proprietary data and intellectual property;
32. Stresses that a high level of data protection and retention as required by Regulation (EU) 2016/679 (the General Data Protection Regulation) and by the right to protection of privacy and personal data should be ensured, as should high IT security, so that the possibility of new accident risks due to remote manipulation of on-board systems or conflicts of compatibility is excluded; recommends that the principle of ownership of data

be explored;

33. Stresses the importance of making use of reliable position and time information from satellite-based positioning systems and of applying the EGNOS/GNSS system to road-active safety; calls for more efforts to be made in order to achieve an EGNOS/GNSS road-active safety accuracy of less than one metre, with a view to a shift from the system's ability to reduce vehicle speed to its ability to automatically intervene and deviate the vehicle trajectory; calls for the promotion of enhanced road safety by integrating EGNOS/GNSS data with on-board control systems;

Safety measures for accident prevention

34. Welcomes the fact that emergency braking is already mandatory, since November 2015, for all new trucks and buses in the EU, but calls on the Commission to make it compulsory to install automatic emergency braking assistants with detection of pedestrians, cyclists, light powered two-wheelers and motorcyclists in cars, light commercial vehicles, buses, coaches and, especially, heavy goods vehicles, as these have a strong potential to prevent road accidents by means of autonomous powerful braking and a resulting shorter stopping distance;
35. Calls for safer front-end design of heavy goods vehicles related to better vision of pedestrians and cyclists, as well as for barriers to avoid collisions and mitigate consequences of collisions;
36. Calls for the compulsory installation of overridable intelligent speed assistant systems that indicate speed limits, stop signs and traffic lights and intervene to assist drivers to remain within speed limits; calls on Member States to ensure that road signs are kept in excellent condition and that road markings are clearly legible; emphasises that for the proper working of intelligent assistant systems it is necessary to have updated online road maps with current speed limit indications;
37. Stresses that, in order to improve road safety, the deceleration of vehicles should be rendered easier for other road users to perceive by means of clear signal lights on vehicles, and expects the compulsory use of an emergency braking indicator in the form of a flashing brake light or flashing hazard lights;
38. Stresses that in view of its relevance to road safety, an overridable lane-keeping assistance that not only warns but also appropriately intervenes, albeit without preventing drivers from acting directly, should be made compulsory; notes that for using this warning system it is necessary that road markings are kept in a condition ensuring that they are clearly recognisable;
39. Emphasises that increasing the direct vision of the driver in heavy goods vehicles, buses and coaches and reducing or eliminating blind spots are vital for improving the road safety of such vehicles; calls on the Commission, therefore, to mandate ambitious differentiated direct vision standards and to make it compulsory to install front, side and rear cameras, sensors and turning assistant systems, while observing that such measures should accord with Directive (EU) 2015/719 and should not result in any extension of the time limits for implementation laid down therein;
40. Stresses the need to provide preconditions for installing alcohol interlock devices and systems to detect driver distraction and drowsiness, and urges the use of alcohol interlocks for professional drivers and for drivers who have caused a traffic accident under the

influence of alcohol and have therefore been convicted of a drunk driving offence, as a rehabilitation measure;

41. Observes that trucks are involved in 15 % of road fatalities, and that vulnerable road users account for approximately 1 000 truck-related fatalities every year; calls on the Commission, therefore, to accelerate the mandatory introduction for trucks of ambitious differentiated direct vision standards, intelligent speed assistance, and automatic emergency braking systems with cyclist and pedestrian detection;

Safety measures to mitigate the effects of accidents

42. Observes that tyre pressure has significant implications for road safety and fuel consumption as well as for emissions; calls on the Commission, therefore, to make it compulsory to install direct tyre pressure monitoring systems; also calls on the Commission to transpose into EU law the tyre pressure measurement systems amendments aimed at delivering in real world conditions agreed at UNECE;
43. Considers it necessary to make it compulsory to install intelligent seatbelt reminder systems for all front seats for all vehicles and for rear seats for M1 and N1 vehicles;
44. Considers it important to make it compulsory to install automated seatbelt adjustment systems in order to avoid neck damage;
45. Calls on the Commission, from 2019, to extend the eCall installation requirement to motorcycles, heavy goods vehicles and buses and coaches, and also to make the system available for retrofitting so as to ensure that it can cover the highest possible numbers of vehicles on the road;
46. Calls for accurate and reliable EU-wide accident statistics, including statistics on the causes of accidents, exposure data and listing of injuries and accident victims, and observes that an event data recorder could be very helpful in this connection, in which context the data must be kept anonymous and used only for purposes of accident research;
47. Calls for data to be collected throughout the EU on vehicle occupants killed or injured due to causes other than collisions; notes that there are no data available on vehicle heat-stroke casualties;
48. Calls for better fire safety rules for buses and coaches with different types of power, including CNG-powered buses, to maximise the protection of passenger safety;
49. Observes that redesigned front underrun protection of trucks could reduce fatalities in head-on collisions between cars and trucks by 20 %; calls on the Commission to mandate improved energy-absorbing front underrun protection for all new trucks;
50. Calls for compulsory frontal, side and rear-end crash tests for:
 - (a) all-terrain vehicles (SUVs) with raised seats and a maximum weight of more than 2 500 kg; and
 - (b) electrically propelled vehicles and vehicles with other new propulsion technologies;
51. Calls on the Commission to also update the testing requirements for motor vehicle passive safety systems so as to include protection of all vulnerable road users in front and rear

impacts, including not only pedestrians but also cyclists;

52. Calls on the Commission to ensure that the market will have sufficient and realistic time to adapt to these measures;
53. Stresses that Directive (EU) 2015/719 on weights and dimensions of heavy goods vehicles has great potential to improve truck safety; calls on the Commission to accelerate work on this directive and come forward with its assessment without delay;

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54. Instructs its President to forward this resolution to the Council, the Commission and the governments and parliaments of the Member States.



MALTA EU 2017

Valletta Declaration on Road Safety

**29 March 2017
Valletta**

Ministerial declaration on road safety

1. Transport ministers of the Member States of the European Union, meeting in Valletta on 29 March 2017 under the Maltese Presidency of the Council of the European Union, reconfirm their commitment to improving road safety. The persistently high number of traffic fatalities (26 100 deaths in the EU in 2015) and serious road traffic injuries is a major societal problem causing human suffering and unacceptable economic costs, estimated to be in the order of EUR 50 billion per year for fatal accidents alone¹, and more than EUR 100 billion when serious accidents are included.²
2. There has been a steady and promising trend towards meeting the common target of halving the number of road deaths between 2010 and 2020, endorsed by the Council of the European Union in 2010,³ but fatality reduction rates have plateaued in recent years. Of particular concern is the number of fatalities and serious injuries among pedestrians and cyclists. The target has therefore become extremely challenging and, unless further efforts are made, it may not be met.
3. The work on improving road safety should not be measured only by counting road deaths; the number of serious injuries is no less worrying as it is five times higher than the number of road deaths.² We should aim towards an ambitious overall target, in the spirit of the UN General Assembly resolution on improving global road safety⁴, to drive the appropriate reduction measures. Such a target needs monitoring through comparable and reliable data, reported using a common definition. Those data have to be thoroughly analysed in collaborative work between Member States and the European Commission so that, based on their robustness, appropriate additional measures can be taken to reduce the number of such injuries in the next decade.
4. The situation with regard to road safety varies widely across the Member States. A special effort should be made in those cases where road safety is below the European Union average, supported by close cooperation and knowledge-exchange among Member States.

¹ European Commission, Road safety study for the interim evaluation of Policy Orientations on Road Safety 2011-2020, 2015, p. 19.

² European Commission, press release, 31 March 2016, IP/16/863.

³ Council conclusions on road safety, 2 December 2010, paragraph 21, ST 16951/10.

⁴ Resolution A/70/260 of April 2016.

5. Speeding, driving under the influence of alcohol or drugs, and being distracted or tired while driving continue to be among the major causes of road traffic collisions. Failure to use protective equipment aggravates the severity of injuries. Particular attention should thus be paid to improving road users' behaviour.
6. There is already a wide range of instruments relating to, in particular, better enforcement of traffic rules in the Member States and across borders, better education of, and awareness-raising among, road users, as well as improvement of infrastructure and vehicle safety, taking into account age and roadworthiness. These instruments should be readily applied.
7. Building on the principle of subsidiarity, road safety is a shared responsibility, which requires concrete and joint action by the institutions of the European Union, the Member States, regional and local authorities, industry and civil society.
8. The transport ministers will undertake to:
 - a) continue and reinforce measures necessary to halve the number of road deaths in the EU by 2020 from the 2010 baseline;
 - b) enhance cooperation between Member States, including relevant authorities, and with civil society, research institutes and the private sector, in particular with regard to road safety plans and strategies following a risk-based or an integrated approach (such as the 'Safe System' approach);
 - c) take cycling⁵ and walking into account in mobility plans, safety policies and measures and, where feasible, consider the inclusion of dedicated infrastructure;
 - d) improve the safety of road users by developing safer road infrastructure, bearing in mind the possibility of extending the application of infrastructure safety management principles beyond the Trans-European Transport Network (TEN-T) roads;
 - e) engage with relevant stakeholders, as part of urban mobility planning, on the possibility of expanding and integrating reduced speed limits, such as 30 km/h, into high-risk areas, in particular areas where people work, cycle and play;

⁵ The policy on cycling is specifically addressed in the Declaration of Luxembourg on cycling as a climate friendly transport mode, October 2015.

- f) ensure the effective deployment of the e-Call system and reduce rescue times;
- g) promote the undertaking of in-depth investigations using relevant samples of severe traffic collisions/accidents and analysing the data to identify priority areas for intervention;
- h) continue, in parallel with our efforts towards reaching the 2020 fatality reduction target, with the work towards: (i) reducing the number of serious injuries in road traffic collisions, and (ii) reporting reliable and comparable data using a common definition based on the MAIS⁶3+ trauma scale by 2018;
- i) set a target of halving the number of serious injuries in the EU by 2030 from the 2020 baseline using this common definition and in the framework of an overall road safety strategy for this period;
- j) continue developing measures to ensure post-collision care, early rehabilitation and social reintegration of road traffic accident victims, in cooperation with the relevant public policy stakeholders, in particular with those representing road traffic victims;
- k) effectively enforce road safety rules and provide support to road enforcement bodies, including through cooperation and exchange of best practices, in particular with regard to speeding, driving under the influence of alcohol or drugs, failing to comply with traffic light and traffic sign rules, being distracted while driving, e.g. by using mobile devices, and failing to use protective equipment. Particular attention should be given to preventive tools such as alcohol interlocks, and to other technical support systems;
- l) continue to work in international road safety bodies⁷ to help accelerate improvements in road safety through technical and non-technical means in Europe and further afield;
- m) ensure adequate levels of funding for future road safety policies, programmes and research in accordance with: (i) the objectives set out in national strategies and (ii) the available financial resources of the Member States;

⁶ *Maximum Abbreviated Injury Scale*, an index ranging from 1 to 6.

⁷ Such as working groups of the UN Economic Commission for Europe (Working Party on Road Traffic Safety (WP.1), World Forum for Harmonization of Vehicle Regulations (WP.29), Working Party on the Transport of Dangerous Goods (WP.15)).

- n) promote, together with the European Commission, a Europe-wide road safety culture based on shared values and improve road users' behaviour through continued and effective education and training targeting different groups, taking into account the specific needs of vulnerable road users⁸ as well as professional drivers;
- o) support the deployment of compatible and interoperable connected and automated vehicles with proven safety benefits, as mentioned in the Declaration of Amsterdam⁹ and the Commission's strategy on Cooperative Intelligent Transport Systems.¹⁰

9. The transport ministers call upon the Commission to:

- a) enhance the protection of road users, and in particular vulnerable road users, by ensuring the deployment of new safety features for vehicles, for instance through accelerating the review of type-approval rules in the General Safety Regulation as outlined in the Commission's report to the European Parliament and the Council entitled 'Saving Lives: Boosting Car Safety in the EU';¹¹
- b) prepare a new road safety policy framework for the decade after 2020, including an assessment of road safety performance taking into account the targets and objectives set out in this declaration;
- c) explore the strengthening of the Union's road safety legal framework with a particular focus on Member States' cooperation on the mutual recognition of the driving disqualifications of non-resident drivers, without prejudice to the appropriate legal base(s) for such proposals;
- d) work with all stakeholders to establish projects and initiatives to protect vulnerable road users and facilitate the exchange of knowledge and best practices among Member States concerning road accident investigation, as well as road safety strategies and campaigns;

⁸ 'Vulnerable road users' includes non-motorised road users, such as pedestrians and cyclists, as well as motor-cyclists and persons with disabilities or reduced mobility and orientation.

⁹ Declaration of Amsterdam on cooperation in the field of connected and automated driving, April 2016.

¹⁰ Document COM (2016) 766 final of November 2016.

¹¹ Document COM (2016) 787 final of December 2016.

- e) explore the potential of connected and automated driving technologies, and of the use of the data that is already available in vehicles and infrastructure, to enhance road safety while ensuring data security;
 - f) ensure that necessary resources are allocated to research, programmes and projects promoting road safety in Europe;
 - g) cooperate with Member States and other key stakeholders on developing a Europe-wide road safety culture.
10. The transport ministers invite industry, in cooperation with civil society in the sector, to:
- a) develop cooperative intelligent transport systems, ensuring that new services and systems are compatible, secure and interoperable at European level;
 - b) develop and promote new technologies, especially those automated driving functions and driver assistance systems that reduce the effects of human error and distraction, such as advanced Intelligent Speed Assistance or Autonomous Emergency Braking, protecting in particular vulnerable road users;
 - c) promote the road safety potential of cooperative, connected and automated vehicles.
11. The transport ministers highlight the importance of continuous work and cooperation on road safety, and take note of the contributions and commitments made by stakeholders prior to and during the Valletta conference.
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European
Automobile
Manufacturers
Association

ACEA Position Paper

General Safety Regulation Revision



March 2018

KEY MESSAGES

- a. The European Automobile Manufacturers' Association (ACEA) is a strong supporter of the EU objective of reducing road casualties and thus welcomes the initiative to revise safety regulations.
- b. An integrated approach is needed, examining the benefits that can be achieved by combining new technology with improving road infrastructure and driver behaviour.
- c. Active safety measures can reduce the number and consequences of accidents.
- d. Passive safety measures will have fewer benefits than active safety measures and may have negative impacts, such as increasing CO₂ emissions.
- e. Safety will also be further improved by the introduction of autonomous driving features, but the successful roll-out of this technology will require a coherent approach across all services within the European Commission, as well as the member states.

KEY RECOMMENDATIONS

Based on the proposed measures of the EU General Safety Regulation (GSR):

- a. The focus should be on active safety measures.
- b. Detailed cost-benefit analysis and impact assessment are needed for all measures considered, separated into different vehicle categories.
- c. When considering measures with an effect on the same type of accidents (eg collisions with pedestrians), synergies have to be factored in to avoid solving the same problem twice.
- d. The measures need to take into account the different usage and characteristics of vehicles (passenger cars, light commercial vehicles, heavy trucks, etc).
- e. ACEA considers the following measures most effective: autonomous emergency braking (AEB) systems (M₁, N₁, stepwise introduction); emergency braking display (EBD) (M, N); lane keeping assistance (LKA)/lane departure warning (LDW) (M₁, N₁); safety belt reminders (SBR) (M, N; all front seats; only buckling monitor on rear seats on M₁ vehicles; further exemptions to be considered such as removable seats, etc); alcohol interlock interface (AI) (M, N, instruction sheet); crash event data recorder (EDR) (M₁, N₁); reverse detection (M, N₁, N₂); tyre pressure monitoring system (TPMS) (M₁, N₁); front-end blind spot cameras and detection (M₂, M₃, N₂, N₃); frontal crash full width protection (M₁, N₁ derived from M₁); pole side impact protection (M₁, N₁ derived from M₁); lateral protection (N₂, N₃, O₃, O₄); fire safety of CNG buses (M₂, M₃); fire suppression for buses (M₂, M₃); and rear crash test (M₁, N₁).
- f. All measures need to be harmonised with the provisions of the United Nations Economic Commission for Europe (UNECE) regulations; specific EU regulations have to be avoided.
- g. Transition time must be aligned with product development time, allowing at least three years for new vehicle types from the date the regulation has entered into force and the final requirements are available.

CONCLUSIONS AND RECOMMENDATIONS

ACEA members welcome the Commission initiative to further improve road safety through the revision of the General Safety and Pedestrian Safety regulations.

As previously indicated, ACEA members are open to considering a large number of the proposed measures, while expressing concerns on only a few. The measures considered are (*N1 two years later):

- AEB (M₁, N₁*): step-wise introduction – step 1, moving obstacles; step 2, stationary obstacles; step 3, pedestrians; step 4, cyclists
- EBD (M, N)
- LKA/LDW (M₁, N₁*)
- SBR (M, N): all front seats; only buckling monitor on rear seats on M₁ vehicles; exemptions to be considered for removable seats and seats in a row with a suspension seat
- AI (M, N): instruction sheet
- EDR (M₁, N₁)
- Reverse detection (M, N₁, N₂)
- TPMS (M₁, N₁): technology neutral requirement
- Front end blind spot cameras and detection (M₂, M₃, N₂, N₃)
- Frontal crash full width (M₁, N₁ derived from M₁)
- Pole side impact (M₁, N₁ derived from M₁)
- Lateral protection (elimination of exemptions; N₂, N₃, O₃, O₄)
- Fire safety of CNG buses (M₂, M₃)
- Fire suppression for buses (M₂, M₃)
- Rear crash test (M₁, N₁)

ACEA recommends that all measures should consider:

- The possibility of solving the problem with other initiatives, by looking at driver behaviour and following an integrated approach.
- A horizontal approach, looking at the benefits of other considered measures, avoiding addressing issues that will be completely or partially solved through other measures;
- A detailed cost–benefit analysis and impact assessment for all considered measures, separated into different vehicle categories.
- That the impact assessment has to take into account the impact on other European priorities, for example the impact of passive safety measures on vehicle weight and consequently CO₂ emissions.
- That heavy M₁/N₁ vehicles and M₂/N₂ vehicles should be evaluated separately from more lightweight vehicles, since they have a different design-principles.
- That the measures need to take into account the different usage and characteristics of vehicles (passenger cars, light commercial vehicles, heavy trucks, etc).

- That all measures need to be harmonised with the provisions of the UNECE regulations and specific EU regulations have to be avoided.
- That transition time must be aligned with product development time, allowing at least three years for new vehicle types from the date the regulation has entered into force and the final requirements are available

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LIST OF ABBREVIATIONS

AEB: autonomous emergency braking

AI: alcohol interlock interface

BAC: blood alcohol concentration

CARE: Community Road Accident Database

EBD: emergency braking display

EDR: crash event data recorder

ESC: electronic stability control

ESOP: European Statement of Principles

GSR: General Safety Regulation

ISA: intelligent speed adaptation

LDW: lane departure warning

LKA: lane keeping assistance

OEM: original equipment manufacturer

PPA: pedestrian protection airbag

SBR: safety belt reminders

SLI: speed limit information

TPMS: tyre pressure monitoring

VRU: vulnerable road user



European
Automobile
Manufacturers
Association

General Safety Regulation

PRIORITY LIST

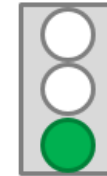
ACEA

Tuesday, 06 March 2018





MEASURES ACEA MEMBERS CAN SUPPORT IF COST/BENEFIT IS POSITIVE

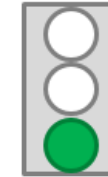


Measure	Vehicle Categories	Description	Comments
Autonomous emergency braking system (step 1: moving obstacles)	M1 – N1	Autonomous emergency braking in case of vehicle in front slowing down	Stepwise introduction is essential due to different maturity of the systems. In line with new UNECE under discussion
Autonomous emergency braking system (step 2: stationary obstacles)	M1 – N1	Autonomous emergency braking in case of vehicle in front stationary	
Autonomous emergency braking system (step 3: pedestrians)	M1 – N1	Autonomous emergency braking in case of pedestrian crossing	
Autonomous emergency braking system (step 4: cyclists)	M1 – N1	Autonomous emergency braking in case of cyclist crossing	
Emergency Braking Display	M N	Brake lights or direction indicator flash rapidly (4 Hz) in case of hard vehicle braking.	As intended in UN-R 48
Lane Keeping Assistance	M1 N1	Driver assistance to keep vehicle in lane, e.g. with application of limited torque to steering wheel	As intended in UN-R 79 Lane Departure Warning should be considered equally (see accident analysis) Vehicles using hydraulic power steering must be exempted as there is no mature system capable of lane keeping assistance for such technology, or LDWS. Need to determine the specification limits for CSF of R79.
Safety Belt reminders	M N	All front seats. Rear seats on M1 vehicles: only buckling monitor	As intended in UN-R 16; Exemptions to be considered for removable seats and seats in a row with suspension seat (as in ECE R16-07 already in force)





MEASURES ACEA MEMBERS CAN SUPPORT IF COST/BENEFIT IS POSITIVE



Measure	Vehicle Categories	Description	Comments
Alcohol Interlock Interface	M N	OEMs to produce "instructions" on how to install Alcohol Interlock on the vehicle. No interface required.	
Crash event data recorder	M1 N1	Mandatory installation of EDR on all new vehicles, to facilitate/enable the acquisition of accident data.	Harmonisation with NHTSA 49CFR Part 563. Measure to harmonise EDR not to make it mandatory, diffusion to be promoted by insurance company as in US. No direct benefits to safety
Reverse detection	M N1 N2	Allow driver to perceive obstacle in the rear of the vehicle during reverse maneuvers	See below for N3 and trailers
Tyre Pressure Monitoring	M1 N1	Reduce/eliminate the risk to drive with underinflated tyres and no driver warning, due to improper "reset" operations	Compare UN-R 64 / improvement via UN R141, See below for other vehicle categories Requirement should be technology neutral
Front End - Blind Spot Cameras and Detection	M2 M3 N2 N3	Extend the driver perception with active safety systems able to cover all dangerous blind spot around the vehicle	Potential requirements to be clarified This is proven to be an important part to improve visibility of trucks (see accident analysis)
Frontal crash full width	M1 N1	Extension of frontal crash test as defined in UN-ECE	Compare UN-R 137, only N1 derived from M1 vehicles. If it is intended to introduce THOR dummies the introduction timing would have to be significantly delayed (THOR currently has very limited availability and is not yet an approved test dummy)
Pole side impact	M1 N1	Introduction of side crash test as defined in UN-ECE	Compare UN-R 135, only N1 derived from M1 vehicles
Lateral protection (elimination of exemptions)	N2 N3 O3 O4	As defined in UN-ECE	Compare UN- R 73, exemptions to be analysed in detail, considering the relative benefits/costs ratio
Fire Safety for CNG Buses	M2 M3	As defined in UN-ECE	Compare UNECE R110
Fire Suppression for Buses	M2 M3	As defined in UN-ECE	Compare UNECE R107
Rear crash test	M1 N1	As defined in UN-ECE	Compare UNECE R34





MEASURES ACEA MEMBERS PROPOSE TO BE DISCUSSED

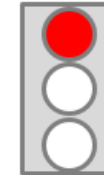


Measure	Vehicle Categories	Description	Comments
Intelligent Speed adaptation	M1 N1	Vehicle keep the speed limits unless driver voluntary decided differently. Speed limits from digital maps and/or traffic sign recognition	Evaluate a step-wise approach, linked with the infrastructure (traffic signs with communication links with vehicles and reliable/frequently updated speed limits also on digital maps). Speed indication must be validated by the driver, because reliability is not good enough for an active system. First introduction of informing and/or switchable systems.
Intelligent Speed adaptation	M2 M3 N2 N3	As above	Evaluate benefits considering the already existing speed limiters and the typical mission of these vehicles.
Reverse detection	N3 O3 O4	Allow driver to perceive obstacle in the rear of the vehicle during reverse maneuvers	Complex for free combined tractor/trailer. Benefits/costs to be evaluated in detail
Frontal impact – Expand the scope or R94	M1 N1	Eliminate the existing exemptions	Benefits to be evaluated in detail. Limited benefits are envisaged for N1 vehicles with higher seating position (see accident analysis). Barrier defined according to the initial scope --> extension of the scope will imply a new barrier/new technical discussion M1 should be limited to 3,5t, too.
Side Impact – Expand scope R95	M1 N1	Eliminate the existing exemptions	Benefits to be evaluated in detail, considering the introduction of the pole side impact test. Limited benefits are envisaged for N1 vehicles with higher seating position (see accident analysis).





MEASURES ACEA MEMBERS PROPOSE FURTHER DETAILED EVALUATION



Measure	Vehicle Categories	Description	Comments
Driver drowsiness and distraction monitoring	M N	To avoid risks of driver distraction considering also the introduction of driver assistance systems, like lane keeping/ACC, that can be perceived as solution.	ACEA suggests addressing driver distraction by promoting, through both education and enforcement, improved driver behaviour concerning the use of mobile devices. Consider positive effects of AEB and LDW/LKA, too. For on-vehicle systems, ACEA members are available for considering measures to ensure that the ESOP guidelines have been followed in the design of the Human Machine Interface.
Frontal crash – small overlap	M1	Extend frontal crash considering small overlap (20%) cases	Advanced emergency braking and lane keeping will reduce the number of these accidents (see accident analysis). Only additional benefits need to be considered. Not considered for GSR2.
Side crash far-side occupant protection	M1 N1	Introduce solutions to reduce the accident consequences on vehicle occupant in the far side of the vehicle, not directly interested by the collision in side impacts	Far side occupant protection; pole side impact regulation will require technology, side airbag curtains, with benefits also for far side occupants. Future AEB systems will prevent, or reduce the severity of, side crashes. Solution to protect far side occupant not available in the market. Not considered for GSR2.
A-Pillar and Windscreen head impact	M1 N1	Protect, for example with airbag, the VRU (pedestrian, cyclist) head in impacts with windscreen or A-pillar	Given the benefits achievable with AEB (see accident analysis), ACEA does not see the need to mandate further passive safety measures requiring external protection against pedestrian head in collision with the A-pillar, header, scuttle and windscreen. Concern over definition of windscreen area (need to define an exclusion boundary around the edges and around any AEB sensors). Difficult to define Zone A/B due to issues with modelling glass.
Direct vision requirement	M2 M3 N2 N3	Extend the driver direct vision (not with mirror) to cover all dangerous blind spot, through a complete redesign of the cab.	The effect on truck cabins is very high while the benefits – additional to those from sensor-based solutions, are limited (see accident analysis).
Tyre Pressure Monitoring	M2 M3 N2 N3	Extension of TPMS to heavy vehicles	Complex system, no evidence of safety benefits. Deep and detailed benefit analysis needed.



ANNEX 10 – MARKET ANALYSIS

This annex provides supplementary figures to description of the market presented in section 2.6.

Analysis is done by following regions:

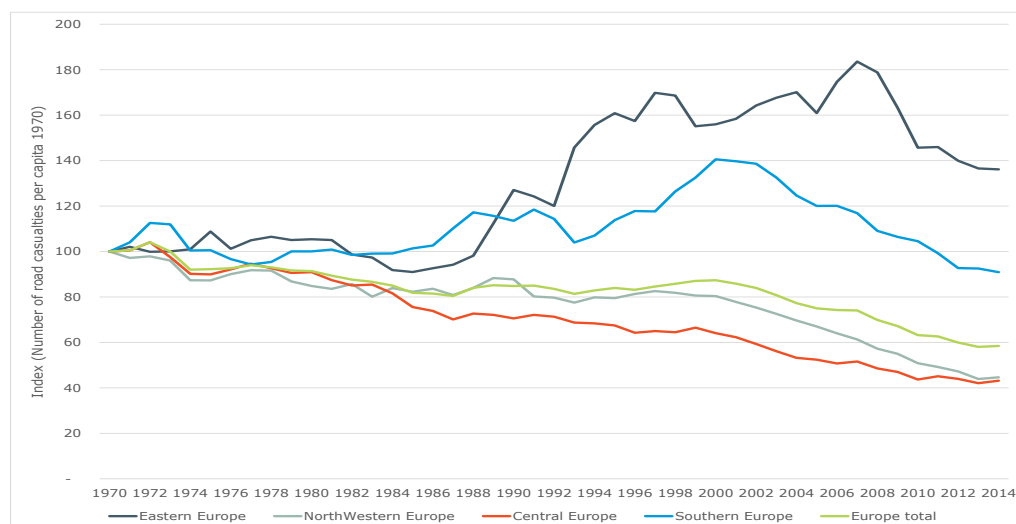
Central Europe: Austria, Belgium, France, Germany, Luxembourg, Netherlands

Eastern Europe: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Republic, Slovenia

North-Western Europe: Denmark, Finland, Ireland, Sweden and UK

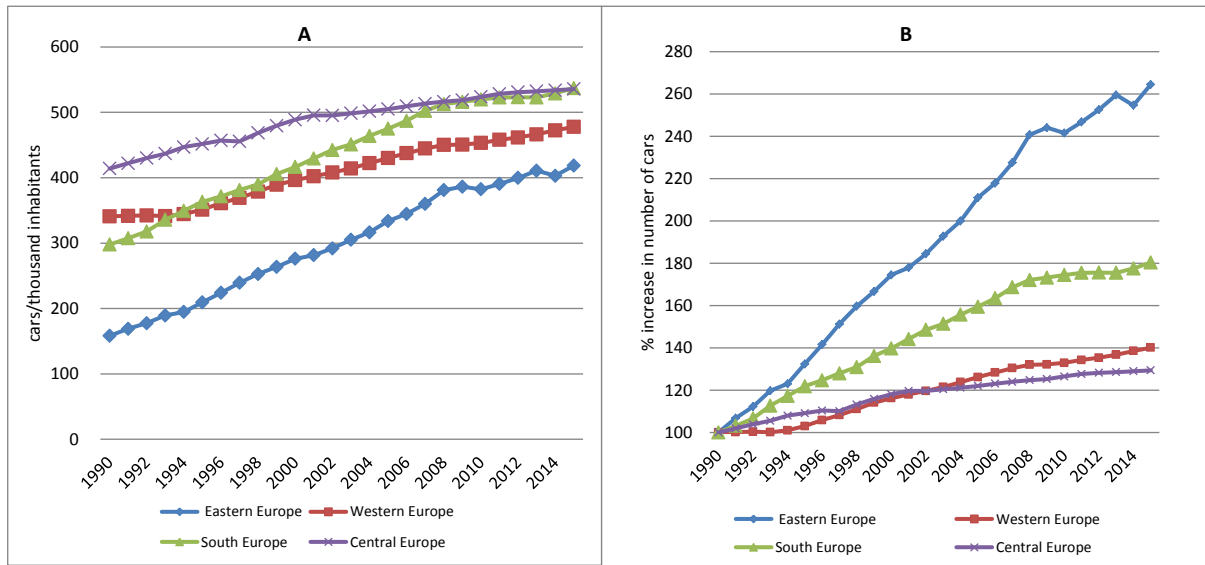
Southern Europe: Greece, Italy, Cyprus, Malta, Portugal, Spain

Figure A10.1 *Development of road accidents for EU regions between 1970 and 2014*



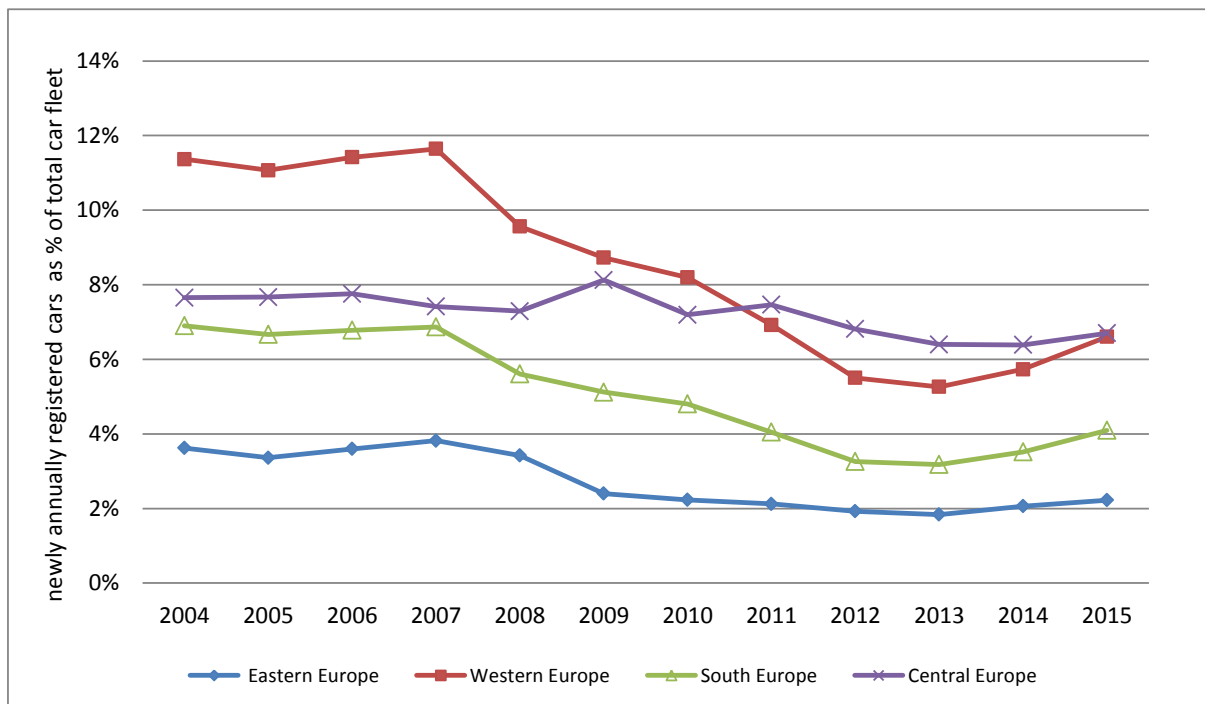
Source: OECD, Eurostat, Provisional data (2014 injury stat) for 2015 is used for Denmark, Estonia, Ireland, France, Italy and Romania. Note: Cyprus is not included due to lack of data on road casualties

Figure A10.2: Number of passenger cars per thousand inhabitants (A) and its evolution from common base year (B) for EU regions between 1990 and 2015



Source: DG Mobility and Transport – Statistical Pocketbook 2017 Chapter 2.6 Means of Transport https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en

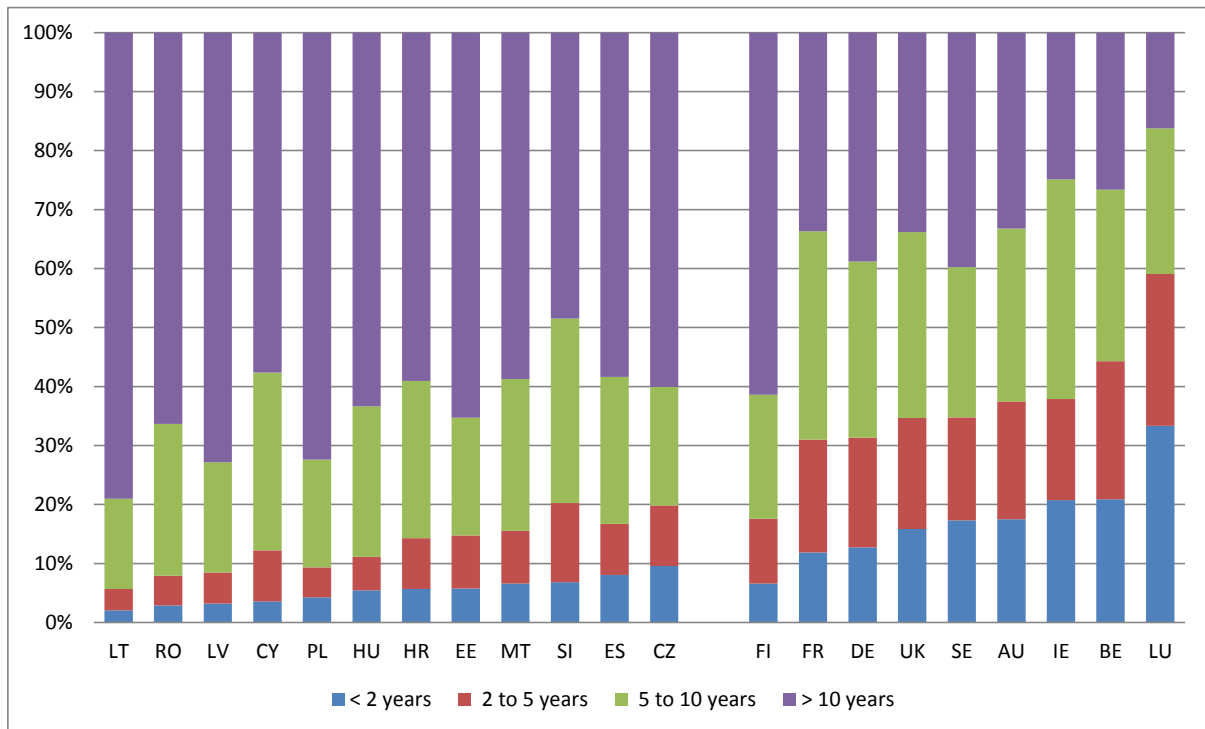
Figure A10.3: Renewal rate of passenger cars



Note: Share of new registrations of passenger cars in a given year to the total fleet per EU region between 2004 and 2015.

Source: DG Mobility and Transport – Statistical Pocketbook 2017 Chapter 2.6 Means of Transport, https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en

Figure A10.4: Average age of passenger cars per EU Member State in 2015



Source: Eurostat, [road_eqs_carage]

ANNEX 11 – COOPERATIVE, CONNECTED AND AUTOMATED MOBILITY (CCAM)

The European Commission European Strategy on Cooperative Intelligent Transport Systems (C-ITS)¹⁸⁸ is a milestone initiative towards cooperative, connected and automated mobility. The objective of the C-ITS Strategy is to facilitate the convergence of investments and legal frameworks across the EU, in order to see deployment of mature C-ITS services in 2019 and beyond. As announced in the Communication and confirmed by public statements of the automotive industry¹⁸⁹ and sizeable investments from Member States, united in the C-ROADS Platform¹⁹⁰, the 2019 target for large-scale C-ITS deployment is now becoming a reality.

In many respects today's vehicles are already connected devices. However, in the very near future they will also interact directly with each other and with the road infrastructure (C-ITS), which will allow road users and traffic managers to share information and use it to coordinate their actions so as to facilitate mobility. This cooperative element, enabled by digital connectivity between vehicles and between vehicles and transport infrastructure, is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation.

The beneficial effect of connectivity, experienced by increasing driver's/users awareness, is achieved by various ways like messages transmitted via smart phones, navigator devices as well as Internet of Things applications. The concept of Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) communication is however not yet mature enough for widespread incorporation in vehicles. This may be viewed as a problem, as communication between vehicles, infrastructure and other road users is crucial to increase the safety of future connected and automated vehicles and for their full integration in the overall transport system. Cooperation, connectivity, and automation are technologies that reinforce each other when it comes to offer increased mobility safety services to the end-user.

In this context, with the progressing digitisation of infrastructure and vehicles the EU Network Information Security (NIS) Directive comes into play, covering operators of essential services (including transport and digital infrastructure) as well as digital service providers. In addition, cybersecurity aspects should not be neglected. The "cyber security package" adopted in September, supports a voluntary certification scheme for cybersecurity in the mobility sector, ultimately resulting in an "EU cyber secure" label.

The European Commission adopted a European Strategy on Cooperative Intelligent Transport Systems (C-ITS)¹⁹¹, a milestone initiative towards cooperative, connected and automated mobility. The objective of the C-ITS Strategy is to facilitate the convergence of investments and legal frameworks across the EU, in order to see deployment of mature C-ITS services in 2019 and beyond.

¹⁸⁸ COM (2016) 766

¹⁸⁹ https://www.car-2-car.org/index.php?eID=tx_nawsecuredl&u=0&g=0&t=1507893218&hash=13650cd84c30c1624e2860180968b35a2c532ad0&file=fileadmin/downloads/PDFs/C2C-CC_Press_Information_on_EC_Masterplan_final.pdf

¹⁹⁰ www.c-roads.eu

¹⁹¹ COM (2016) 766

As announced in the Communication and confirmed by public statements of the automotive industry¹⁹² and sizeable investments from Member States, united in the C-ROADS Platform¹⁹³, the 2019 target for large-scale C-ITS deployment is now becoming a reality. To progress towards this shared goal important work on security, data protection and compliance assessment is required and key advances in these areas were achieved during the second phase of the C-ITS platform.

In addition, the European Commission adopted a strategy for deployment of 5G GSM technologies¹⁹⁴ and to foster the collaboration between telecom and automotive industries by organising Roundtable sessions¹⁹⁵ which resulted in the establishment of the European Automotive Telecom Alliance (EATA)¹⁹⁶ and the 5G Automotive Alliance (5GAA)¹⁹⁷.

The Amsterdam Declaration on cooperation in the field of connected and automated driving¹⁹⁸ was signed by the transport ministers of all EU Member States on 14 April 2016. It lays down agreements on the steps necessary for the development of self-driving technology in the EU. It notably invites the automotive industry, that welcomed¹⁹⁹ it as an important milestone promoting much-needed cooperation between automobile manufacturers, national governments and the EU institutions, to acknowledge that standardisation will be a key factor in driving scale, both at the European and international level, and to support the development of standards in the relevant domains through developing V2V and V2X communication systems and continue standardisation work to ensure that new services and systems are interoperable at EU level.

In March 2017, in the margin of the 60th anniversary of the signature of the Treaties of Rome, during the Digital Day in Rome, 27 Member States, plus Norway and Switzerland acknowledged the importance of cross-border cooperation on Connected and Automated Driving (CAD) by signing the Letter of Intent (LoI)²⁰⁰ on the testing and large scale demonstrations.

The follow-up of Member States initiatives is further discussed in the High Level Structural Dialogue. The 2nd meeting took place in September 2017 and resulted in the "Action plan for connected and automated driving (CAD)" addressing key issues like cross-border

¹⁹² https://www.car-2-car.org/index.php?eID=tx_nawsecuredl&u=0&g=0&t=1507893218&hash=13650cd84c30c1624e2860180968b35a2c532ad0&file=fileadmin/downloads/PDFs/C2C-CC_Press_Information_on_EC_Masterplan_final.pdf

¹⁹³ www.c-roads.eu

¹⁹⁴ Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: "5G for Europe: An Action Plan" - COM(2016)588 and Staff Working Document - SWD(2016)306

¹⁹⁵ <https://ec.europa.eu/digital-single-market/en/cooperative-connected-and-automated-mobility-europe>.

¹⁹⁶ <http://www.acea.be/press-releases/article/37-leading-companies-join-forces-in-european-automotive-telecom-alliance>

¹⁹⁷ <http://5gaa.org/>

¹⁹⁸ <https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/04/29/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving.pdf>

¹⁹⁹ <http://www.acea.be/press-releases/article/ministers-eu-policy-makers-and-auto-industry-push-for-connected-and-automate>

²⁰⁰ <https://ec.europa.eu/digital-single-market/en/news/eu-and-eea-member-states-sign-cross-border-experiments-cooperative-connected-and-automated>.

cooperation on testing, public awareness, social impact and ethical issues, data access and use as well as international standardization.

Justification for discarding this option

As part of another area not covered by the scope of the regulatory framework and this impact assessment, the ITS Directive 2010/40/EU²⁰¹ with its Delegated Acts on road safety, real-time-traffic and multimodal travel information, providing the necessary legal and technical framework to steer and ensure the interoperability of deployed ITS services, is a suitable example. Specifications and standards for aspects related to the exchange of data or information between vehicles or between vehicles and infrastructure are also highlighted as important, but concrete prescriptions do not yet exist. The automotive industry could therefore take the initiative and to consider a self-regulatory approach to lead the development of V2V and V2X standards on European and international level. It would cover a forward-looking approach on issues such as how to deal with data security, data protection, communication protocols, interoperability and compliance assessment processes.

In this context it may also be appropriate to consider whether or not the EU should impose a specific technology and communication protocol. However, given that there is no clarity yet on the best way forward, as indicated above, it must be noted that it is premature at this stage to already elaborate or commit to a decision concerning these far reaching regulatory aspects and that this should be part of a future assessment of impacts in due course.

The self-regulation approach to address the need for implementation of V2V and V2X communications is in principle also feasible, but given that a sensible and comprehensive analysis of the cost-benefits was deemed very premature at this stage, it should be taken forward to be part of a separate track in the overall context of C-ITS developments. Therefore the self-regulatory approach had to be discarded from further analysis. There are however anticipated benefits²⁰² in terms of road casualty reduction in the EU through future (voluntary) implementation of V2V and V2X communications, but this information is of a considerable high-level nature with many uncertainties and subsequent assumptions.

²⁰¹ Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport (OJ L 207, 6.8.2010, p. 1)

²⁰² <https://ec.europa.eu/transport/sites/transport/files/2016-c-its-deployment-study-final-report.pdf>

ANNEX 12 – LIST OF TERMS AND ABBREVIATIONS USED IN THE ANNEXES

<i>Term/abbreviation</i>	<i>Explanation</i>
5GAA	5G Automotive Alliance
ABS	Anti-Lock Braking System
ACEA	European Automobile Manufacturers' Association
AEB	Autonomous Emergency Braking
AEB-PCD	Autonomous emergency braking for pedestrians and cyclists
AEB-VEH	Autonomous emergency braking for driving and still-standing vehicles ahead
ALC	Alcohol interlock installation facilitation
BAS	Brake Assist System
BCR	Benefit-to-Cost Ratio
CAD	Connected and Automated Driving
CARE database	Community Road Accident Database
CARS 21	The Competitive Automotive Regulatory System for the 21st century High Level Group on the competitiveness and sustainable growth of the automotive industry in the EU with representatives of the EU Member States, EU institutions, automotive industry, Trade Unions, NGO, users and the Commission.
CCAM	Cooperative, Connected and Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
CLEPA	European Association of Automotive Suppliers
C-ROADS Platform	The C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability.
DDR-ADR	Distraction recognition
DDR-DAD	Drowsiness and attention detection
DG	Directorate-General
EATA	European Automotive Telecom Alliance
ECMT	European Conference of Ministers of Transport
EDR	Event (accident) Data Recorder
EFTA	European Free Trade Association
EGNOS	European Geostationary Navigation Overlay Service
EPA	United States Environmental Protection Agency
ESC	Electronic Stability Control
ESS	Emergency Stop Signal
ETRMA	European Tyre and Rubber Manufacturers' Association
EU	European Union
Euro NCAP	European New Car Assessment Programme is a voluntary European car safety performance assessment program backed by the European Commission and several European governments, as well as by motoring and consumer organisations. Euro NCAP publishes safety reports on new cars, awarding 'star ratings' based on the performance of the vehicles in a variety of crash tests, including front, side and pole impacts, and impacts with pedestrians. The top rating is five stars.
FFW-137	Full-width frontal occupant protection crash test

FFW-THO	Full-width frontal occupant protection crash test with advanced measuring dummy and lower appropriate injury criteria thresholds to encourage adaptive restraints
GNSS	Global Navigation Satellite System
GSR	General Safety Regulation
HDV	Heavy Duty Vehicles
HEATCO project	Developing Harmonised European Approaches for Transport Costing and Project Assessment project
HED-MGI	Head impact zone enlargement for pedestrian and cyclist protection (to include the windscreen area)
IA	Impact Assessment
ISA	Intelligent Speed Assistance
ISA-VOL	Intelligent Speed Assistance (through non-intrusive haptic feedback)
ISO	International Organisation for Standardisation
ISOFIX	The international standard for child seat connectors
ITS Directive	Intelligent Transport Systems Directive - Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport
LDV	Light Duty Vehicles
LDW	Lane Departure Warning
LKA-ELK	Lane Keeping Assist (emergency lane keeping system that intervenes only in case of an imminent threat such as leaving the road, or leaving the lane with oncoming traffic)
LoI	Letter of Intent
MAIS	Maximum Abbreviated Injury Scale
MEP	Member of the European Parliament
MPV	Multi Purpose Vehicle
NGO	Non-Governmental Organisation
NHTSA	United States National Highway Traffic Safety Administration
NIS Directive	Network Information Security Directive - Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union
OEM	Original Equipment Manufacturer / vehicle manufacturer
PO	Policy Option
PRIMES-TREMOVE	Price-Induced Market Equilibrium System - Transport Energy Demand Transport Model
PSI	Pole Side Impact Occupant Protection
PSR	Pedestrian Safety Regulation
REV	Reversing Camera or Detection System
R&D	Research and Development
RSB	Regulatory Scrutiny Board
SAE	Society of Automotive Engineers
SBR	Safety Belt Reminder
SMEs	Small and Medium-Sized Enterprises
SUV	Sport Utility Vehicle
T&E	European Federation for Transport and Environment

TFEU	Treaty on the Functioning of the European Union
TNO	Netherlands Organisation for Applied Scientific Research
TPM / TPMS	Tyre pressure monitoring (system)
TRL	Formerly the UK Government's Transport Research Laboratory subsequently transformed into a private company in 1996
UNECE	United Nations Economic Commission for Europe
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Infrastructure
VIS-DET	Vulnerable road user detection and warning on front and side of vehicle
VIS-DIV	Vulnerable road user improved direct vision from driver's position