Heavy Duty Vehicles eSafety Working Group

Brussels, October, 2005

FINAL REPORT OF HEAVY DUTY VEHICLES WORKING GROUP

Activity report for the year 2004

(V1.2)

1 Preamble

This report is the result of the Heavy Duty Vehicles Working Group's activities over a period of almost a year, as part of the EC eSafety project. The Working Group has been a purely voluntary initiative, with no contractual arrangements of any kind. The results of the Group's endeavors as presented in this report are now in the public domain, and may be quoted, subject to specification of the source.

As Chairman of the Working Group, I want to thank all members for their open, cooperative, and highly effective contributions. It has been a real pleasure to coordinate the inputs from my colleagues in a range of companies and institutions, all of whom are top people in their field. In spite of the diverse individual interests involved, the Working Group has consistently provided an excellent example of our ability to work together to make a difference in enhancing road safety.

The Working Group is most grateful for the European Commission's initiative that led to the establishment of the Group, thereby creating a forum that could focus on the specific issues of heavy duty vehicles with a view to improving road safety. We hope that our recommendations will produce some tangible results.

October 2005

2 Executive Summary

The e-Safety Working Group Heavy Duty Vehicles has been set up to review known road safety enhancement measures and approaches specific to heavy duty vehicles, to evaluate the measures according to the accident figures for heavy duty vehiclesand and to formulate recommendations for Member States and the EC on enhanced road safety performance.

The Working Group realized from the outset that it would be unable to provide a comprehensive view of the issue of “road safety of heavy duty vehicles,” because of the lack of clear information on the accidents that occur and the wide variety of developments and initiatives throughout the world for improved road safety. To avoid getting bogged down in detail, the Group also consistently restricted its focus to the main points, without trying to provide a comprehensive coverage of the topic. By adopting this approach, we were able to agree on significant findings within a short time, and to keep costs down to a moderate level.

So the group provided a summary of the significant accident types across all sub-categories of accidents. These scenarios represent more then 40% of the accidents analyzed in Europe.

With a second step the Group evaluated about fifty safety measures regarding there efficiency to reduce accidents of the significant accident types. The available and the most efficient measures are reported within this paper.

The group analyzed the introduction obstacles for safety measures. In every case, the cost was one of the obstacles to implementation, if not the critical obstacle. This is the reason why a number of safety systems already available in the marketplace (e.g. ESP) are not penetrating the market in the case of heavy duty vehicles.

In some cases also regulations are introduction obstacles.

With these introduction obstacles given the group defined the recommendations regarding the business case and the regulations. Further on from the evaluation process we were able to formulate some recommendations on research issues that may contribute to road safety.

3 Objective, approach, and role of the Working Group

3.1 Terms of reference

The EC white paper of 2001 set out a quantitative target for increased road safety: by 2010, to halve the annual number of road accident fatalities in the year 2000 (see Fig.1). The establishment of the eSafety project in 2002 led to some important initiatives and the formulation of recommendations on the approach to be followed (e.g. COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT, Information and Communications Technologies for Safe and Intelligent Vehicles (SEC (2003) 963).

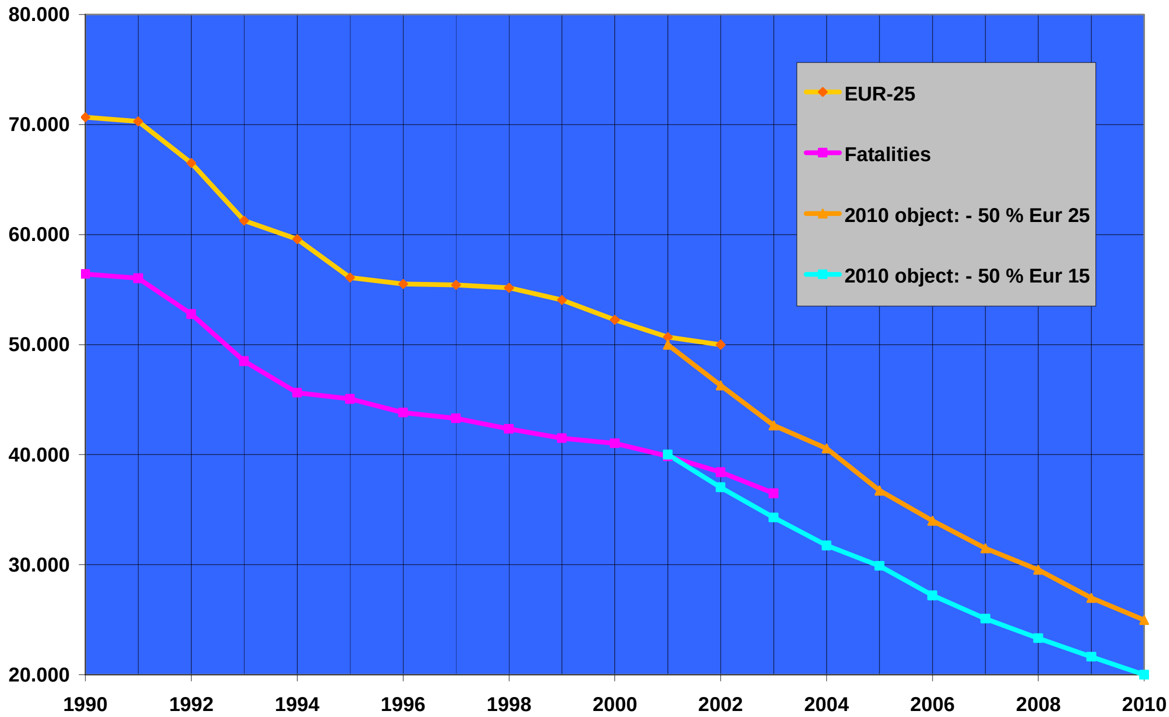

Fig. 1: Road deaths in Europe since 1990 (source: www.escope.info).

It was not the role of the Working Group to duplicate those outcomes, much less to question them. Our task was rather to investigate the extent to which enhanced road safety performance could be achieved in the context of the specific conditions of the market for heavy duty vehicles. Technology-based, infrastructure, and social blueprints for improving road safety do not operate in the market for heavy duty vehicles in the same way as in the mass market for passenger cars. The clear differences in the vehicles themselves (mass, handling characteristics, etc.), in the reason for the vehicles being on the road, in driver training and skills, and in particular the very different economic factors involved, along with many other aspects, make it impossible to apply the same approaches to heavy duty vehicles as those adopted for passenger cars. And of course, the same applies to the extrapolation of concepts or technical solutions for heavy duty vehicles to passenger cars.

The task list for the Working Group was as follows:

- **To review known road safety enhancement measures and approaches specific to heavy duty vehicles.**
  (The review of approaches was to be carried out from a holistic perspective, which would also include non-electronic approaches, such as passive safety measures and driver training issues.)
- **To evaluate the measures according to the accident figures for heavy duty vehicles.**
  (The evaluation of the various approaches was to be carried out with respect to their potential for reducing the number of accidents and fatalities, technical availability, and cost.)
- **To formulate recommendations for Member States and the EC on enhanced road safety performance.**
  (Experience indicates that safety systems take a long time to become established in practice in the heavy duty vehicles sector. The task was to formulate measures to improve the situation on the basis of the preceding terms of reference for the Working Group.)

3.2 Membership of the Working Group

In order to ensure a genuinely holistic approach for the Working Group's activities, it was clearly desirable to seek participation from the widest possible circle of actors involved in this issue; another primary concern was to create a Working Group that could operate effectively, in accordance with the "Terms of Reference for the (eSafety) Working Groups." Representatives from the following sectors were therefore actively invited to participate:

- Heavy duty vehicle manufacturers (OEMs)
- European Commission
- Insurance companies
- Road accident investigation experts
- Haulage contractors
- Road operators
- Associations

Our efforts to secure active participation were unsuccessful in the case of insurance companies, haulage contractors, and road operators. The continuous involvement of all European OEMs, some leading accident investigation experts, the EC, and other institutions ensured that the Working Group was more than able to fulfill its task. Representatives of other sectors received progress briefings in the course of the group's activities, and opinions will be sought from those sectors during the consultation phase of the project. The names of the individuals who attended our workshops, and who thereby made a major contribution to the overall outcome, are given in Table 1.

Surname	First name	Organization	Contact details
Andrade	Mariana	ERTICO	m.andrade@mail.ertico.com
Avedahl	Claes	Volvo 3P	claes.avedal@volvo.com
Berg	Alexander	DEKRA	Alexander.Berg@dekra.com
Bowerman	Neil	EC	Neil.Bowerman@cec.eu.int
Buck	Manfred	DaimlerChrysler AG	Manfred.Buck@DaimlerChrysler.com
Dörner	Karlheinz	MAN Nutzfahrzeuge AG	Karlheinz_Doerner@mn.man.de
Ferreira	Francisco	EC	Fransisco.Ferreira@cec.eu.int
Freij	Ghassan	Ertico	g.freij@mail.ertico.com
Galantina	Gianluca	IVECO SpA	galantina@iveco.com
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Hipp	Eberhard	MAN Nutzfahrzeuge AG	eberhard_hipp@mn.man.de
Jongerius	Coco	DAF TRUCKS N.V.	coco.jongerius@daftrucks.con
Larsson	Kenneth	Scania CV	l.larsson@scania.com
Niewöhner	Walter	DEKRA	Walter.Niewoehner@dekra.com
Palmquist	Lennart	Volvo 3P	Lennart.palmquist@volvo.com
Radia	Bipin	EC	Bipin.Radia@cec.eu.int
Schmitz	Peter	EC	peter-alexander.schmitz@cec.eu.int
Schoch	Dieter	DaimlerChrysler AG	dieter.c.schoch@daimlerchrysler.com
Trost	Jürgen	DaimlerChrysler AG	Juergen.Trost@DaimlerChrysler.com
Ulmer	Berthold	DaimlerChrysler	berthold.ulmer@daimlerchrysler.com
Vågstedt	Nils Gunnar	Scania CV	nils-gunnar.vagstedt@scania.com

Table 1 – Workshop participants.

Not all participants were able to attend all the workshops. We were, however, able to set up the required proxy arrangements, or conference calls where necessary, to ensure that all members who were interested in the issues could be involved in drawing up the results of our investigations. It was partly for this reason that we were able to agree on the text of the “Recommendations” (see Appendix 1) within a relatively short time.

The task list, approach, and results were drawn up by consensus, following discussions that were sometimes intense, but always constructive.

3.3 Methods and approach

3.3.1 Focus of the Working Group

The Working Group defines "Heavy Duty Vehicles" as referring to trucks (chassis vehicles) with a permissible total weight exceeding 12 t. All our proposed measures, recommendations, assessments, etc. are based on this category of vehicle, and would in some cases be different for other vehicle categories.

Buses with a permissible total weight exceeding 12 t were not specifically considered, but may be regarded as included, given that they are largely equipped with the same technology as the trucks of the kind referred to.

3.3.2 Methodology

The Working Group realized from the outset that it would be unable to provide a comprehensive view of the issue of "road safety of heavy duty vehicles," because of the lack of clear information on the accidents that occur and the wide variety of developments and initiatives throughout the world for improved road safety. It was also clear, however, that if major European experts on commercial vehicle safety issues were able to collaborate effectively, it would be possible to describe the prominent accident scenarios, to specify measures seen as critical for improving road safety, and to clearly identify the main obstacles to the implementation of these critical measures. To avoid getting bogged down in detail, the Group also consistently restricted its focus to the main points, without trying to provide a comprehensive coverage of the topic. By adopting this approach, we were able to agree on significant findings within a short time, and to keep costs down to a moderate level.

At the kick-off meeting on March 16, 2004, the Group adopted the above task list and approach for formulating its results. It was decided to conduct a further four workshops, focusing on the following issues:

- The incidence of accidents
- Measures to improve road safety
- Evaluation of the proposed measures
- Action priorities and recommendations

The workshop on the incidence of accidents was run by the Accidentology sub-group led by Mr. Walter Niewöhner (DEKRA). The results on accident data given in this report were compiled by that sub-group. Their work relied on input from a European network of accident experts, with the direct involvement of the following.

	Name	Company	Country
Workshop participants	Alexander Berg	DEKRA	D
	Gianluca Galantina	IVECO	I
	Kai Morschheuser	DC	D
	Walter Niewöhner	DEKRA	D
	Mattias Sjöberg	Scania	S
	Dr. Jürgen Trost	DC	D
Additional sources	Claes Avedal	VOLVO	S
	Dr. Köfalvi	IRU	HU
	David Pedrero	CIDAUT	E

Table 2: Participants involved in identifying the prominent accident scenarios.

3.3.3 Measures for further enhancing the road safety performance of heavy duty vehicles

The proposed measures for enhanced road safety performance were contributed by Working Group members, also drawing on the interim results of the eSafety-Roadmap Working Group where regarded as relevant for heavy duty vehicles. Given the approach as agreed on by the Group, the proposed measures cannot be regarded as a complete list, but it can be assumed that all the most important such initiatives are covered.

The categories specified for the description of the measures were as follows:

- Identification of the measure
- Brief description of the measure
- Description of the prominent accident scenarios addressed by the measure
- Commercial availability of the measure
- Customer acceptance level
- Obstacles to implementation
- Classification of the measure according to:
    - Effectiveness in preventing accidents
    - System costs
    - Engineering costs

3.3.4 Evaluation of the proposed measures

The measures were evaluated in qualitative terms, according to the criteria shown in the table below and the standards documented therein. Given a higher resource input, it would clearly have been possible to provide a finer subdivision into valuation categories, but the score assigned to these measures ultimately depends on judgments regarding their effectiveness on the road, which inevitably incorporates a measure of uncertainty. Accordingly, the Group decided to apply a scoring system that is approximate, but sufficiently robust to identify the most important measures as the basis for deciding on action priorities.

Score	Customer acceptance	Effectiveness	System costs[1]	Engineering costs
-2	N/A	No perceptible benefit for road safety	4x the price of ESP (or more), or higher running costs	Major impact on vehicle concept design or infrastructure investments required
-1	Customers not prepared to accept the system in their vehicles	Little road safety benefit	3x the price of ESP	Minor impact on vehicle concept design or minor infrastructure investments required
0	Customers prepared to accept the system in their vehicles, but not to make the required investment	Low contribution to a prominent accident scenario or significant contribution to an accident scenario	2x the price of ESP	No impact on the vehicle concept design, many vehicle systems affected
1	Customers demanding the system	Medium contribution to a prominent accident scenario or significant contribution to an accident scenario	Comparable to ESP	No impact on the vehicle concept design, several vehicle systems affected
2	N/A	Major contribution to a prominent accident scenario	1/2 the price of ESP or lower running costs	No impact on the vehicle concept design, only one vehicle system affected

Table 3 – Scoring criteria for safety initiatives.

All scores are to be taken as estimates by specialists who work with safety systems on a daily basis. Particularly in the case of systems whose implementation still lies far in the future, the scores are not accurate in the scientific sense. In order to document the uncertainties involved in the estimates of effectiveness, the Group has provided lower and upper limit values for effectiveness (see Appendix 2, columns headed “Effectiveness – low” and “Effectiveness – high”).

[1] Since the costs incurred relate to a supplier’s competitiveness, the Working Group agreed on the ESP as a “common currency” for comparing the costs of safety systems. The cost information, too, cannot be applied to other vehicles, because of the different base technologies involved.

3.3.5 Formulation of action priorities and recommendations

Since the obstacles to implementation were identified along with the measures for further improvements to road safety, we were able to formulate action recommendations on the basis of this data. The discussion of these recommendations is here restricted to the systems that scored the highest, but in principle they can be extrapolated to all systems for heavy duty vehicles.

3.4 Reports, cooperation with other eSafety Working Groups

The Working Group's task list, membership, and approach, particularly the workshop dates, were presented and agreed in the eSafety Forum and eSafety Steering Group.

To reduce efforts, the Working Group decided not to publish progress reports. Our results are documented in the recommendations for the next EC communication to the Council (to be handed to Mr. Jääskeläinen, EC, in 10/04) and in this report. The Group decided to treat their working minutes, presentations, and documentation of interim results as confidential. This approach has proved its value, since this enabled participants to crosscheck with their organizations between workshops, so that the Group's activities were not held up by harmonization problems. In isolated cases where legitimate reasons were given for seeking access to interim records, the Chairman cleared this with the Group.

The work being done by the "Accident Research" and "Roadmap" working groups had many points of contact with this Working Group. The arrangements to avoid duplication of effort and inconsistencies were as follows:
Mr. Walter Niewöhner, DEKRA, who played a major role in coordinating the accident research for this Working Group, is also a member of the "Accident Research" working group, which ensured a smooth flow of information between the two groups.

The "Roadmap" working group mainly comprises experts on passenger car safety. It was therefore agreed with that group that issues relating to heavy duty vehicles would be addressed in the "Heavy Duty Vehicles" Working Group, and that the results would be provided to consolidate the findings of the "Roadmap" working group. That policy is implemented in this report and in a report presentation that was to be given by the Chairman of the "Heavy Duty Vehicles" Working Group in the "Roadmap" Working Group in early 2005.

4 Results of the "Accident Research" sub-group

4.1 Available accident data

In accordance with the focus for the Working Group, the work of the "Accident Research" sub-group began with a review of the available accident statistics. This showed that there are no reliable EU-wide statistics on accidents involving heavy duty vehicles (chassis vehicles with permissible total mass exceeding 12 t). This represents a major gap in European statistics, since information that is important as the basis for political decisions on vehicle and road safety is simply not available. This means that the priority scenarios in the area of heavy duty vehicle accidents cannot be adequately described at present. This makes it difficult to make any rapid progress with the development and implementation of measures likely to achieve the maximum benefit with the limited resources available. And following the implementation of measures, it is virtually impossible to monitor their impact on the incidence of accidents over time, and hence to provide a statistically based description of the effectiveness of specific measures.

One of the recommendations from the Working Group is therefore for the Europe-wide provision of accident statistics based on the vehicle definitions according to the type approval of vehicles and their trailers under Directive 70/156/EEC. Among other classes, the Directive defines the class of motor vehicles for goods transport (Class N), which is further subdivided into classes N_1 (permissible total mass up to 3.5 t), N_2 (permissible total mass over 3.5 t and up to 12 t), and N_3 (permissible total mass exceeding 12 t). And for accidents involving trailer units or semitrailer rigs, the trailer vehicle also has to be taken into account. Directive 70/156/EEC provides Class O for this purpose. Here again, the class is subdivided into class O_1 (permissible total mass up to 0.75 t), O_2 (permissible total mass over 0.75 and up to 3.5 t), O_3 (permissible total mass over 3.5 and up to 10 t), and O_4 (permissible total mass exceeding 10 t). If required, a restructuring of European accident statistics could even include a more finely divided classification system, on the basis of the national standard DIN 70 010, for example. That standard provides a classification for road vehicles, with definitions for motor vehicles, motor vehicle combinations, and trailer vehicles.

An appropriate basis for an initial overview of accidents involving heavy duty vehicles, notwithstanding the unsatisfactory data situation, is the OECD International Road Traffic and Accident Database IRTAD. IRTAD currently covers the following countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, the Republic of Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the UK, and the USA.

Previously, these statistics simply had one class for “trucks.” Since 2000, however, this database, too, gives figures for trucks for classes above and below a permissible total mass of 3.5 t for some countries. Fig. 4.1 shows the trends for absolute frequency of accidents with injuries involving trucks exceeding 3.5 t for the years 2000 to 2003 for Austria, Finland, France, Germany, the Netherlands, Portugal, and the UK. This data has since also become available for Greece, Spain, the Czech Republic, South Korea, and Canada, and will therefore also be able to be taken into account for subsequent analyses. Fig. 4.2 shows the corresponding figures for accidents with fatalities. The trend is steady or falling in both cases.

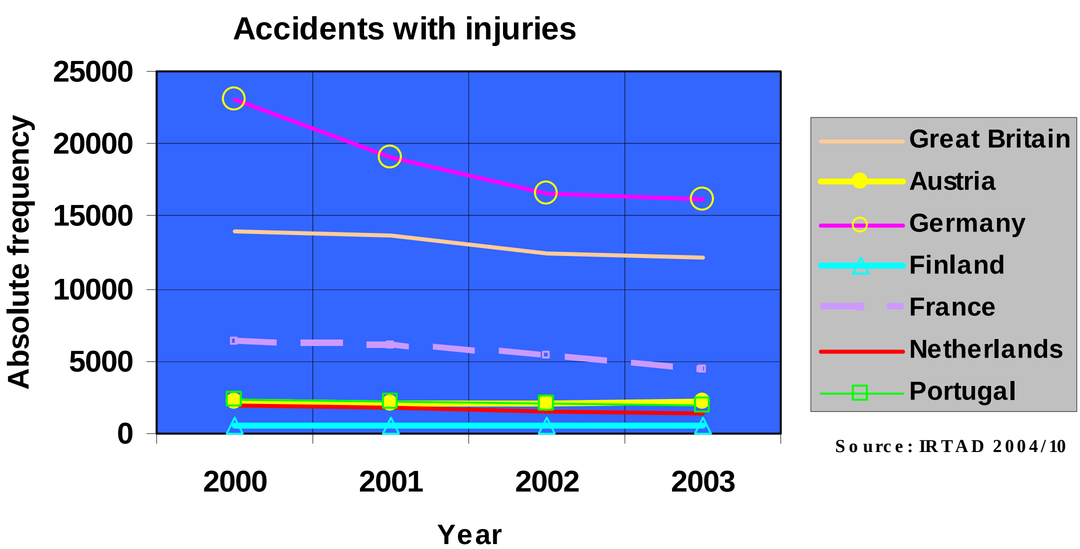


Fig. 2: Comparison of accident trends for accidents with injuries involving commercial vehicles (> 3.5 t) in some European Union countries. Source: IR TAD 2004/10.

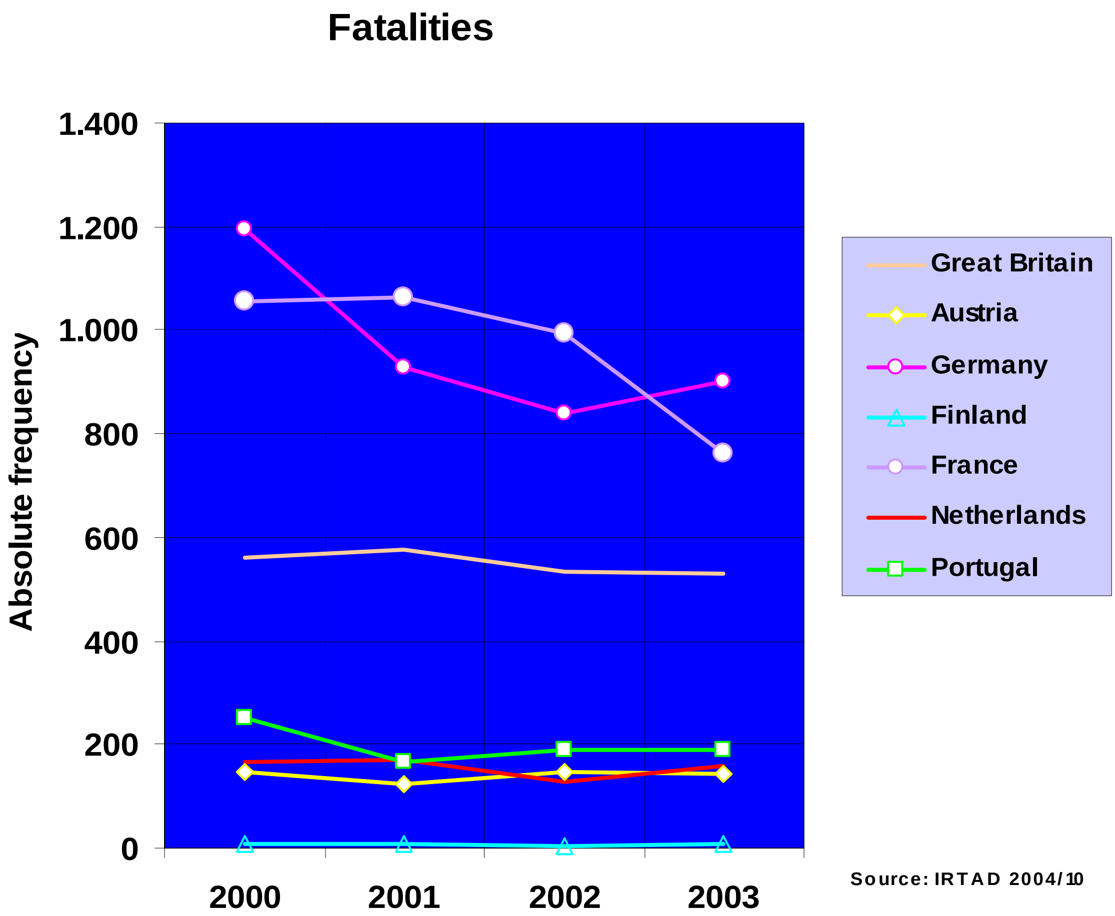


Fig. 3: Comparison of the trend for accidents with fatalities involving commercial vehicles (> 3.5 t) in some European Union countries.

Currently, there is no information available on a more detailed level on accidents involving commercial vehicles, particularly heavy duty vehicles with permissible total mass exceeding 12 t, for use as a basis in identifying EU-wide priority issues, and, where applicable, accident trends. A range of institutions have, however, conducted studies and research projects on a regular basis over many years regarding accidents involving commercial vehicles, which have also been published.

In the early 1990s, for example, DEKRA Accidents Research was commissioned by the German Federal Highway Research Institute to conduct a safety analysis of road freight traffic *(Grandel J, Berg F A, Niewöhner W: Sicherheitsanalyse im Strassengüterverkehr. Berichte der Bundesanstalt für Strassenwesen, vol. M 7, Bergisch Gladbach, 1993)*. Under a contract from the Automotive Technology research group within the German Association of the Automotive Industry [*VDA*], DEKRA also conducted a study on the internal safety of truck cabins *(Grandel J, Niewöhner W: Untersuchung der inneren Sicherheit von Lkw-Fahrerhäusern, FAT Schriftenreihe No. 115, July 1994)*. DEKRA has also recently published a paper on accidents involving heavy duty freight vehicles in Germany *(Niewöhner W, Berg F A, Egelhaaf M: Unfälle mit schweren Güterkraftfahrzeugen in Deutschland. Verkehrsunfall und Fahrzeugtechnik, vol. 10, Oktober 2003, vol. 11, November 2003, and vol. 12, December 2003)*.

Examples of published results from accidents research on trucks by OEMs include the Volvo Reports *(Svenso L, Viden S: Accidents involving Volvo trucks resulting in driver injury and the estimated effect of the SRS Airbag. Volvo Report 4, Gothenburg, May 1994. Högström K,* *Svenson L: Accidents involving Volvo trucks resulting in personal injury. Volvo Report 3, Gothenburg, May 1980. Högström K, Svenson L, Weimar, L: Heavy Commercial Vehicles/vulnerable road users. Volvo Accident Investigation, Report 1, Gothenburg 1973.).*

The current EU research program is addressing the issue of commercial vehicle safety in the APROSYS (**A**dvanced **PRO**tection **SYS**tems) integrated project. Within that project, the AP2 Truck Accidents work package is examining possibilities for reducing the number of serious injuries and fatalities in accidents involving heavy duty vehicles in Europe (*see also www.aprosys.com*).

In view of the inadequate availability of data in official statistics, the members of the Working Group decided on a best-practice approach, based on using the analysis, using a standard template, of case record compilations and data on accidents involving trucks, including some in-house data, and the compilation of the results. The task of compiling accident statistics at the European level for heavy trucks is made more difficult by vehicle classification systems based on different weight limits, company-specific procedures for recording truck accidents, and different focuses in terms of the research priorities in each case.

In fact, we found that a template originally developed from the accident research carried out by Volvo provided a suitable basis for identifying the main issues for this accident category. The template was used to analyze the data from Volvo case records (mainly accidents in Sweden), from DEKRA accidents research (accidents in Germany), data from CIDAUT (accidents in Spain), and IVECO records (accidents in Italy). CIDAUT was able to draw on the available figures from official accident statistics on all Spanish accidents. For system-related reasons, IVECO had to run analyses on two sets of Italian statistics, recorded in different ways, without always being able to apply a precise demarcation between mass classes (up to and exceeding 3.5 t, respectively).

4.2 Prominent accident scenarios involving trucks

The situation regarding truck accidents in individual countries of the EU is partly dependent on the types of vehicles mainly used by private motorists. Two-wheeled motor-driven vehicles are more widely used in southern Europe than in central and northern Europe. This is reflected in the “other party involved” data for accidents involving trucks in the accident databases of DEKRA (for Germany) and IVECO (for Italy), see Fig. 4.3. The Scandinavian countries are characterized by the more frequent use of trucks on rural roads. Because of its central location, Germany has a higher proportion of transit traffic. There are significantly more bicycles on the roads in the Netherlands and Denmark. These are just some of the reasons for the differences between European countries in terms of frequent accident scenarios.

The reporting template used for the analyses from this point comprises three categories of accidents involving heavy trucks: accidents killing or severely injuring truck occupants, occupants of another passenger vehicle involved, and vulnerable road users (pedestrians and drivers of two-wheeled vehicles, including motorcycles).

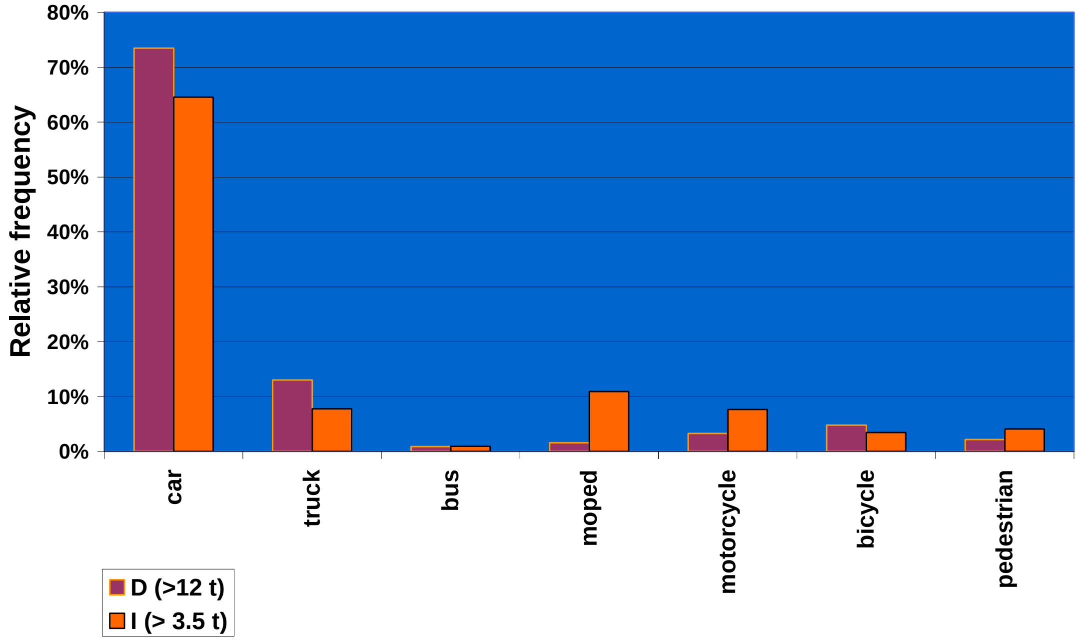


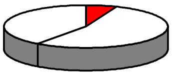
Fig. 4: "Other party involved" figures for truck accidents involving injuries according to the DEKRA incident reports (accidents in D, trucks with more than 12 t permissible total mass) and IVECO records (accidents in Italy, trucks with more than 3.5 t total mass).

4.2.1 Accidents with killed and severely injured truck occupants

Accidents with killed and/or severely injured truck occupants (often abbreviated to "KSI," = killed and severely injured) are the smallest overall category in accidents involving trucks. This is related to the size and weight of the trucks. Under the laws of mechanics, trucks are at an advantage in collisions with lighter and smaller vehicles or with vulnerable road users. Another factor placing truck occupants at an advantage is their higher position in the truck cabin. Injury risks for truck occupants are correspondingly low, particularly if they are wearing their safety belts. This situation can be dramatically different in the case of single-vehicle accidents. In a frontal collision between a truck and a stationary obstacle, for example, the limit scenario for retention of minimum survival space for the occupants of the cabin of a heavy truck is reached at much lower impact speeds than in a modern passenger car.

Our analyses of case and data records identified five accident scenarios that stand out as prominent accident scenarios for accidents with killed or severely injured truck occupants, see **Fig. 4.4.**

A.
Truck Occupants



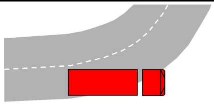
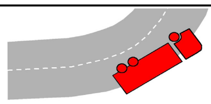
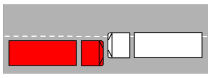
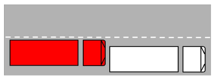
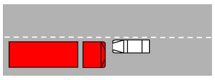
No.	Scenario		S Volvo	E Cidaut	D DEKRA	I IVECO
1	Truck single Driving off road		**35%**	**52%**	***21%***	**30%**
2	Truck single Rollover on road		**12%**	**8%**	***0%***	**11%**
3	Truck- truck collision, oncoming traffic Front vs. front		**10%**	**2%**	***0%***	**13%**
4	Truck- truck collision, traffic ahead in same direction Front vs. rear		**20%**	**6%**	***79%***	**25%**
5	Truck-car collision, oncoming traffic Truck front vs. car		**10%**	**2%**	***0%***	**2%**
A1	other			**24%**		**19%**

Fig. 4.4: Prominent scenarios for accidents will killed or severely injured truck occupants.

In the databases of Volvo (35%), Cidaut (52%), and IVECO (30%), single-vehicle accidents with the truck leaving the road represent the highest proportion of accidents. Such accidents often occur in curves. It is also frequent in this type of accident for the vehicle to tip onto its side or overturn during the accident.

In the corresponding case records of DEKRA, this type of accident, at 21%, is only the second-most frequent category, behind front-rear collisions between two trucks traveling in the same direction, at 79%. Such accidents often occur on motorways. These accident frequency differences could be due to differences in the infrastructure, and also to the density of traffic, which clearly plays a role in this context.

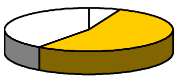
Further accident scenario categories involving killed or severely injured occupants can be identified on the basis of the case records and accident analyses of Volvo, CIDAUT, and IVECO: single-vehicle truck accidents, where the truck skids and possibly also rolls on the carriageway; front/front collisions between two trucks traveling in opposite directions; and front/front collisions between a truck and a car traveling in opposite directions. Similar accidents involving car-truck collisions can also be found in the DEKRA case records, but in this case they do not stand out as a prominent accident scenario. In such cases, the cause of truck occupant injuries or fatalities is generally loss of control of the truck after an initial collision with a car, followed by a second collision with more severe consequences for the truck occupants, e.g. with a stationary obstacle. There are also cases where a truck occupant not wearing a safety belt has been thrown out of the truck cabin after an initial, less serious collision, and has then been severely injured or killed, e.g. by being run over.

4.2.2 Truck accidents with killed or severely injured occupants in the passenger car involved

Truck-car accidents in which occupants of the car are killed or severely injured form the largest category overall. This is related to the fact that, in all European countries, by far most of the vehicles on the roads are passenger cars, with a correspondingly high probability of accidents involving passenger cars, of all levels of severity. Along with the large mass of the truck, other factors involved include the geometrical incompatibility between these vehicles in terms of their ladder-type frame structures. If the car passes underneath the truck at the time of the collision, the passenger car safety design feature to maintain a survival space for the occupants, e.g. the crash zone or mechanical side protection, is not able to perform its function. In accidents of this type, the impacting parts of the truck are forced downwards through the windshield into the inside of the car. In such cases, fatal consequences for the occupants can occur even at relatively low collision speeds.

Our analyses of the case records and accident data identified seven accident scenarios as the main situations leading to killed or severely injured car occupants, see **Fig. 4.5.**

B.
Car Occupants



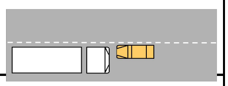
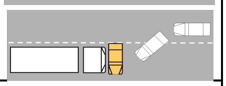
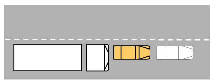
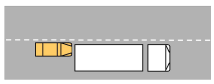
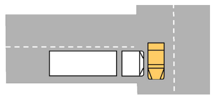
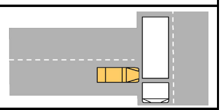
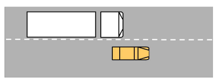
			S Volvo	E Cidaut	D DEKRA	I IVECO
6	Truck- car collision, oncoming traffic Truck front vs. car front,		30%	19%	19%	21%
7	Truck- car collision, oncoming traffic Truck front vs. car side		5%	27%	19%	11%
8	Truck- car collision, traffic ahead in same direction Truck front vs. car rear		15%	15%	16%	11%
10	Truck- car collision, traffic ahead in same direction Car front vs. truck rear		12%		6%	10%
9	Truck- car collision, intersection Truck front vs. car side		15%	1%	6%	18%
11	Truck- car collision, intersection Car front vs. truck side		12%		13%	9%
12	Truck- car collision, lane change accident Truck side vs. car side		10%	7%	6%	9%
B1	Other			32%	*15%*	11%

Fig. 4.5 Prominent scenarios for car-truck accidents with killed or severely injured car occupants.

In the analyses of Volvo and IVECO case records and data, the highest frequency figures here are for front/front collisions with the vehicles traveling in opposite directions (30% and 21%, respectively). For the DEKRA case records, this is one of the two most frequent scenarios, alongside accidents in which the front of the truck collides with the side of a skidding car (19% in each case). In the Spanish accident data analyzed by CIDAUT, the latter constellation is the most frequent, at 27%, followed by front/front collisions, at 19%. The third most frequent scenario was a frontal impact of the truck on the rear of a car traveling in the same direction, e.g. when driving up behind a traffic jam. The front of the truck is also involved in the fifth most frequent scenario, in which the truck drives into the side of a car driving across its path.

The fourth-ranked scenario is the frontal impact of the car on the rear of a truck traveling in the same direction. These accidents have appalling consequences for the car occupants, and are frequently reported in the media. They generally occur at high initial speeds on motorways, when the truck is standing at the end of a traffic jam. There are also isolated cases of such accidents in rest and parking areas, when trucks are parked in the access way in the absence of any dedicated parking places.

This is followed in sixth place by the frontal impact of the car on the side of a truck driving across its path. If the collision is with the tires of the truck, the front of the car may take the impact, allowing the crash zone to perform its function. Given a very robust passenger cabin design and an effective retention system, the car occupants then have a real chance of surviving such an accident with slight or severe injuries, provided that the equivalent impact speeds do not significantly exceed the range of the relevant crash tests. The worst case for this impact constellation is where the front of the car passes laterally between the truck tires, and under the truck chassis.

Equally frequent, in seventh place, is an accident scenario in which a truck and a car are initially traveling in the same direction alongside one another, and one of them then changes lanes. This kind of accident is generally caused by impeded visibility or lack of attention, or the driver becoming distracted at the time of the lane change. Car drivers are usually not aware of the specific visibility problems truck drivers have to deal with, and are therefore not conscious of the risk they face.

4.2.3 Truck accidents with killed and severely injured vulnerable road users

The term “vulnerable road users” generally refers primarily to pedestrians and cyclists. After a thorough discussion of the matter, the Working Group decided to include motorcyclists in this group as well. While motorcyclists and their pillion passengers generally wear protective clothing, comprising a suit, boots, gloves, and a helmet, their risk of injury in traffic accidents is significantly higher than that of car occupants, who are surrounded by the vehicle body as a protective structure.

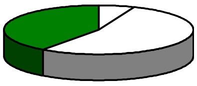
Two truck/pedestrian collision scenarios were identified as prominent in this category, along with another three truck/cyclist scenarios, see **Fig. 4.6.**

Most truck/pedestrian accidents occur in built-up areas, where the same space is frequently used by these two road user categories. One of the main problems here is the limited visibility for the truck driver immediately in front of and beside the vehicle. DEKRA Accident Research has recently carried out a project commissioned by the German Federal Highway Research Institute on risks to pedestrians and cyclists at intersections from trucks turning to the right *(W Niewöhner, F A Berg: Gefährdung von Fussgängern und Radfahrern an Kreuzungen durch rechts abbiegende Lkw, Berichte der Bundesanstalt für Strassenwesen, Unterreihe Fahrzeugtechnik, vol. F 54, December 2004)*. This issue is similarly being addressed in the Netherlands, where the TNO applied scientific research organization was commissioned by the Netherlands Ministry of Transport to carry out a study on the “analysis of fields of visibility and the position of parties involved in accidents with trucks” (*TNO Report 01.OR.BV.003.1/YdV*).

This was a prominent scenario in the case records and statistics analyzed by the Working Group, at 10% for Volvo, 26% for DEKRA, and 7% in Italy (IVECO). Truck/pedestrian accidents were also a major scenario in Spain (CIDAUT), at 38%, but in this case there was no further breakdown in terms of the location of the pedestrian when struck by the vehicle.

Another prominent scenario is that of pedestrians being struck by the back of the reversing truck, with frequencies of 20% in the Volvo case records, 4% in the DEKRA figures, and 20% in the IVECO statistics.

C.
Unprotected



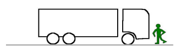
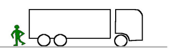
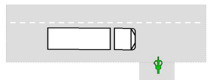
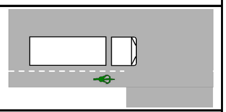
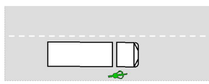
				S Volvo	E Cidaut	D DEKRA	I IVECO
13	Truck- unprotected collision, truck front vs. Unprotected when taking off			**10%**	**38%**	***26%***	**7%**
14	Truck- unprotected collision, truck vs. Unprotected when reversing			**20%**		***4%***	**20%**
15	Truck- unprotected collision, cross road collision			**20%**	**24%**	***9%***	**27%**
16	Truck- unprotected collision, truck side vs. Unprotected when turning			**20%**		***26%***	**18%**
17	Truck- unprotected collision, truck rear vs. Unprotected, lane driving			**10%**	**13%**	***22%***	**13%**
C1	other				**25%**	***13%***	**15%**

Fig. 4.6 Prominent scenarios for accidents involving trucks and killed and/or severely injured vulnerable road users.

For truck / two-wheeled vehicle accidents, high-frequency categories are accidents in which the front of the truck impacts a two-wheeled vehicle crossing its path, and accidents in which the truck and two-wheeled vehicle were initially traveling in the direction alongside one another. The accident happens either as the truck then turns, or as it continues straight ahead, with its side colliding with the two-wheeled vehicle.

There are also some significant levels of “other” truck / two-wheeled vehicle accident scenarios, particularly in the DEKRA accident material.

4.2.4 Prominent accident scenarios overall

A summary of the significant accident types across all sub-categories as prominent accident scenarios is provided in Fig. 4.7. These scenarios represent 49% of all Volvo accidents, 40% of the accidents analyzed by CIDAUT in Spain, 62% of the DEKRA accidents, and 42% of the accidents analyzed by IVECO in Italy.

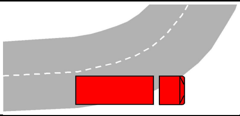
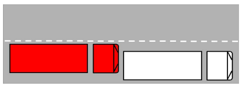
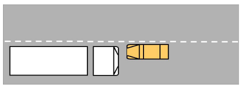
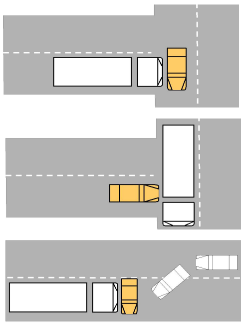
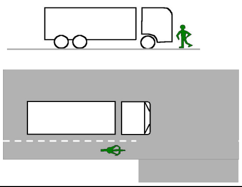
<table>
<tr><th></th><th></th><th>S
Volvo</th><th>E
Cidaut</th><th>D
DEKRA</th><th>I
IVECO</th></tr>
<tr><td>1</td><td></td><td rowspan="5">49%</td><td rowspan="5">40%</td><td rowspan="5">62%</td><td rowspan="5">42%</td></tr>
<tr><td>4</td><td></td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>7+9+11</td><td></td></tr>
<tr><td>13+16</td><td></td></tr>
</table>

Fig. 4.7 Prominent accident scenarios involving trucks, overall summary.

4.2.5 Basic concept of an EU-wide core accident database on accidents involving heavy trucks

In formulating the best-practice approach for the identification and description of prominent accident scenarios involving heavy trucks, the members have demonstrated how a useful overview can be arrived at in spite of the inadequacies in official statistics, through effective cooperation between the stakeholders. If further information on the scenarios described is required, for research projects, for example, the institutions involved may be approached with an application for assistance or provision of the case material. The Group remains open to the idea of further examination and analysis of accident data with other partners. In this way, it would be possible to go beyond the compilation of prominent scenarios for this type of accident to create an EU-side core database. The small number of details recorded in the database would cover the essential features required for the description and identification of accident scenarios. If required, the more extensive data held by the various partners and information on individual accidents could then be accessed through the appropriate query and release procedures.

5 Technical approaches to reducing road deaths

The Working Group discussed a list of around 50 technical and non-technical approaches for enhancing the road safety performance of heavy duty vehicles. The systems already available are now described, followed in the next section by a discussion of the most effective approaches.

5.1 Current state of the art in commercial vehicles

In view of the target date of 2010 for decreasing the number of road deaths, the systems already in the marketplace are obviously of great importance, even where they are regarded as less effective than future systems are expected to be. The systems for heavy duty vehicles presented and assessed in this section are already commercially available.

5.1.1 ESP for semitrailer rigs (including rollover protection)

There are two main reasons for heavy duty vehicles leaving the road. The first is the vehicle getting out of control because of an incorrect appreciation of the driving situation by the driver. In this event, the ESP helps the driver to slow down the vehicle and bring it back under control.

The operating principle of ESP is now well known, following the large-scale series production of the system, particularly in Germany. The system assesses the dynamic driving situation of the vehicle by monitoring the yaw rate, wheel revolutions, and steering angles. If the vehicle behavior becomes unstable or the driving situation becomes critical, i.e. the vehicle may be about to roll, the driving situation is automatically stabilized by independent wheel braking interventions, and the vehicle is simultaneously slowed down by automatic braking. The braking intervention takes place on the tractor vehicle, and also on the trailer as an independent trailer braking operation.

The positive impact of ESP shows up quickly in the accident statistics for passenger cars because of the rapid introduction of the system onto the market. The market introduction of the system for trucks is going to be a very slow process (see also under 6). No technical solution for trailer units is yet available.

5.1.2 Lane departure warning

The second reason for a truck leaving the road is loss of concentration by the driver, which can be for any of a number of reasons: loss of alertness, becoming distracted, or stress. This then leads to the driver unintentionally leaving the lane, or even the road.

The lane departure warning system uses video-based sensors to monitor the position of the vehicle in the lane, and activates a (generally acoustic) alarm when there is a risk of the vehicle leaving its lane.

Since trucks are often forced to drive over lane markings because of the dimensions of heavy duty vehicles, the activation of a warning is usually restricted by certain limit settings, e.g. at low speeds, or it can even be switched off by the driver.
Recent variants that automatically switch the system back on after it has been switched off by the driver are now in use, in the NAFTA market and elsewhere.

5.1.3 Flexible underrun protection

As shown in 4.2, a car/truck collision is one of the prominent accident scenarios, and, accordingly, legislation now requires the use of a rigid front underrun protection system. The rigid front underrun protection system operates by activating the crash zone of the car when it collides with the truck, before the structural parts of the truck have penetrated into the survival space of the car. The crash zone of the car then performs the function of absorbing the energy of the accident.

Some OEMs have now enhanced the rigid front underrun protection system by providing this protection with a flexible structure. That structure is able to absorb the energy created by the accident in the same way as the car's crash zone. This increases the collision speeds at which the car occupants may be able to survive a crash with a heavy duty vehicle. It has been demonstrated by measurements (indicative figures only, since the characteristics of the car itself have a significant impact on the results) (quotation), that flexible front underrun protection increases the survivable collision speed by 60 km/h.

5.1.4 Seat-belt warning

In spite of campaigns including the active involvement of OEMs, the belt-wearing rate for heavy duty vehicles lags far behind that for passenger cars, which continually results in fatalities among truck drivers. A technical method for increasing the belt-wearing rate could be the introduction of systems to warn drivers before they can start a journey without fastening their seat belt. The acceptance level for such systems is low, and they would therefore have to be imposed by regulation or a joint campaign by all OEMs.

5.1.5 Driver alertness monitoring system

Lack of attention is a frequent cause for a range of accident scenarios, such as leaving the lane, or the standard rear-end collision. In the Japanese market for heavy duty vehicles, a system is available that assesses the alertness of the driver by monitoring the driving situation and the driver's behavior. The assessment is then displayed to the driver. When the situation is critical, a driver alarm is activated, and in some cases invigorating fragrances are released.

Because of the range of driver responses to the onset of tiredness, and the limited personalization capacity of the system (although the personalization process proceeds quite rapidly), the alertness monitor will sometimes make mistakes, including both false alarms and failures to issue warnings at the right time.

Here again, because of the limited market penetration to date, we do not have any information on the effectiveness of the system in the field.

5.1.6 Adaptive cruise control

The adaptive cruise control system was introduced as a luxury feature, particularly for bumper-to-bumper driving. There are a range of such systems in the market. The approach shown in this diagram seems to be gaining dominance, because of its better performance in Europe (Fig 5).

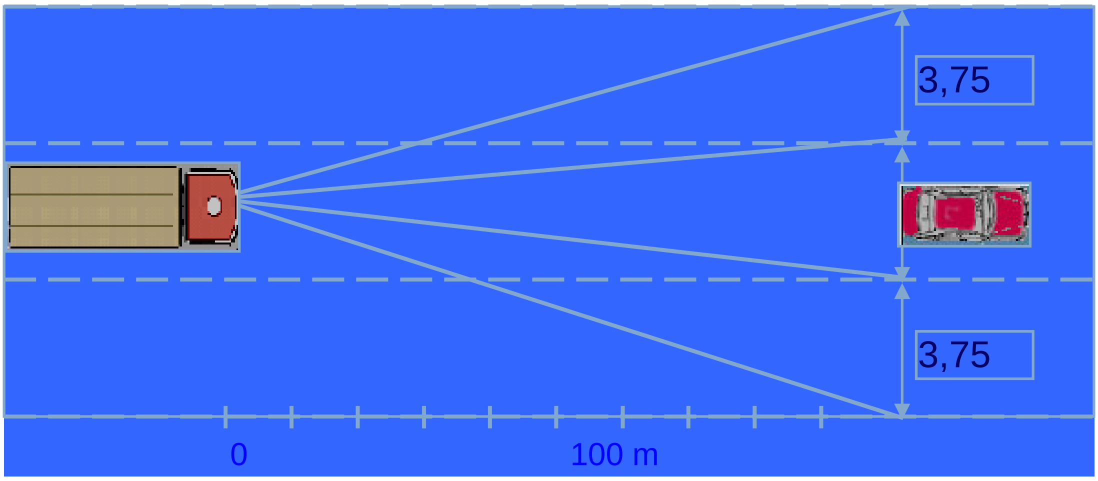


Fig 5: Adaptive cruise control.

The distance and relative speed against the vehicle ahead and other objects (road barriers, signs, oncoming vehicles, etc.) are measured with a radar sensor. On the basis of the measured data, the system calculates a traffic situation, extracts the vehicle ahead, and adjusts the speed of the truck to keep the required distance.

Safety features center around the automatically set distance, and the fact that the cruise control system often also includes alarm algorithms to warn the driver when the system detects a critical driving situation.

5.1.7 Event data recorder

The event data recorder is a system that continuously records important vehicle variables such as accelerations, speed reductions, speed, etc. in a ring store. In the event of an accident, these data can be analyzed and used to clarify the cause of the accident, subject to the quality of the data and the accident scenario.

Naturally, this does not make any direct contribution to accident prevention, but experience in the American market shows that accidents have decreased in fleets using the event data recorders. It is not clear whether this is caused by the educational effect of the recorder, or the stronger focus on road safety on the part of fleet management (see [2], for example).

5.2 Evaluation of the available systems

The results of the evaluation are documented in Fig 6.

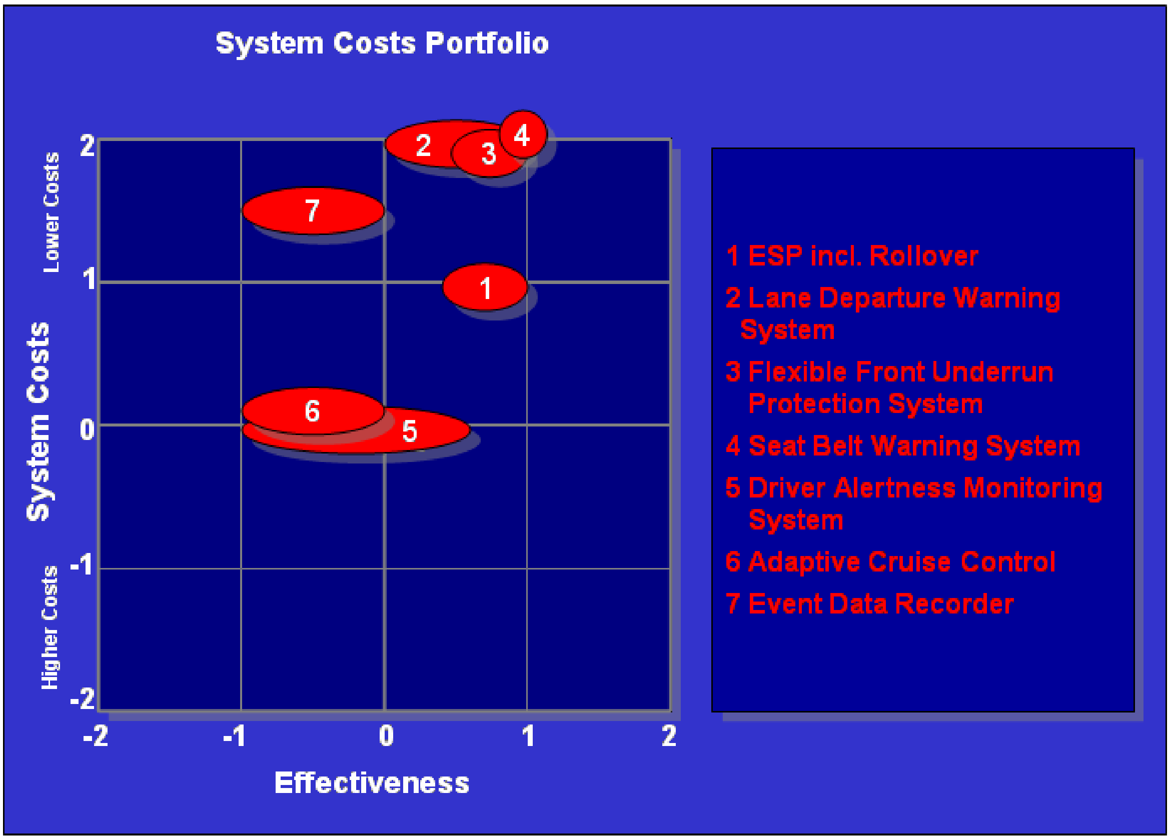


Fig. 6: System costs of implemented safety systems.

5.3 List of highly effective approaches from various initiatives

The Working Group discussed a list of around 50 technical and non-technical approaches for enhancing the road safety performance of heavy duty vehicles. This section discusses only those systems that the Working Group expects to make the highest contribution to increased road safety. This does not mean that other systems will not be able to assist in improving road safety. However, any measures to promote the use of these systems will also help to boost the market penetration of systems not examined here, apart from measures specifically designed to change the provisions for the official approval of a particular system.

The Working Group decided against the use of quantitative indicators of reductions in road deaths in its evaluation of the systems for enhanced road safety performance, for two reasons. First, the data on accidents, as discussed in section 4, does not provide a sufficient basis for any such assessment. Secondly, it is not possible to assess the effectiveness of any particular system, particularly in comparison with other solutions or in an environment changed by the implementation of other systems. The Group has therefore made a qualitative assessment of the impact of each proposed system on a prominent accident scenario (see also 3.3.4).

5.3.1 Improving the frictional properties of commercial vehicle tires

There are significant performance differences between brake systems in heavy duty vehicles and passenger cars. Whereas cars achieve braking performance in the order of 10 m/s², a good figure for truck braking performance is around 6.5 m/s². Increased braking capacity has a direct positive impact on accident statistics.

The data of both the German Federal Statistics Office and insurance companies shows a marked decline (of around 10%) in the accident frequency of heavy Mercedes-Benz trucks against the market average following the implementation of an improved braking system as standard on those trucks. The potential for any further increase in braking performance is limited by the characteristics of commercial vehicle tires, as optimized for mileage and low rolling friction losses. On the basis of the physics involved, any optimization of tire characteristics requires either poorer mileage performance and rolling friction losses – which the market will not accept for financial reasons – or significant expenditure on tire research.

5.3.2 Emergency braking system

The high volumes of road traffic in central Europe make bumper-to-bumper driving a normal driving situation for heavy duty vehicles. Rear-end collisions are therefore one of the main accident scenarios, normally assumed to represent around 30% of all accidents involving heavy trucks on central European roads. In around 60% of such accidents, there was no reaction or an inadequate reaction from the driver.

The emergency braking system was developed to ameliorate this accident scenario. On the basis of the adaptive cruise control systems already on the market, the emergency braking system detects the risk of a rear-end collision and warns the driver. If the driver fails to respond, the system activates an emergency braking operation to prevent the accident or mitigate the consequences.

The Working Group discussed three development stages for emergency braking systems. The first technology to become commercially available will be a system that responds to traffic in front of the vehicle traveling in the same direction. The next development stage will also cope with stationary traffic, which accounts for a further approx. 10% of heavy truck accidents. The final stage will also respond to oncoming traffic. In a head-on collision scenario, applying the truck brakes just 1 s earlier dissipates as much energy as the flexible underrun protection system referred to below.

5.3.3 Pedestrian protection system

In contrast with the situation for accidents involving passenger cars, passive measures designed to diminish the impact of the person against the vehicle structure are not among the viable strategies to reduce pedestrian fatalities in accidents involving heavy duty vehicles. Many injuries to vulnerable road users in accidents involving trucks take place when the person is thrown out onto the road after the collision with the vehicle, or when people are run over by the truck. As also in other contexts, the priority is to prevent accidents rather than mitigating their consequences.

Particularly in inner-city traffic, accidents involving pedestrians and cyclists are caused by the poor visibility for the driver in the immediate vicinity of the truck. The Working Group discussed an electronic system to detect the presence of vulnerable road users in the danger area around the truck, and to warn the driver or actively intervene if the driver fails to take action.

Technical solutions based on short-range radar, video systems, or laser scanners are currently at the research stage. The Working Group did not evaluate the differences between these technologies in terms of effectiveness, but did look at the legal constraints applicable to the use of short-range radar technology as part of the availability estimation process.

5.3.4 Extended flexible front underrun protection

In a front/front collision between a car and a truck, there are often fatalities in the car because of the very different masses of the vehicles and the geometrical incompatibility of the frontal structures. The legislative authorities have reacted to this situation by requiring a (rigid) front underrun protection system. Some truck manufacturers (i.e. MAN, Volvo) offer enhanced flexible front underrun protection systems that can be provided within the existing legal constraints (dimensions and weight).

The Working Group evaluated a system based on a proposal from Scania. If the front of the truck could be made approx. 300 mm longer than the legally permitted maximum length, the survivable differential speed for a frontal collision between a passenger car and a truck would rise significantly.[2]

This system and its effectiveness were intensively debated in the Working Group, particularly since the latest results from the VC–Compat project showed that, in addition to the optimization of the truck front structure, it would also be necessary to make improvements in the car (retention system activation conditions). The evaluation provided below was the agreed Group consensus from that debate.

5.3.5 Inter-vehicle communication systems

Accident prevention systems based on inter-vehicle communication technology are currently at the initial research stage. The Working Group assessed a system that is able to communicate the vehicle’s planned trajectories to other vehicles in the vicinity. Such a system would clearly make a significant contribution to accident-free traffic, since this would create an environment requiring traffic participants to cooperate and think ahead.

5.3.6 Infrastructure-supported intersection assistant

Accident statistics show that intersection accidents represent a major accident scenario. Preliminary studies by DaimlerChrysler research specialists and DEKRA have shown that purely vehicle-based systems are not able to make any significant contribution to reducing accidents, because the accidents in this situation are so diverse.
The Working Group assessed a system in which infrastructure facilities – traffic sign systems, for example – can forward information on traffic approaching the intersection to intersecting traffic.

5.3.7 Interactive driver training

Some 85% to 95% of all road accidents, according to the statistics used, involve human error as a causal element. All the above suggested road safety enhancements are designed to compensate for human failure. It is well known that intensive driver training can make a significant contribution to traffic safety. For example, Shell AG [1] has demonstrated how

[2] Due to different experiences of the group members the group is not able to give a concrete number for what is “significantly.”

road safety can be improved by identifying this as a priority for the actors involved. A number of techniques using driver training and awareness-raising to achieve enhanced road safety performance have been designed and implemented in practice. It is particularly interesting to note that some of these initiatives have been implemented in so-called third-world countries. The basic idea behind these campaigns is that road fatalities can be avoided by reducing the number of critical situations arising, through training and awareness-raising measures (including incentives). And the prevention of critical situations will inevitably diminish the probability of all kinds of accidents, whether minor, severe, or even fatal.

One approach to integrate driver training and awareness-raising is that of telematics-supported interactive driver training, which is already being provided by the industry. The driver's on-the-job driving behavior is recorded, assessed according to various criteria (e.g. safety and economic use of resources), and reflected back to the driver in a feedback interview. This form of training has been shown to have a marked impact on fuel consumption. The Working Group believes that a similar impact on safety can be achieved, even through this cannot be demonstrated statistically because of the small number of drivers that have undergone this training to date.

5.4 Evaluation of future systems

Since there are always restrictions of one sort or another on the availability of resources for the enhancement and implementation of new technologies or measures, it is necessary to focus in the first instance on those measures that can achieve maximum impacts with limited resources in terms of time, budget, or professional expertise. Such assessments are never one-dimensional, and, accordingly, the Working Group assessed the approaches that are likely to have the highest impact on reducing road deaths (see also 5.3) in terms of the associated issues, mainly regarding resources, and placed them in portfolios.

5.4.1 Availability

Given the product development lead times required for heavy duty vehicles, measures that have not yet been developed (i.e. by 2005) will not be able to play any significant part in reducing road deaths in 2010. The first priority, therefore, is to support the market penetration of those measures that are already available or are about to become so, in order that positive impacts can be achieved even in the short term.

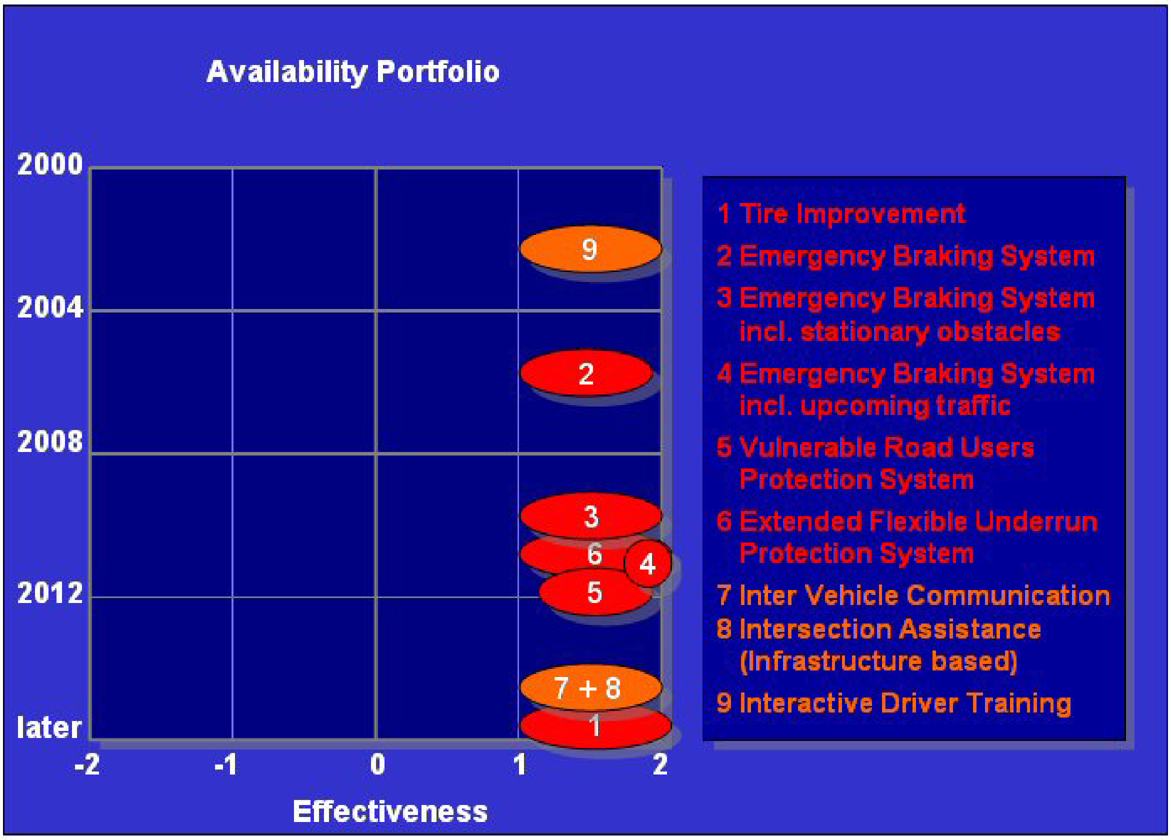


Fig. 7: Availability of effective approaches towards enhanced road safety performance for heavy duty vehicles.

Interactive driver training is already offered by the industry, even if on only a small scale to date. This form of training could be provided on a larger scale to meet the demand through the more widespread installation of telematics platforms in heavy duty vehicles.
The industry has announced the impending arrival of the various forms of emergency braking systems on several occasions. The market launch of the first system is imminent, and further stages are in preparation.

Person detection processes based on short-range radar technology are already available. Since current legislation does not allow the widespread implementation of these systems, and the other technologies have not reached the required level of maturity, the Working Group has assessed systems for preventing the accidents involving vulnerable road users as becoming available only in the medium term.

The Group has also assessed the availability of an extended flexible front underrun system as medium-term at best, since the relevant legal requirements would not allow its implementation at present. Even if the required legal changes were made, there would still be a considerable period of development time, in view of the significant impact of this solution on the vehicle design concept.

Infrastructure-based measures could make a major contribution towards reducing road deaths. The Working Group’s assessment of availability only in the long term is based on the lack of business models for the implementation of this kind of technology and the inadequate resources available in the area of traffic infrastructure systems.

At present, there is no prospect of the introduction of commercial vehicle tires with similar friction values to those of passenger car tires, since the friction value is directly related to the rolling friction losses of the tires. As a result, any improvement in the friction characteristics would lead directly to increased fuel consumption, and therefore to an increased environmental burden. In this case, we have a conflict between two social values. The Working Group believes that achieving technological improvements that bring advances in both directions will be a slow process.

5.4.2 System costs

For systems not required by law, their success in the marketplace will be defined by their acceptance by the end customer. An important aspect of building acceptance is the price. The price factor for safety systems is much more prominent for trucks than it is for passenger cars, because of the extremely difficult economic situation facing truck drivers for some years. It can therefore be assumed that the lower the cost of a safety system to the end customer, the more likely it is to gain the required level of acceptance.

In its estimates of the costs for interactive driver training, the Working Group has assumed that the vehicle is fitted with a telematics platform that is economically viable through its use for fleet management purposes. If such a platform had to be purchased solely for training purposes, the system cost score would be between -1 and -2.

Extended flexible front underrun protection could be offered at low cost if it can be incorporated into the overall vehicle design concept, which impacts on availability, as shown above, and the associated engineering costs.

An infrastructure-based alarm system to provide warnings of potential intersection accidents could be implemented in the vehicle very economically, since today’s vehicles are essentially already fitted with all the operating and display components required for such a system.

The approaches requiring the use of an additional mechatronic system (emergency braking system, pedestrian protection system) have comparable cost ranges.

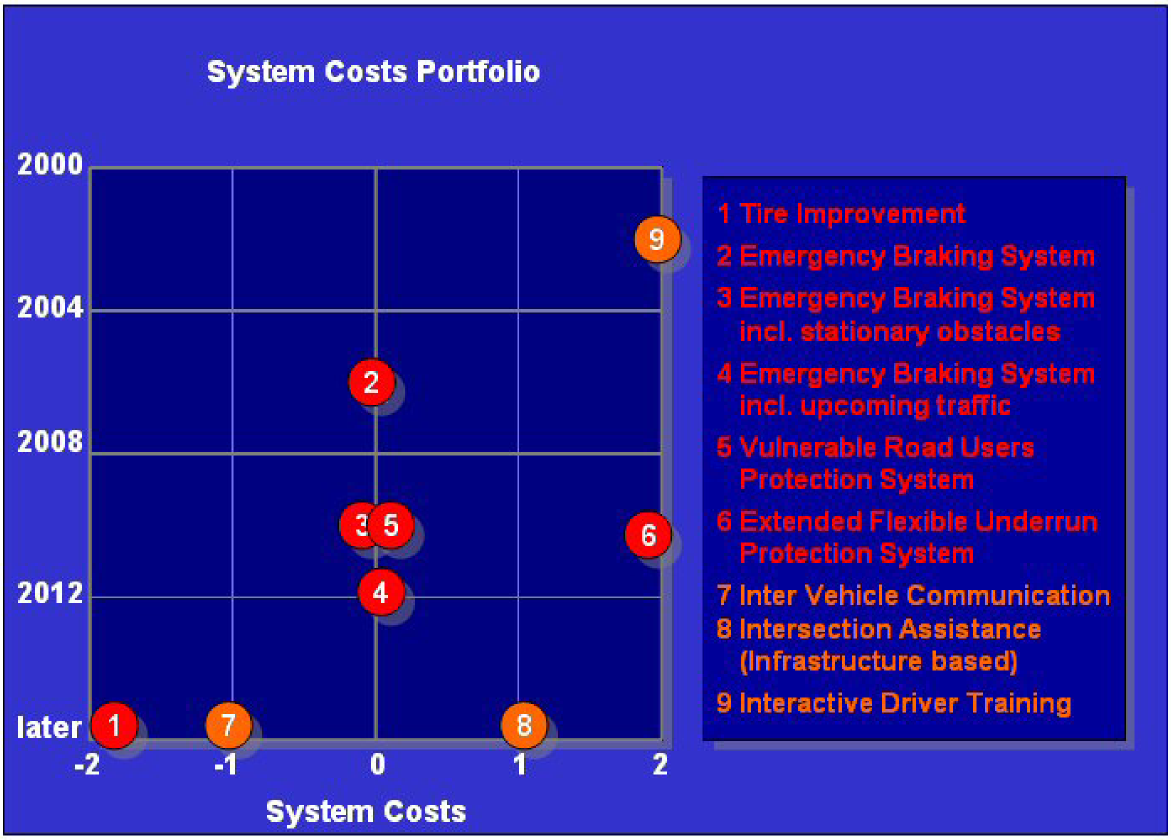


Fig. 8: System costs of effective approaches towards enhanced road safety performance for heavy duty vehicles.

Systems designed to communicate their trajectory to other vehicles and respond reliably to information received from other vehicles are assessed as significantly more resource-intensive, and therefore more expensive. In addition to the communications facilities, this would require intensive networking of the system with other vehicle systems, leading to significant additional costs in comparison with other solutions.

The Working Group believes that any significant enhancements to the friction characteristics of commercial vehicle tires would lead to increased operating costs, even in the long term, hence the low score assigned for system costs.

5.4.3 Development costs

Another success criterion for the implementation of new road safety improvement systems is the risk carried by the industry for their development. Experience shows that safety systems are generally not profitable, because of the constraints associated with heavy duty vehicles. Accordingly, the higher the resource input required for a given approach, the less likely it is to be successful.

This is particularly evident in the case of infrastructure-supported systems, for which there are development and implementation costs to be borne by public authorities.

All the substantive development work for interactive driver training has already been done. The educational blueprint may have to be refined, but no further significant investments are likely to be required (Fig. 9).

The first-generation emergency braking system is based on the adaptive cruise control system that has been on the market since 2000, and the required investments are therefore expected to be reasonably low.

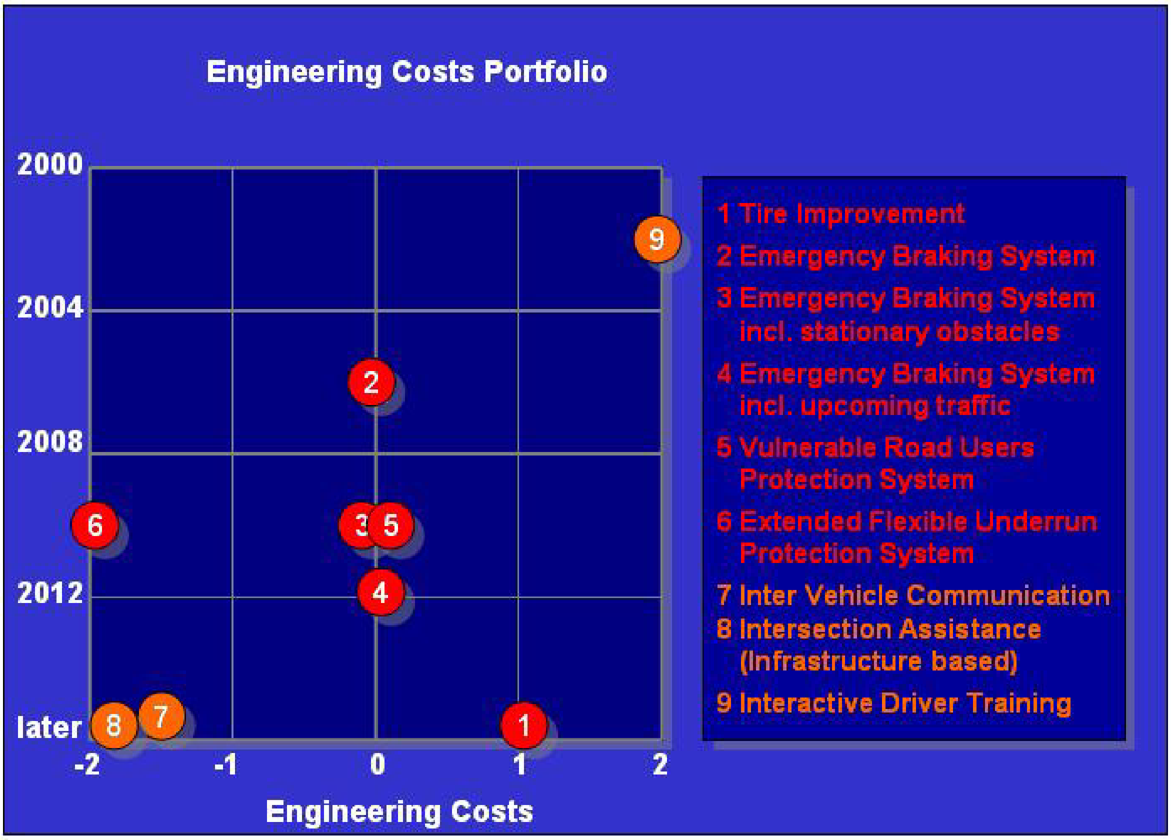


Fig. 9: Engineering costs of effective approaches towards enhanced road safety performance for heavy duty vehicles

There are major development risks associated with the extended flexible front underrun protection system, because of the impact on virtually the entire vehicle concept design.

The Working Group also believes that the implementation of intersection assistants would involve significant development costs, in view of the required changes to infrastructure systems.

Inter-vehicle communication systems could make a significant contribution towards accident prevention, but are highly complex and currently have made little progress towards maturity for their actual use in practice, hence the above score assigned by the Working Group for engineering costs.

5.4.4 Acceptance

Another important criterion for the market success of safety systems is the level of acceptance of the safety system as such. Systems that give the driver the impression of being monitored are often rejected. These include systems that directly evaluate driver performance and those that store data that are not transparent for the driver. It is interesting to note that no system of this type achieved a high ranking as an effective approach for the prevention of road deaths.

This is probably due to the fact that such systems are generally effective only if appropriately enforced. Acceptance rankings from contacts with end customers were as follows.

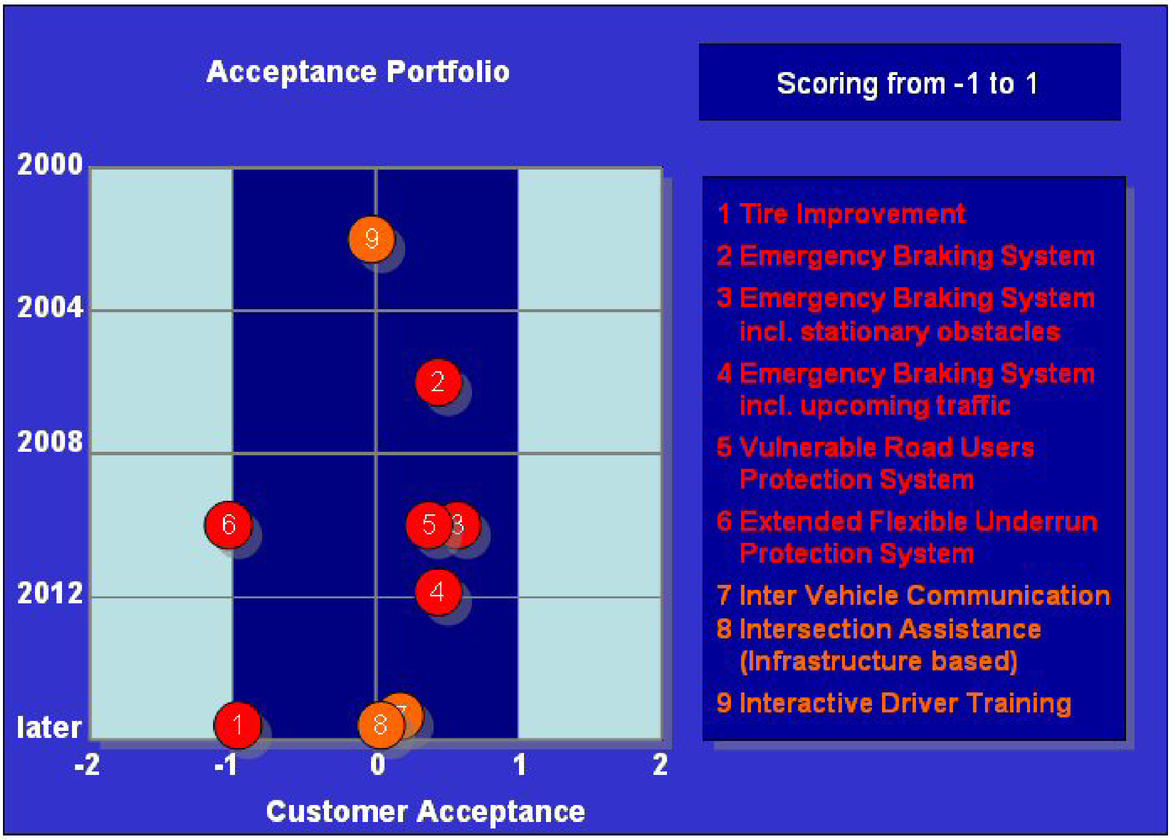


Fig. 10: End customer acceptance of effective approaches towards enhanced road safety performance for heavy duty vehicles.

Most of the systems examined here would be accepted by the customer provided that no additional cost was incurred. One requirement for customer acceptance would be met if there was another customer benefit in addition to increased safety. This kind of benefit is seen as being provided in the case of the emergency braking system, through the offer of adaptive cruise control functionality. For the system for preventing accidents involving vulnerable road users, greater ease of parking maneuvers or the prevention of minor damage could be seen as ancillary benefits of this kind. Experience shows that, in these conditions, a small proportion of customers are prepared to bear the additional costs for such a system.

The Working Group assessed improvements in tire performance as not acceptable to haulage operators, because of the higher operating costs involved. The extended flexible front underrun system is also considered to be unlikely to gain acceptance if it involves economic disadvantages through load volume and weight constraints.

6 Implementation obstacles and action priorities

6.1 Economic constraints

6.1.1 Business model

The Working Group evaluated approximately fifty suggestions for the enhanced road safety performance of heavy duty vehicles. In every case, the cost was one of the obstacles to implementation, if not the critical obstacle.

The heavy duty vehicles market differs significantly from the passenger car market on this point. Short-term economic considerations dominate all others in the commercial vehicle market. This explains the completely different penetration rates and speeds for safety systems in the two markets. Indeed, that difference was one of the reasons for setting up this Working Group.

Relevant publications (e.g. www.iru.org) indicate that road freight traffic in Europe is subject to very high underlying costs, even in terms of an international comparison, and also that haulage business operators are working in an extraordinarily tough competitive environment.

It is therefore understandable that economic survival is the first consideration for haulage companies when making decisions on vehicle equipment. Any investments required to meet social goals must take second place in this competitive environment.

This is the reason why a number of safety systems already available in the marketplace (e.g. ESP) are not penetrating the market in the case of heavy duty vehicles. In turn, the lack of market acceptance means that it is difficult for the manufacturers to continue work on the further development of these systems, since they are neither profitable, nor capable of achieving an adequate impact on reducing the occurrence of accidents. The technology leadership in driver assistance systems built up by the European industry over the last decade now seems to have been all for naught, judging by recent products coming onto the market in Asia.

Many sources (including eSafety) indicate that improved road safety includes economic aspects as well as the ethical issues involved.

6.1.2 Action priorities

Given that the need for an appropriate business model for safety systems in heavy duty vehicles (and other road safety initiatives) has long been clearly identified, and since road safety is both a social goal of the European Union and an economic goal, ignoring this issue is simply not an option. The Working Group concludes that there are basically two approaches towards actively encouraging the implementation of safety systems.

6.1.2.1 Implementation by regulation

There have been a few examples of the successful introduction of safety systems onto the market, including in the heavy duty vehicle sector. However, these examples also demonstrate that this is an extremely slow process, and essentially applies to situations where the technologies are already standard, and it is a matter of bringing them into more widespread use. The creation of an “eSafety Project” designed to bring about the use of new technologies to increase road safety is not, therefore, a viable option in the view of the Working Group. This view is clearly supported by the latest examples of safety systems introduced by regulation: the special rear-view mirror or the rigid front underrun protection system.

6.1.2.2 Creation of attractive financial conditions

It has long been established practice in Europe to provide incentives for new systems as an effective way of supporting their introduction prior to the entry into force of the relevant regulations. The Group believes this approach would be more productive in both the long and short term.

In the short-term perspective, this view is based on the period of time required to implement regulations on the one hand, and incentives on the other. Experience shows that the pace of the implementation of regulations is dictated by the slowest member states. Incentives can also be introduced in individual member states. If incentives came into force in a few key states, they would then effectively apply Europe-wide, given the high volume of long-distance traffic movements.

In the long-term perspective, the Group's thinking is based on the business model used by OEMs. Systems introduced by regulation do not provide the basis for any differentiation from the competition, or any advantage for individual OEMs. And particularly for highly complex safety systems, regulation can require only the implementation of systems that already exist. If safety systems were to be implemented essentially by regulation, there would be no economic stimuli for OEMs to develop the systems in the first place, since a business model could not be achieved either by a market pull or technology push. The result would be to make the introduction of new systems a much slower process.

To speed up the introduction onto the market of systems that are already developed or about to be launched on the market, the Working Group strongly advises using the tried and proven method of incentives. The low market penetration of safety systems at this stage in the heavy duty vehicle sector means that there is potential for achieving enhanced road safety performance, even within the short term.

6.2 Legal constraints

In an age in which electronics and software systems are playing a crucial role in the operation of motor vehicles, it is probably inevitable that legislative and regulatory provisions are unable to keep up with the latest technical advances. This means there is a danger that obsolete laws and regulations could jeopardize any form of technical enhancements. Conversely, legislation can play a valuable role in laying down a solid, enduring framework for ongoing technical advances. Setting the right balance between flexible legislation that can keep abreast of the latest technology on the one hand, and provide robust ground rules on the other is a major part of creating an attractive business environment. Particular concerns of the Working Group were the authorization of new electronics systems and the drafting of regulations on the dimensions and weight of heavy duty vehicles.

6.2.1 Authorization of new electronic systems

The recent authorization of electronic braking systems, ESP, steer-by-wire, and other comparable systems demonstrates that if public authorities are involved in the process at the appropriate time, the process of implementing such products – while not without its problems – is not actually impeded. A particularly positive feature is the fact that certifying bodies have significantly improved their expertise over the last few years, and are therefore in a position to assess state-of-the-art electronic safety systems.

A further improvement in the authorization process will come with the introduction of the "horizontal approach." At present, different provisions apply for specific vehicle systems, under a "vertical approach": brake systems regulations, steering systems regulations, etc. Today's electronic safety systems can no longer be classified in the traditional sense, however, so that several sets of regulations may apply in a given case. This means that the vertical approach is reaching its limits, making it difficult to obtain the required permits. The competent committees are currently working on drafting a generally applicable (horizontal) directive for the authorization of complex systems, which will simplify the permit process for modern systems.

6.2.2 Dimensions and weights

The situation regarding adaptations to the regulations on dimensions and weights appears to be less flexible. These regulations significantly affect vehicle design concepts, and it is important for any changes in these regulations to be announced well in advance, because of the major impact at the capital investment level.

The extended flexible front underrun protection system is discussed above under 5.3.4. This approach towards enhanced road safety performance could make a real contribution to reducing the number of fatalities in passenger car / truck collisions. The implementation of the system requires a longer vehicle front structure. The total length of a truck is laid down by law, i.e. the introduction of this protection system would be at the expense of cargo length, which would make trucks fitted with this safety system less profitable to operate. As pointed out several times in this report, the economic situation of haulage companies does not allow any increase in operating costs at present, and, accordingly, this safety measure would achieve only very low market penetration rates.

6.2.3 Action priorities

For all OEMs, it is crucial to have an official statement from the European Commission on whether, and in what way, the Commission is considering changes to the provisions on dimensions and weights, as the basis for the design of future products. At any given time, one or other of the OEMs is working on developing future vehicle design concepts, which involves significant capital investment commitments, and such a statement should therefore be issued as soon as possible.

The implementation of the horizontal approach for the authorization of complex systems is to be supported.

6.3 Research priorities

The Working Group was not primarily concerned with formulating research priorities for safety systems, once it became clear that the priority was for the effective implementation of already developed technologies rather than further development work. The Group's investigations did, however, reveal a number of gaps which should be addressed by future research funding decisions.

6.3.1 Accident research for heavy duty vehicles

As clearly shown in section 4, the data required for any quantitative evaluation of the benefits gained from safety systems are not available at present. For the continuing development of safety systems and, where applicable, to ensure the appropriate allocation of future capital investments, a European database for commercial vehicle accidents should be set up. This is not just a matter of accumulating and compiling the statistics of all member states; it will also be necessary to introduce uniform classification parameters. Along with the creation of a comparable body of statistics, it will also be important to set up a European database of reconstructed accidents, since reconstructions are often the only way to identify the action priorities for the further development work on the vehicles.

6.3.2 Technology

A number of issue-based measures were rated as having a high potential for enhancing the road safety performance of heavy duty vehicles, but in each case one of the obstacles to their introduction is that the required level of technical maturity has not been reached. These systems are identified in the following table, along with the outstanding issues.

Measure	Outstanding issues
Commercial vehicle tires	For profitability and environmental reasons, commercial tires are optimized for low wear and low rolling friction. Because of the characteristics of the materials used, this optimization is achieved at the expense of brake friction. In order to bring the braking performance of commercial vehicle tires into line with that of passenger car tires, the braking characteristics of commercial vehicle tires would have to be optimized while retaining the same levels of rolling friction and wear.
Intersection assistant	Intersection accidents are a prominent accident scenario for trucks (and cars). Studies show that autonomous vehicle systems are not a viable approach for reducing the incidence of intersection accidents, because of their very diverse nature. The research objective should be to develop a cooperative system in which the driver is warned of an impending accident by the infrastructure.
Inter-vehicle communication	The ultimate approach for the prevention of traffic accidents is inter-vehicle communication, where the vehicles exchange data on their planned trajectories, and collision avoidance strategies are applied in the vehicles. The research objective should be the specification of such a system and development of an implementation strategy.
Pedestrian protection system	The authorization of close-range radar will make initial approaches for cars available on the market in the near future. The use of this type of approach for the special requirements of commercial vehicles has not yet reached the technical maturity stage. The research goal would be to specify a system for monitoring the heavy duty vehicle driver’s blind spot areas, in order to prevent accidents involving pedestrians and cyclists.
Emergency braking system	The research goal would be to extend known emergency braking systems to cover accident scenarios with stationary obstacles and oncoming other parties.

Table 4: Research priorities.

7 Acknowledgements

As Chairman of the Working Group, I would like to express my thanks to the members for their intensive, but always constructive and committed input. Their contributions are made all the more impressive by the fact that all their work, as well as the data made available by the various parties, has been provided without financial remuneration. I am particularly grateful that, in spite of all our conflicting interests in the highly competitive heavy duty vehicles market, all members have demonstrated their commitment to achieving a remarkable outcome.

Special thanks are also due to the members of the “accident data survey” sub-group, whose results are reported in section 4 of this report.

We are grateful for the constant support for the Working Group from representatives of the European Commission. I would specifically like to mention Mr. André Vits and Mr. Juhani Jääskeläinen by name in this regard.

Valuable input was received from our colleagues in the “Implementation Roadmap” and “Accidentology” working groups, and we would like to express our gratitude to them, and also to acknowledge their results.

The actors and institutions involved have long been aware of the issue of providing appropriate incentives for safety systems, and the Working Group is extremely pleased to note that this is to be addressed as a priority matter in the near future. In particular, we welcome the work done by the eSafety project on the implementation of an incentives scheme. Especially worthy of attention is the document entitled “Incentives Schemes applied by the Member States in the Transportation Sector: Towards the Design of a Strategy to Support the Adoption of Safety,” archived under www.escope.info. The statement includes the following statement from FIA President Max Mosley, which is the perfect way to end this report:

> “As yet there have been no fiscal incentives for safety related products. This is a serious omission that is unnecessarily delaying the introduction of vehicles that can save lives on our roads today. If consumers can have tax breaks for cleaner cars, why not safer cars too? After all, safety should really be considered as another aspect of a healthy and sustainable environment.”

Sources
[1] www. Shell-international.com
[2] www.ntsb.gov/events/symp_rec/proceedings/authors/kowalick.htm
[3] www.iru.org

Appendix [1] Recommendations
Appendix [2] Extract from scoring table

Appendix [1] - Recommendations

Recommendation Part

3.4 Heavy Duty Vehicles

The differences between passenger cars, vans and heavy duty vehicles give a need for a special treatment to ensure a further increase of vehicle safety of heavy duty vehicles.

Due to the high mass of heavy duty vehicles the avoiding of accidents (primary safety) should have a higher priority than the reduction of accident consequences (secondary safety). Surely the combination of both measures will have the highest impact in reducing fatalities.

The broad market penetration of available or ready to market vehicle safety systems is hindered by a missing business case.

The current regulations for masses and dimensions hinder, if the load length should be kept, the introduction of an advanced passive safety system.

The member states therefore should

(1) promote the market penetration of safety systems by granting incentives,

(2) agree in a harmonized approach for additional length and weight for a passive safety system.

Page 41 – corrected on the table the words “Working Group”.
Row 15 changed “thirt party” to “third party”
Row 11 changed “his alertness” to “their alertness”

Action Items for the EC

	Commission Action	Explanation / Progress
12	The Commission will actively promote the introduction of incentives for Safety Systems in Heavy Duty Vehicles (HDV).	The main obstacle for the introduction of safety systems in the market for HDV is the cost aspect. The Commission will promote the introduction of incentives for Safety Systems that affect main accident fields. Incentives may be the adoption of taxes and tolls or other non financial advantages.
13	The EC will urgently clarify whether or not it will adopt legislation on mass and dimensions for a time frame of 2008 to 2012 to support an advanced passive safety system.	A Safety System that may have significant impact on fatalities is the Extended Flexible Underrun Protection Device. The Extended Flexible Underrun Protection Device needs an extension of 300mm of the vehicle length and an additional weight of 100-150 kg. The extension of the length and the additional weight need a change of the legislation (mass and dimensions) to be successful in the market. This change of legislation should allow additional length and weight as long as particular crash compatibility is achieved.
14	The Commission will investigate the socio economic impact of high rated Safety Systems for Heavy Duty Vehicles.	Taking main accident fields for HDV into account the following Safety Systems may contribute significantly in the reduction of fatalities: Primary Safety: High Performance Braking Systems, Emergency Braking System, Vulnerable Road User Detection, Warning and Braking system, Intersection Assistance, Inter Vehicle Communication Secondary Safety: Extended Flexible Underrun Protection Device
15	The EC will promote further investigations on heavy duty vehicle accidentology in order to achieve comparable data bases.	

Appendix [2] – Extract from scoring table

	Safety Measures Working List - eSafety Working Group Heavy Duty Vehicles Market Introduction 2004 or earlier				Portfolio				
	Safety Measure	**Short description**	**Accident Type (primary) / normal driving**	**Introduction Obstacle**	**Customer Acceptance**	**Effectiveness- low**	**Effectiveness- high**	**System Costs**	**Engineering Costs**
1	ESP for semitrailer trucks, slippery conditions	Stabilize vehicle by single wheel braking when yaw-rate does not reflect the steering angle	single truck accidents	costs	0	0,5	1	1	1
2	Rollover Protection for single trucks and semitrailer trucks	Stabilize vehicle by single wheel braking when speed and steering angel causes threat of roll over	single truck accidents	costs	0	0,5	1	1	1
3	Lane departure warning system	Driver warning if vehicle is likely to leave the lane	single truck accidents	costs	0	0	1	2	2
4	Adaptive Cruise Controll	Controlls distance to vehicle in front	normal driving / rear end collisions	costs	0,5	-1	0	0	0
6	Flexible Front Underride Protection	Activates car crumble zone in case of a front crash	Car/Truck accident	costs	-1	0,5	1	2	2
8	Lane Change Assistant	Driver warning if vehicle is likely to hit other vehicle in case of a lane change	Car/Truck accident	costs	0	0	0,5	1,5	1
9	Backing assistance /video or ultra sonic based	Alert if obstacle occurs while backing	general approach/normal driving	costs, responsibilities, harmonization of interface	0,5	-1	-1	1,5	1
10	Seat Belt Warning	Warning to driver, if vehicle is starting and belt is not properly fixed	general approach	user acceptance	-1	1	1	2	2
11	Driver Alertness Monitoring, Driver Drowsiness Monitoring, Health monitoring	Monitor drivers behaviour to gain information about their alertness	normal driving	Maturity, liability, customer acceptance	-1	-1	0,5	0	0
12	Event data recorder	Store vehicle data in case of an accident	general approach	user acceptance, cost	-1	-1	0	1,5	2
13	On Board Diagnostics	Measure the vehicle health status	general approach		1	-2	-2	2	2
14	Runflat Indicator / Tire Pressure Monitoring System	Driver warning if tyre runs flat	general approach/normal driving	costs	1	-2	-1	1	1
15	Service-/Assistance Call	Service provided by OEMs and third parties	general approach/normal driving	costs	0,5	-2	-2	1	1
16	interactive driver training	give feedback to driver about his behaviour	general approach/normal driving	costs	1	1	2	0	2

	Safety Measures Working List - eSafety Workinggroup Heavy Duty Vehicles				Market Introduction				Portfolio				
	Safety Measure	Short description	Accident Type (primary) / normal driving	Introduction Obstacle	2004 and earlier	2004 to 2008	2008 to 2012	later	Customer Acceptance	Effectiveness- low	Effectiveness- high	System Costs	Engineering Costs
1	tyre improvement	increase tyre/road friction	general approach/normal driving	costs				X	-1	1	2	-2	1
12	Emergency Braking System	driver warning and/or emergency braking in case of rear end collision	Car/Truck accident	costs		X			0,5	1	2	0	0
12a	Emergency Braking System stat. Reflections	driver warning and/or emergency braking in case of front/front collision	Car/Truck accident	maturity, costs			X		0,5	1	2	0	0
13	Emergency Braking System +	driver warning and/or emergency braking in case of front/front collision	Car/Truck accident	maturity, costs			X		0,5	2	2	0	0
14	Vulnerable Road User detection, warning and braking system	system sensors and data processing sensible to vulnerable road users	Vulnerable road users	maturity, costs,			X		0,5	1	2	0	0
18	Extended Flexible Front Underride Protection	Activates car crumble zone in case of a front crash	Car/Truck accident	costs, legal issues,			X		-1	1	2	2	-2
38	Inter vehicle Communication	Driver warning if other vehicle seems to hit own trajectory	general approach	maturity, introduction concept				X	0	1	2	-1	-2
40	Intersection Assistance /Infrastructure	Driver warning in case of risk of upcomming intersection accident	Car/Truck accident	Infrastructure, costs, maturity				X	0	1	2	1	-2
51	interactive driver training	give feedback to driver about his behaviour	general approach/normal driving	costs	X				1	1	2	0	2