

SAFETY OF LIGHT GOODS VEHICLES – FINDINGS FROM THE GERMAN JOINT PROJECT OF BAST, DEKRA, UDV AND VDA

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ABSTRACT

Light goods vehicles (LGVs) are an important part of the vehicle fleet, providing a vital component in the European transportation system. On the other hand, LGVs are in the focus of public discussion regarding road safety. In order to analyse the accident situation of LGVs in an objective manner, Federal Highway Research Institute (BAST), VDA, DEKRA and German Insurers Accident Research (UDV) launched a joint project. The aim of this project, which will be finished by mid of 2011, is to identify reasonable measures which will further improve the safety of LGVs. For the first time, these partners jointly together conducted a research project and put together their know-how in accident research. Analyses are based on real-life accident data from the GIDAS database, the Accident Database of UDV (UDB), the DEKRA database and national statistics. The findings deliver answers to questions within the arena of future legislative actions and consumer protection activities.

The analyses of databases cover areas of primary and secondary safety of LGVs with a special focus on advanced driver assistance systems (ADAS), driver behaviour as well as partner and occupant protection. Key figures from national statistics are used to highlight hotspots of accidents of LGVs in Germany. Finally, the proposed countermeasures are assessed regarding their potential effectiveness.

Amongst others, the results show that the accident situation of LGVs is very similar to that of passenger cars. Noteworthy variations could be found in collisions with pedestrians, at reversing and regarding accident causes.

Occupant safety of LGVs is on a higher level compared to cars. Results indicate that seatbelt use is on a significantly lower level compared to cars. This leads to higher-than-average injury risk for unbelted LGV occupants. When it comes to partner protection, there are problems with compatibility at LGVs. For car occupants there is a very high injury risk when colliding with a LGV. It indicates that higher passive safety test standards for LGVs would be counterproductive if they further increase stiffness of LGVs.

The analysis of LGV-pedestrian accidents shows that pedestrian kinematic differs significantly from car-pedestrian accidents. At this point, existing pedestrian related test standards developed for cars can not be adopted to LGVs. When it comes to active safety, ESC proved its effectiveness once again. Beyond that, rear view cameras, advanced emergency braking systems and lane departure warning systems show a safety potential, too.

In addition to any technical countermeasures previously discussed, the importance of the driver behavior and attitude regarding the accident risk was investigated. In order to develop successful actions it is important to understand the main target population. In the case of LGV especially the crafts business and

smaller companies are the major contributors the safety issue.

INTRODUCTION

The LGV (also known as van) has established itself as a link in the supply chain between logistic centres and the retail trade or end consumer. However, the LGV is also a mainstay in fast and flexible long-distance cargo and goods transport as well as in courier and delivery services. As LGVs have become increasingly relevant on the road other road users have automatically began to take more notice of these vehicles. Over the years this has generated to a discussion about the safety of these vehicles in the media, political circles and the population that has not always been objective.

All efforts should be undertaken to reduce the accident risk of LGVs further and to enhance the safety of occupants and other road users. To derive suitable measures for improvement it is, therefore, important that the accidents involving LGVs are analysed in detail. To do this, the Federal Highway Research Institute (BASt), the German Insurers Accident Research (UDV), DEKRA Accident Research and the Association of the Automotive Industry (VDA) teamed up to set up a joint research project.

The GIDAS database, the UDV database, and DEKRA data as well as national statistics were examined. Thus empirically reliable and meaningful data on LGV accidents was extrapolated. The focus was placed on active and passive safety, with special emphasis placed on advanced driver assistant systems, occupant and partner protection as well as driver behaviour.

DATA BASIS

Several accident databases were trawled for data for the research project. These are described below.

Official Road Traffic Accident Statistics

Federal statistics are continuously maintained on accidents in which fatalities or material damage have

been caused as a consequence of road traffic on public roads and open spaces. They serve to produce an up-to-date, comprehensive and reliable database on the structure and development of road accidents [1].

LGVs are not considered a separate category of vehicle and are not registered as such in the police accident record. Information on the vehicle type and permissible total weight provided by the Federal Motor Transport Authority (KBA) enables LGVs to be identified in the official statistics data. The data basis for LGV accidents is consequently composed of individual data from the official road accidents statistics supplemented by the central vehicle register of the Federal Motor Transport Authority. For this reason the data material solely comprises LGVs registered in Germany, the registration plates of which can be clearly identified.

GIDAS Database

GIDAS (German In-Depth Accident Study) is a joint project conducted by the Federal Highway Research Institute (BASt) and the Research Association of the Automotive Technology (FAT) of the VDA. The project makes available detailed and statistically representative data of real-life road accidents in Germany.

The GIDAS project originates from the accident research team of the Hanover Medical School (MHH), which has examined and documented accidents on behalf of the BASt since 1973. In 1999 the catchment area was expanded to the Dresden conurbation. The survey was carried out there by the Road Accident Research Unit of the Technical University of Dresden (VUFO GmbH). The survey criteria are:

- Road accident
- Accident location in the conurbation of Hanover or Dresden
- Accident during a survey shift (specific random sample scheme)
- At least one person injured

A team is on standby on every shift to record the accident data and contains two technicians, a doctor and a coordinator.

The GIDAS project has recorded around 3,000 individual facts on each of approximately 2,000 accidents annually since 1999. The GIDAS Database

currently comprises 18,990 accidents with 33,661 involved vehicles and a total of 47,315 persons of which a percentage were injured.

The following data is recorded at the site of the accident and in its aftermath:

- Environmental conditions
- Type of road, traffic regulation, building features
- Vehicle deformations
- Impact locations of occupants or other road users
- Key technical data such as vehicle type and technical equipment
- Crash information and key data (collision and travelling speed, delta-v and EES, deformation depths)
- Circumstances of the accident and accident causes
- Person-specific data such as weight, size, age, etc.
- Injury pattern, preclinical and clinical treatment

The recorded data and reconstructed accident sequences are stored in an anonymous format in a database for future reference by the project members. It is augmented by extensive images of the vehicles involved, accident site and the injuries.

The defined random sampling procedure and the use of weighting factors enables the GIDAS Database to give a representative reflection of those national accident statistics involving personal injury. The number of cases is so high that statistically significant results can be achieved. The high level of detail of the cases also enables in-depth investigations.

Accident Database of German Insurers Accident Research

The evaluated case material of the UDV is primarily comprised of the claims files of the insurers that are routinely drawn on a random sampling basis from the total number of all third party liability claims in Germany for the purpose of conducting accident research. The LGV accidents here are accidents involving personal injury and damage of at least €15,000. They took place during the period 2001 - 2006.

A few cases (approximately 5%) come from an overall survey of all heavy commercial truck accidents (involving at least one fatality or serious injury), that took place in Bavaria in 1997 as well as from a collection of reconstructed accidents of vehicles equipped with Event Data Recorder (EDR) involved in accidents in Berlin between 1998 and 2006.

The contents of the claims files vary from case to case but are generally made up of the following sources of information:

- Accident reports from the police
- Statements from accident involved parties and from witnesses
- Accident reconstruction
- Vehicle damage expertise
- Pictures of the accident site and of the vehicles
- Medical reports submitted by doctors and hospitals with descriptions of injuries and period of hospitalisation
- Correspondence between the lawyers
- Court judgement

The accident database (UDB) of the UDV contains as of October 2009, 4,496 accidents with 8,161 victims.

DEKRA Accident Database

DEKRA maintains a national network of road accident analysis experts. Accident reconstruction reports are prepared primarily for the courts, public prosecution services, police and insurance companies. DEKRA Accident Research has access to these reports.

The cases were selected on a random basis, analysed and added to an accident database. The data sets contain an extremely high level of technical information; information on the injuries suffered by those involved is usually of a more basic nature. The cases as a rule contain:

- Accident reports from the police
- Statements from accident involved parties and from witnesses
- Accident reconstruction
- Vehicle damage expertise

- Pictures of the accident site and of the vehicles
- Special appraisals (lights, tachograph evaluation, tyre appraisal, determination of the cause of fire)

The database currently contains about 3,000 accidents.

GENERAL ANALYSIS

There are distinct differences in the longer-term development of accidents in Germany within the LGV category. As part of the process of harmonisation of the legal regulation within the EU, key changes were made to the motor vehicle sector in 1997. As a consequence both the number of vehicles as well as the accident involvement of commercial vehicles over 2.8t - 3.5t rose dramatically at the same time. Therefore, the vehicles were subdivided into the following subgroups based on the registration-related information of the KBA and the permissible total weight:

- Small LGVs up to 2t (permissible total weight up to 2,000kg)
- LGVs over 2t to 2.8t (permissible total weight 2,001 - 2,800kg)
- LGVs over 2.8t to 3.5t (permissible total weight 2,801 - 3,500kg)

In addition, trucks over 3.5t - 7.5t were included in the investigation as a comparison group.

Analysis of the German national statistics

With 6,323 LGVs over 2.8t - 3.5t permissible total weight in 2006, the number has increased 3.6-times in comparison with 1996 (1,733 vehicles). The greatest rise took place between 1997 (1,892 vehicles) and 2001 (5,273 vehicles), Figure 1.

The significance of the accident involvement of these LGVs related to the total amount of accidents is comparatively low at 1.9 per cent (2006).

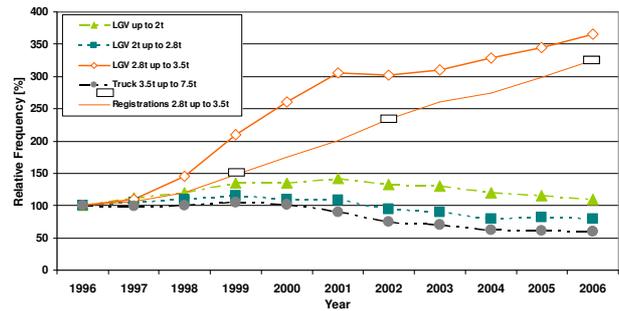


Figure 1. History of the figures of accidents with injuries involving LGVs up to 3.5t and of the comparison group, trucks between 3.5t and 7.5t; history of the figures of registrations in Germany LGVs 2.8t up to 3.5t. 1996 = 100%.

A subdivision of the accident involvement of LGVs over 2.8t - 3.5t according to location reveals that a greater increase was recorded on the motorway than in urban environments and on country roads. The trend changed from 2001, Figure 2.

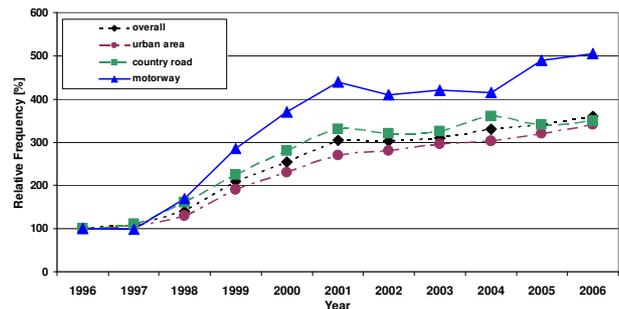


Figure 2. History of the figures of accidents with injuries involving LGVs from 2.8t to 3.5t subdivided by location. 1996 = 100%.

A total of 5,091 persons died on Germany's roads in 2006 (1996: 8,758; 2001: 6,977). The number of fatalities in accidents involving LGVs over 2.8t - 3.5t has increased from 50 in 1996 to 132 in 2001. In 2006 111 fatalities were registered. In contrast the number of fatalities in accidents involving LGVs over 2t - 2.8t for the same period fell significantly, Figure 3.

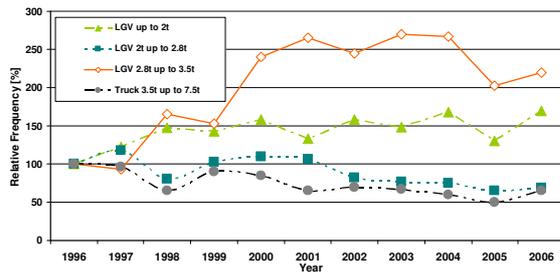


Figure 3. History of the figures of fatalities resulting from accidents involving LGVs up to 3.5t and of the comparison group, trucks between 3.5t and 7.5t. 1996 = 100%.

The continuing rise in the number of LGVs over 2.8t - 3.5t differs considerably from the development in the comparison groups. The stock of 164,000 vehicles rose during the period 1997 - 2006 by 234% to around 548,000 vehicles. In contrast, the development of the stock of comparison groups displayed only minor changes.

The number of vehicles is a major factor in the accident involvement (accident involvement per 1,000 registered vehicles). The accident involvement of LGVs over 2.8t - 3.5t differs from those in the comparison groups. It rose starkly from 1997 (10.9 participants per 1,000 vehicles) to 15.9 participants in 2001. This figure suggests that the accident involvement is falling continually and achieved with 11.5 participants in 2006 a more favourable figure that is only slightly above the level of 1997, Figure 4. In comparison, the figure for cars in 2006 was with 8.8 participants lower.

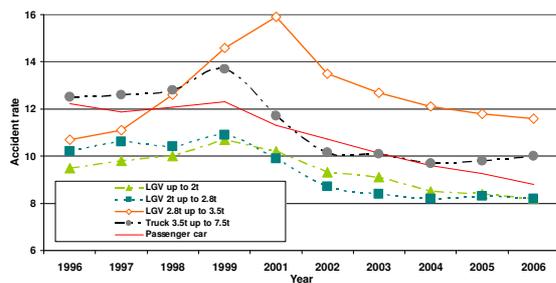


Figure 4. History of the accident rate figures (involved per 1,000 registered vehicles) of LGVs up to 3.5t and of the comparison group, trucks between 3.5t and 7.5t.

Overall, it can be determined that the sharp rise in the accident figures up to 2001 has not continued after 2001 although the number of LGVs over 2.8t - 3.5t has continued to increase significantly.

In-depth analyses

A consideration of the impact areas reveals that cars and LGVs display no significant differences. The analysis of the databases also reveals no relevant deviations. Over 70% of the cases were limited to one impact. Collisions with the vehicle front are the most commonly recorded, Figure 5.

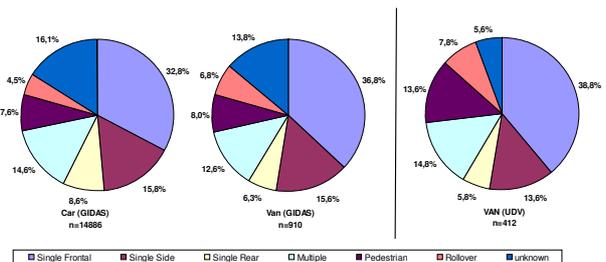


Figure 5. Impact type (Source GIDAS, UDV).

In line with its frequency on the road, the car represents the main accident opponent both for cars as well as LGVs. Its share is about 50%. In around 30% of cases the vehicles collided with unprotected road users, i.e. pedestrians or cyclists, Figure 6.

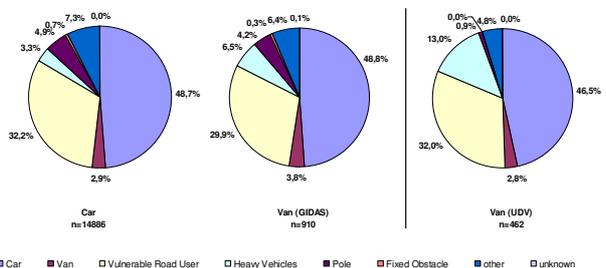


Figure 6. Impact opponents (GIDAS, UDV).

An analysis of the GIDAS data shows that the speed with which car and LGV collide either frontally with a vehicle ahead, or with an oncoming car or LGV is virtually identical. In contrast, there are significant deviations in the change in delta-v caused by the collision. The comparatively greater mass of the LGV means that delta-v here is lower, Figure 7.

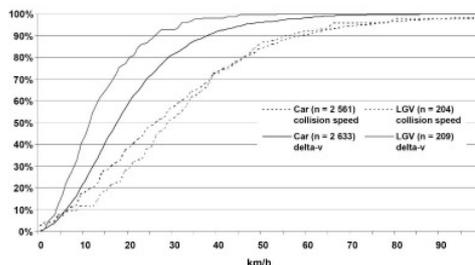


Figure 7. Impact speeds in single frontal impacts against cars or LGVs and the resulting delta-v (GIDAS).

However, if it is a rear-end collision, the comparison of the delta-v figures display no significant differences, Figure 8.

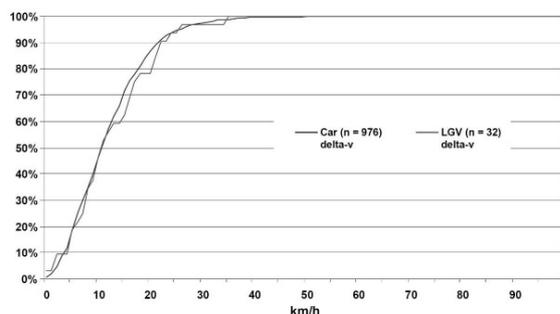


Figure 8. Delta-v in single rear impacts with cars or LGVs (GIDAS).

PASSIVE SAFETY

Seat belt and injury severity

DEKRA Accident Research has recorded the percentage of commercial vehicle drivers making use of their seat belts depending on vehicle type and location since 1999. Since 2004 the N1 vehicles have been recorded separately. Over the years the percentages have gone up and down, but two factors can be clearly discerned: The percentage of N1 vehicle drivers wearing their seat belt is significantly lower than that for car drivers and the figure rises with increasing road class. Whereas 63% to 71% drivers use their seat belts in urban environments, the figure for outside town is 67% to 79% and on the motorway between 76% and 84%. These are, depending on location, up to 15 - 20 percentage points lower than for a car [2].

These findings equate well with those of the GIDAS Database. Here the figure for front occupants using a seat belt is about 80% (~ 16% unknown). The UDV data pool puts the number of unknown classified cases as very high. The analysis would suggest a somewhat lower belting-up percentage, Figure 9.

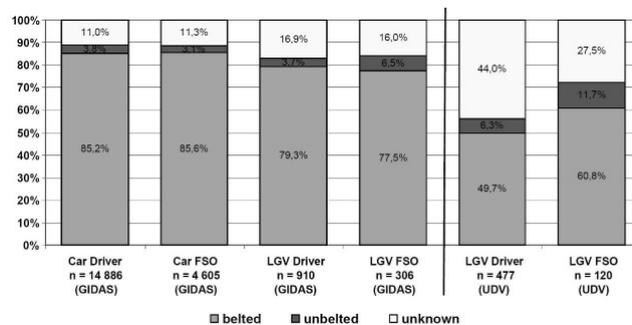


Figure 9. Safety belt usage of front seat occupants (GIDAS, UDV).

When the injury severity is considered and related to the wearing or non-wearing of a seat belt, the effectiveness of the seat belt as a passive protection element becomes apparent as it influences the injury severity quite significantly. Likewise, it can be seen that the risk of injury for LGV occupants is lower than that for car occupants, Figure 10.

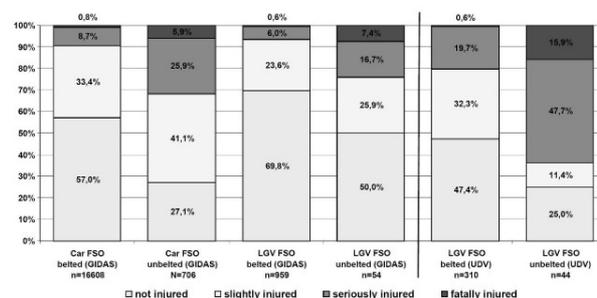


Figure 10. Injury severity by safety belt usage if known (GIDAS, UDV).

Possible measures to improve the percentage of drivers wearing a seat belt are:

- Driver instruction
- More intensive monitoring
- Seat belt reminder

The risk of suffering cervical spine distortion also differs significantly greater in a rear collision. While this injury is suffered by 42.2% of belted front car occupants, the figure for LGV occupants is around 25% (GIDAS data). If all LGV occupants were

included, the figure would be even lower. The test procedures used to evaluate seat systems on cars are of less relevance for LGVs.

Compatibility

Apart from the protection of the vehicle's own occupants, the protection of other road users also plays an important role. This means, for example, that the safety systems of a small car must also be able to function effectively in a collision with a LGV. If, however, differences in height between the vehicles lead to an over- or underrun, not all the safety reserves can be fully exploited. Excessively rigid structures can increase the risk of injury for the other occupants as it means that greater energy needs to be transformed. The differences in mass have a special role to play in this respect. As regards pedestrian protection, both structural rigidity in the frontal region as well as the shaping of same need to be given consideration.

In a collision between a car and a LGV, the risk of injury for a car occupant wearing a seat belt is considerably higher than for the LGV occupant wearing a seat belt, as Figure 11 shows. The UDV figures also support this findings. The percentage of car front occupants wearing seat belts with MAIS2+ injury is at 35 per cent significantly higher than on LGVs (11%).

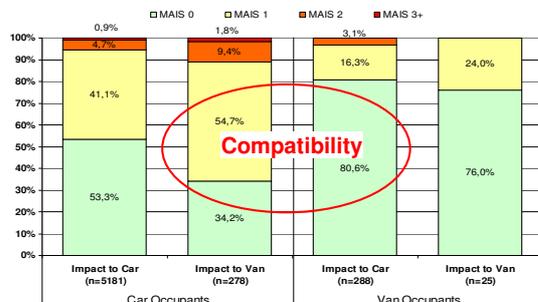


Figure 11. Injury severity of belted front seat occupants in single impacts between cars and LGVs (GIDAS).

The above-mentioned information shows that a common interaction zone in the frontal impact area would have a far greater benefit than the expansion of the ECE-R94/95 to LGVs. A higher test speed (such as, for example, for consumer protection tests) would, in contrast, lead to interventions in the vehicle structure that, in turn, would lead to an increase in the injury risk for accident participants with smaller

vehicle – and thus the majority of the other road users.

Pedestrian accident

The accident kinematics differ considerably and are caused by the different shaping of the vehicle front of car and LGV. While 56% of the pedestrians colliding with the front of a car are raised up onto the vehicle, about 75% are ejected away in a LGV collision.

This fact means that the relevance of the injury-causing parts and, in particular, the impact with the ground are particularly important. According to a study conducted by Road Accident Research Dresden (VUFO) entitled “Scope Extension on Pedestrian Legislation” around 50 per cent of head injuries can be traced to this ground impact [3]. In contrast, a GIDAS-based study found that the contact with the front bumper leads to fewer than 6% of all injuries.

The different distribution of injuries in car and LGV accidents is shown in Figure 12. This makes it clear that collisions with a LGV lead to more serious accident injuries than with a car. Leg injuries, however, occur more frequently in pedestrian-car collisions.

The findings show that application of the test procedure used for cars on LGVs would bring about no improvements in collisions involving pedestrians. Suitable test procedures have not been devised so far.

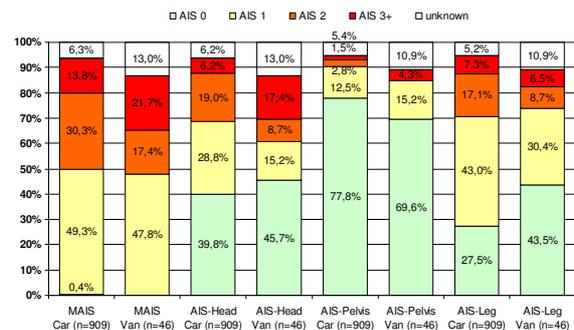


Figure 12. Injury severity of pedestrians in car or LGV impacts (GIDAS).

ACTIVE SAFETY

It is necessary to know the circumstances and causations of accidents first before being able to answer the question of avoidance and mitigation. To better understand the main accident pattern of LGV, only crashes were considered where the LGV driver was responsible for the collision. The development of potential safety benefits was done on this basis. This leads to a conservative estimate of the potential benefit, due to the fact that some systems might also be beneficial in LGVs, which are involved in accidents as the non guilty part. 4.7% of all accidents in the GIDAS database were caused by LGV. These 4.7% can be separated in four main accident scenarios (Figure 13): rear-end collisions predominate with 26%, followed by turn into or crossing accidents (21%) and loss of vehicle control accidents (17%). Accidents when reversing form the fourth major accident scenario with 6%. This order is also seen by analyzing the accident data of the UDV database.

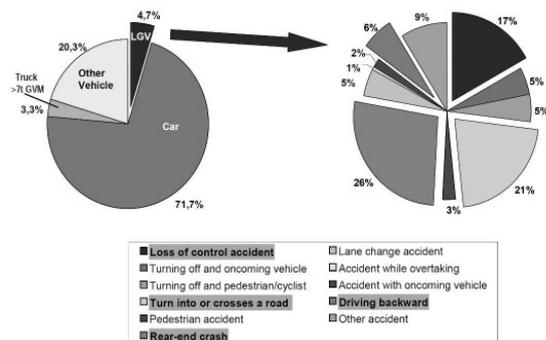


Figure 13. Shares of main causers (left, n = 11,694) and accident scenario of LGVs (right, n = 550) (GIDAS).

Rear end collisions

In terms of rear-end collisions, the accident pattern of LGV does not significantly differ from the one of cars and trucks. Rear-end collisions caused by LGVs are characterized by driving into a moving vehicle ahead, driving into a traffic jam and a collision with a vehicle that was stationary due to road signs traffic control or due to traffic lights.

These three collision types cover between 85% (GIDAS) and 95% (UDV) of all rear-end collisions

of LGVs. Technologies that could address these accident scenarios have not been developed for LGV.

About 37% (source GDV) of the rear-end collisions caused by LGVs might be avoided or mitigated if all LGV would be fitted with an advanced emergency brake system that assists the driver in the pre collision phase of a potential crash against moving and stationary two-track vehicles. Further preconditions like an ideally responsive driver and partial pre braking by the system must be fulfilled to reach this quota. These are 9% of all accidents in the UDV database caused by LGV drivers and represent 0.7% of all accidents. It was always assumed in case of a real accident the driver would properly respond to the warning of the system with braking (ideal driver behavior). In cases where the driver showed no initial reaction, the partial braking of the system was used to determine the potential benefit. If we extend the analysis to the data where an LGV was involved in a rear end collision irrespectively if guilty or not (include accidents where the LGV driver could not avoid the collision, e.g. the car in front suddenly and without reason slowed down or cut in situations from the adjacent lane), 43% of the rear-end collisions involving LGVs might be avoided or mitigated (based on the UDV data only). Compared to the figures above, this underlines the conservative nature of this analysis method.

Accidents while turning into or crossing a road

Accidents caused by LGVs while turning into or crossing a road are ranked second of the main accident scenarios with 21%. Another focus is the crossing of pedestrians and cyclists. However, it must be noted that from a general perspective these accident scenarios could not be covered by technical countermeasures, based on currently available vehicle technologies. It is more important to train the awareness of driver for such critical situations.

Loss of control accidents

The LGV loss of vehicle control accidents (LGV driver responsible) correspond to 17% of the main accident scenarios. As defined, the accident caution is based on the fact that the driver lost the control over the vehicle. These are mainly cases where the vehicle left the carriage way to the left or right side or had an unstable driving condition before the first impact. A

comparison of vehicles shows that a higher share of cars has to leave the road in a bend than trucks or LGVs. For trucks and LGVs it is more common to leave the lane on straight roads. In addition, a further comparison of the vehicles categories shows that cars had more often unstable driving conditions before the event than LGVs and trucks.

The GIDAS analysis showed that in about 50% of all driving accidents caused by LGVs an unstable driving condition was reported. In the UDV dataset, this figure raised to 70%. These accidents could be positively influenced by an ESC system. This would mean that 7% of all UDV accidents and 8% of all GIDAS cases could be addressed. According to an UDV estimation, ESC might address approximately 20% of the seriously and fatally injured persons in accidents caused by LGV. The consideration of only one specific group of accidents - which is the case when using the definition of a certain type of accident (as done here) - means a restriction in the analysis and leads to a conservative estimation in the same way as the restrictive view in terms of the accident causer does. In general, this should be kept in mind when analyzing the potential benefit of driver assistance systems. This is true even if this type of accident is clearly dominant (see driving accident and ESC). Taking also into account all involved LGVs and other ESC relevant accidents from other types of accident, the potential target group will increase to 10% based on the UDV analysis.

Loss of vehicle control accidents could be positively affected by an ESC and / or a lane departure warning system. This has been demonstrated by the results of a study carried out by Daimler [4]. With the standardization of ESC, the Mercedes-Benz Sprinter showed meaningful results in before-after studies based on the official statistics in Germany. It was found that the number of traffic accident involvement of the Sprinter was reduced due to ESC by one third.

The driving accident is not only characterized by an instable vehicle condition before impact, but also by the unintended lane departure. This circumstance could be addressed by lane departure warning system (LDW). The following assumptions were made to perform the analysis:

- The initial speed of the LGV involved was higher than 60 km/h
- At least one visible road marking was present (at the side of the lane departure)

- All types of white lane markings are detected by the system
- An ideal driver responds immediately and correctly after being warned
- The system will not operate under the following conditions:
 - o Lane marking other than white
 - o At road construction sites
 - o Curves with a radius below 200m
 - o Lane change maneuvers
 - o Road surface covered by snow

The real world data analysis implies, that such a generic lane departure warning system might address (provided an ideal reaction of the driver) up to 37% (GIDAS) and 30% (UDV) of all accidents where of the LGV driver caused the accident. This would mean 3% (UDV) and 6% (GIDAS) of all accidents caused by LGV. If the analysis is extended to other relevant accident types of UDV database, the results is 6% compared to 3% based on a conservative approach.

Expert opinions showed that for some accidents both LDW and ESC systems might show a potential benefit. Therefore the calculated potential target groups could not be added. Taking this into account, both systems might contribute to 76% (GIDAS) and 88% (UDV) of all driving accidents caused by the LGV driver. This figure represents 9% of all accidents where the LGV driver was responsible for the collision (UDV data) and respectively in 13% of the GIDAS cases.

It should be noted that the conservatively calculated potential benefits are maximum values which could never be achieved in the real world. In addition the figures are based on a 100% equipment of all LGVs with these systems. It is common knowledge that influencing factors like the human machine interface, weather conditions, switched off systems and inappropriate speed would further significantly reduce the benefit.

Accidents while reversing

The fourth major accident scenario is reversing. The comparison with other vehicles categories (cars,

trucks) show that in both datasets, GIDAS and UDV, the share for LGVs is higher for accidents while reversing. At least 6% of the LGV caused accidents can be attributed to the reverse. For both LGV models, LGVs with rear windows as well as without the accident type 713 [8] in which a pedestrian is crossing behind the vehicle, is the most common. Of these pedestrians, primarily the elderly (60 years and above) are affected. It needs to be further investigated if parking sensors or a rear view camera are beneficial to reduce the number of involved pedestrians.

DRIVER ASPECTS

From the accident analysis it becomes obvious that the users of LGVs play a determining role. This should be considered when handling traffic safety aspects related to LGVs. However, the consideration of driver aspects by means of an accident data analysis is only conditionally possible. That sets limits for the partners involved in this project. The group of LGV drivers is very heterogeneous and their driving behaviour is strongly affected by their working environment. The description of this group of drivers is the aim of a current research project which has been commissioned by the BAST [5]. This clearly illustrates that in order to be able to perform a conclusive causation analysis and to derive effective countermeasures in special, figures derived from accident analysis must always be seen within the context of the heterogeneous users groups and their working area.

Type of use and purpose of use

According to the analysis of the LGV accidents in the UDV database, a clear pattern is visible regarding the type of use and the purpose of use (Figure 14). Only 4% of the LGV drivers who caused the accident belong to a courier service. The majority of the LGV drivers who caused the accident were driving on behalf of a crafts business (66%), smaller companies and other tradesmen. Here, the business trip of the typical craftsman is dominating with a share of 32%. As one part of the analysis, this aspect corresponds approximately to the results from a study performed by the German Insurance Institute for Traffic Engineering in 2004 [6]. Besides this, private persons

using their own vehicle can not be neglected in this consideration either, as they have a share of 30%.

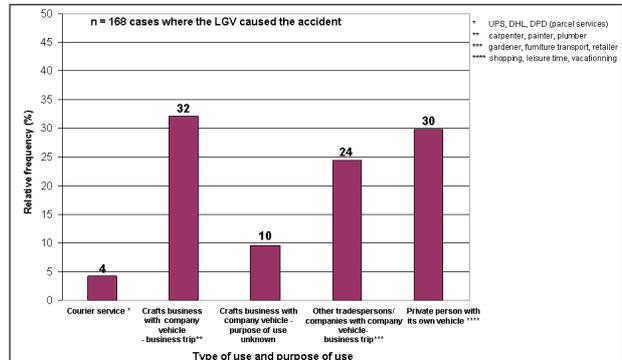


Figure 14. Tpe of use and purpose of use for LGVs that were responsible for the accident (UDV).

Driver attitude and behavior

A look at the age of the LGV drivers involved in accidents shows that drivers between the ages of 18 and 24 years have a share of 17% in the data of the German Insurers. Thereby, 78% of these drivers had caused the accident. The BAST analysis from 2008 shows that 74% of the involved LGV drivers between the ages 18 and 24 years were also the main accident causer [7], whereas the share of accident causing car drivers is clearly lower, accounting for 55%.

In order to evaluate the driver aspects, different driver attitudes and driver behaviours were analysed with the GIDAS database. Drivers who had caused an accident with personal injury were taken into consideration here. For example, information regarding age, pre-existing illnesses, medication, hours behind the wheel as well as driving experience with the respective vehicle type were investigated. Within the analyses, the groups of LGV drivers, passenger car drivers and truck drivers were compared to each other. Altogether, no noticeable differences between the groups could be found in so far as these could not be justified with the basic differences in the use of the vehicles within the groups. One example is the annual driving performance of the vehicle type used at the day of accident. This is shown for the drivers of passenger cars, LGVs and trucks in the following figure 15. Accordingly, as trucks are mainly used in long-distance traffic, their driving performance is higher than that of cars and LGVs.

Km per Year with this Vehicle

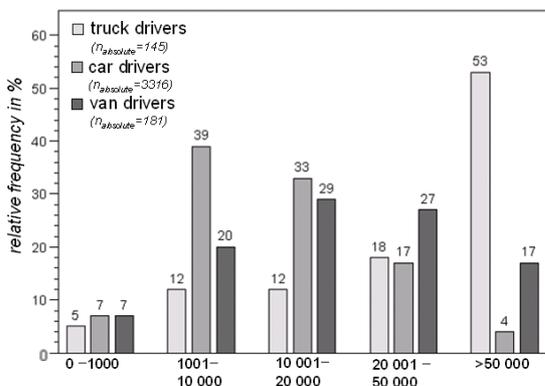


Figure 15. Annual driving performance of the three compared groups (GIDAS).

The issue of the time between the last break and the accident was also part of the evaluation. These analyses, along with the other investigated aspects, are based on interviews which were made with the involved drivers at the accident scene. As seen in the following figure 16, both for passenger cars and for LGVs, more than half of the accidents occur within 30 minutes after the last break or after beginning the journey. As expected, for truck drivers there is a shift in the time spent behind the steering wheel until the accident occurs, which means a longer travel time. For all three compared vehicle groups, it can be seen that only few accidents with personal injury are caused after journeys (without break) that last longer than 4.5 hours.

The Time since the Last Break of Car, Truck, Van Drivers

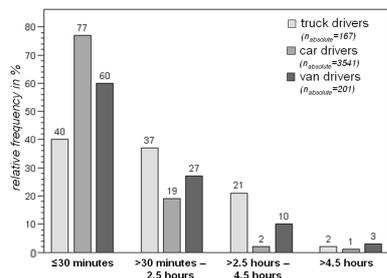


Figure 16. Time between the last break and the accident (GIDAS).

Accident causes

It could be shown by means of the accident analysis that some focal points regarding driver misconduct become visible for the accident causing LGV drivers. According to a BAST analysis from 2008 with respect to the accident involvement of LGVs, the most frequent category of accident cause is „insufficient safe distance“ (18%) together with the category „turning off from a road, turning, reversing, entering and starting up“. This category also accounts for approx. 18%, followed by the category “speed” (16%) [7]. On motorways, however, a clearly higher share could be identified for the category “speed” (approx. 35%). The figures analysed by the BAST are based on the police records which are filled by the police at the accident scene without using any detailed analysis. Especially for the issue “speed” (unadjusted speed, exceeding the maximum permissible speed), this allows only limited statements. At this stage, it is essential to integrate detailed accident data analyses in the study.

Accident causes on motorways

UDV data were used to determine the accident causes for those groups of LGV and car drivers who were found to be responsible for the accident. The type of use and purpose of use for the LGV were not taken into consideration here. In a single case study, the most relevant accident causes were identified. This was done each for accidents on motorways and for accidents on rural roads, following the definitions for an “accident cause” as used by the police. Thereby, it was taken into account that several accident causes can simultaneously be attributed to one involved party (e.g. “insufficient safe distance” and “inattentiveness/distraction”). Thus, from case to case it might result in a higher number of accident causes than officially recorded by the police. Regarding accidents on motorways, the same ranking in terms of the three most relevant accident causes was found both for the LGV and passenger car drivers (Table 1):

Table 1.
Accident causes on motorways (UDV)

Passenger car	%	LGV	%
„inappropriate speed“	31	„inappropriate speed“	46
„inattentiveness, distraction“	27	„inattentiveness, distraction“	12
„insufficient safe distance“	17	„insufficient safe distance“	10

For LGV and passenger car drivers who were responsible for the accident, figure 17 shows the main results from the analysis of the accident causes on motorways.

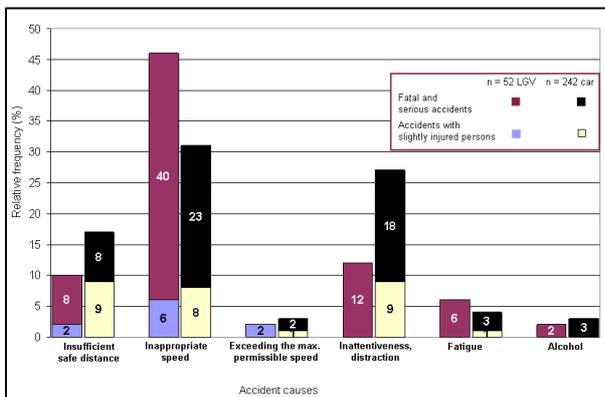


Figure 17. Comparison of the accident causes on motorways for LGV and passenger car drivers responsible for the accident (UDV).

It can be observed that for passenger car drivers the accident cause “insufficient safe distance” is 1.7 times more frequent than for LGV drivers. However, with regards to severe accidents, the share of this accident cause is 1.7 time higher for LGV drivers. The accident cause “inappropriate speed” is 1.5 times more frequent for LGV drivers and it also results in more severe accidents than within the group of passenger car drivers. In contrast, for passenger car drivers, the share of the accident cause „inattentiveness, distraction“ is more than twice as high as for LGV drivers, but it results less frequently in severe accidents. For both groups, “alcohol” and “fatigue” are under-represented in terms of their share, however they nearly always cause severe accidents. The higher injury severity which is generally found in accidents involving an LGV can

be explained with their higher vehicle mass in comparison to passenger cars.

Accident causes on rural roads

The results from the analysis of the accident causes on rural roads (non built-up areas without motorways) are shown in table 2.

Table 2.
Accident causes on rural roads (UDV)

Passenger car	%	LGV	%
„right of way / turning off from the road“	35	„inappropriate speed“	32
„inappropriate speed“	15	„right of way / turning off from the road“	29
„inattentiveness, distraction“	8	„inattentiveness, distraction“	17
„insufficient safe distance“	5	„insufficient safe distance“	11

According to table 2, for car drivers, the accident cause “right of way/turning off” predominates, accounting for 35%. For LGV drivers, this accident cause is the second most common accident cause with a share of 29%.

A summary of further findings from this analysis of accident causes on rural roads are depicted in figure 18.

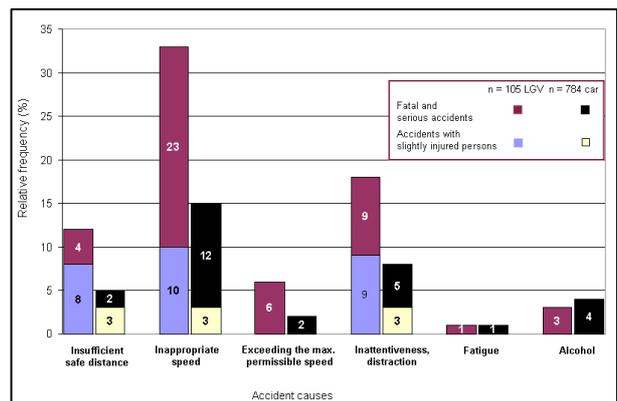


Figure 18. Comparison of the accident causes on rural roads for LGV and passenger car drivers responsible for the accident (UDV).

For the group of LGV drivers, the accident cause „inappropriate speed“ was found to be more than twice as frequent as for passenger car drivers. On rural roads, the share of the accident cause “inattentiveness, distraction” is twice as high for the group of LGV drivers. In terms of severe accidents, the relative frequency of this accident cause is slightly higher for car drivers. LGV drivers were found to keep „insufficient safe distance“ twice as often as car drivers. “Exceeding the maximum permissible speed” occurred three times more frequently for LGV drivers and for both groups these accidents always end up seriously. In absolute terms however, this accident cause does not belong to the three most common accident causes found for LGV drivers.

The analyses of the UDV accident data clearly demonstrate that on rural roads there is a strikingly visible accident causation behaviour among LGV drivers in comparison to passenger car drivers. This brings the LGV driver into the spotlight, thus setting him apart from car driver in this respect. One major focus that can be put here on the accident cause is „speed“. Compared to car drivers, LGV drivers are found noticeably often to travel “exceeding the maximum permissible speed“ or to travel with “inappropriate speed” on rural roads. Referring to all accident causes, however, only „inappropriate speed“ is of high relevance here.

This problem can be only partially addressed with the technical tools of road infrastructure and vehicle engineering. One can take preventive measures against “exceeding the maximum permissible speed” through more controls by the police. Also ISA-systems (Intelligent Speed Adaptation) may possibly offer a solution. But the more relevant issue of the “inappropriate speed” can not be addressed here, either by vehicle engineering or road infrastructure or by controls. The sensitisation and training of the LGV drivers and respectively of the responsible companies will build the focus regarding the field of action. The driver must become aware of the fact that, in terms of the general handling of its vehicle and especially in critical situations, the LGV with its cargo is not comparable with a car.

A further key area of focus refers to the accident cause „right of way / turning off from the road“. This accident cause is relevant both for LGV and for car drivers. Though, infrastructural aspects (e.g. view obstruction) play a role in these accidents, as well. These should also be taken into consideration when raising the awareness of the LGV drivers.

SUMMARY

This paper presents the final work which was done in this project. The investigation into LGV accidents has shown that they align well, with a few exceptions, with those of passenger car. Major deviations can only be detected in collisions with pedestrians, when reversing and accident causation. Moreover, special characteristics of LGVs needs to be considered like vehicle use, mileage, driver's workplace, load retention etc.

The occasional sharp rise in the accident figures for LGVs can be trace to the equally high rise in registration figures. Relative to the numbers on the road, accident involvement of LGVs has been falling continually since 2001.

Basically, the LGV provides very good protection for the occupants (self protection). However, the low numbers of LGV occupants that wear seat belts is worrying. Here, the figures significantly lag behind those of passenger car occupants. The risk to receive an injury in case of an accident is significantly lower for occupants of LGVs than for car occupants, but LGV occupants not belted are subject to an above-average risk in comparison with LGV occupants availing themselves of their seat belt. This risk could be greatly reduced by introducing suitable road safety education measures, training as well as devices such as a seat belt reminder.

The main accident opponent of the LGV is, in line with its numbers on the road, the passenger car. This could generate compatibility problems for the car occupants in particular, and lead to a very high risk of injured car occupants. It is important here to place more emphasis on protecting the accident opponent. On the other hand more stringent requirements in the crash safety of LGVs would have a negative effect.

LGV accidents involving pedestrians are as relevant as those involving cars. However, the test procedures developed for passenger cars cannot lead to an improvement in the accident situation for LGVs due to the different kinematics.

The cervical spine distortions frequently suffered by car occupants play less of a role for LGVs. Similar to the existing test modes for pedestrian protection, the frequently used seat (whiplash) tests designed for passenger cars are not leading to a desired result for LGVs.

Even though LGV drivers lose control of their vehicle less frequently than car drivers, ESP is still a

useful safety system. It has been proven that ESP has a high degree of potential benefit.

Advanced emergency brake systems and lane departure warning systems have some potential, but the high expectations that some place in these systems are unlikely to be achieved.

The accident causation factors of LGVs on rural roads differ significantly from those identified for passenger cars. This brings the LGV driver into the spotlight. In order to develop successful actions it is important to identify the main driver target population. In the case of LGV accidents, especially the crafts business and smaller companies are the major contributors to this safety issue. Further research in the area of driver behavior is necessary to develop suitable countermeasures to influence both, the driver itself but also the approach taken by companies.

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