ACCIDENTS WITH VANS AND BOX-TYPE TRUCKS (TRANSPORTERS): RESULTS FROM OFFICIAL STATISTICS AND REAL-LIFE CRASH ANALYSES

Walter Niewöhner

F. Alexander Berg

Markus Froncz

DEKRA Automobil GmbH

Accident Research/Crash Centre

Stuttgart

ID#: 316

ABSTRACT

Everyone who is ordering goods via catalogue or internet initialises the use of a van or box-type truck (so called transporter) for delivery close to the front door. Increasing needs lead to an increasing number of such vehicles on the road and corresponding increasing number of accidents. In Germany there is a considerable increase in the frequency of registered goods vehicles with a maximum permissible weight less than 7.5 t and of accidents with involvement of these vehicles in the long term since the end of the 80ies. Transporters are the majority within this vehicle category. With this background the accident research unit of DEKRA started to study real world crashes with involved transporters.

A result of the study is that transporters drive and collide at similar speeds as cars but only 20 % of the transporter drivers wear seat belts.

Transporters collide most frequently with passenger cars. The study shows that the frontal impact with oncoming traffic is the most frequent group. In 10 % of the analysed accidents the opposing vehicle of the transporter is a truck. This accident group causes very often severe or fatal injuries to the transporter occupants. Single vehicle accidents of transporters are also momentous for the occupants. Last but not least transporters also cause accident consequences for the opponents.

One of the main working area of transporters is the delivery traffic. Due to the operation area they are mostly driving and colliding in local area. The number of accidents involving transporters inside urban area is twice often as accidents outside urban area. The most frequent road users in local area are the so-called unprotected, pedestrians and bicyclists, who suffer severe consequences.

INTRODUCTION

In recent years the traffic density has increased because of a growing number of vehicle registrations and a growing individual kilometrage. In the year 1991 43.07 million motorized vehicles including 1.76 million trucks and semitrailer tractors were registered in Germany. Eight years later in 1999 there were 50.1 million motorized vehicles with 2.62 million trucks and semitrailer tractors registered. This corresponds to an increase of 16.4 % of all motorized vehicles and 48.9 % of trucks and semitrailer tractors [1]. In 1991 all motorized vehicles have driven 574.2 billion km. The corresponding value for trucks and semitrailer tractors is 51.7 billion km. In 1999 the statistics show a value of 639.3 billion km for all motorized vehicles and 73.7 billion km for trucks and semitrailer tractors. The driven kilometres of all motorized vehicles increased by 11.3 % and by 42.5 % for trucks and semitrailer tractors.

The changes within the society do not only influence the number of vehicles and the distances covered by them, but also the use of the different traffic carriers. New means of transportation are used more intensely because of new requirements of the society or new technical possibilities. E. g. ordering more goods via catalogue or internet leads to an increase of transportation directly to the front door.

These are some of the reasons why the number of commercial vehicles has been clearly increasing for the last decade. A more detailed view shows the raise of goods vehicles up to a maximum permissible weight of 7.49 t, Figure 1. In contrast to this the number of heavy trucks with a weight of 7.5 t or more is relative constant except for some years just after the German reunion.

The share of the transporters in the road traffic in general has much increased in recent years. This vehicle category, placed between trucks and passenger cars, offers the possibility to carry relative great loads at speeds similar to those of passenger cars. The mechanics of transporters correspond partly to those of passenger cars, partly to those of bigger trucks.

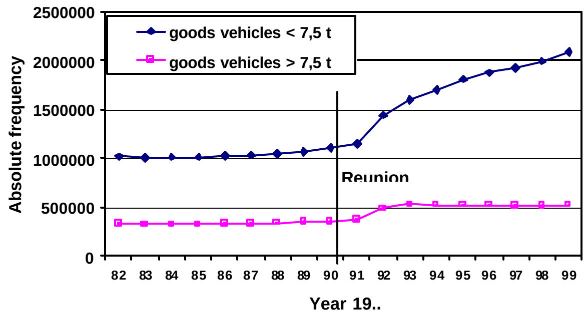

Figure 1. Absolute frequency of registered goods vehicles in Germany from 1982 to 1999 (Source: Federal Statistics, [1]**)**

Neither in the federal registrations nor in the traffic or accident statistics there is a group defined officially as transporters. This vehicle category contains box-type trucks and vans and is not delimited by definitions or regulations from passenger cars or trucks. In order to make statistical analysis about traffic and accident involvement of the transporters, a delimitation by weight seems to be helpful. Those vehicles that are usually called transporters by manufacturers or users have a maximum permissible weight of 2.3 to 7.49 t, a wheel base of 2.2 to 4.8 m and a power of 50 kW to about 100 kW.

The equipment of the transporters is different for every single model. A power assisted steering is part of the standard equipment for all modern transporters. Seat-belt tensioners are state of the art for modern transporters, too. But they are not a standard fitting in every new vehicle of this category. Equipment features such as ABS in the area of primary safety, airbags as part of secondary safety or even lashing points are standard for some transporters, for others option and for some vehicles they are not available.

The accident research unit of DEKRA started to study the traffic and accident involvement of transporters with a systematic analysis in 1999 [3]. Some updated results based on 100 accident involved transporters are being published and discussed in this paper.

ACCIDENT STATISTICS

The official road accident statistics based on evaluations of accident reports by the police show over the years in the long term a slightly upward trend of goods vehicle accidents with injured or killed persons, Figure 2. The increase of the figures between 1990 and 1991 is caused by the reunion. It is important to know that the German definition of goods vehicles (so called "Güterkraftfahrzeuge") does not only include light and heavy trucks and transporters. Station wagons are also included if they are registered as goods vehicles. The official statistics distinguishes between vehicles with a gross vehicle weight up to 7.49 t and those with 7.5 t and more. In general vehicles with 7.5 t and more are heavy trucks as in conventional understanding with a ladder frame and a separation between cab and body. Lighter goods vehicles could also be smaller trucks or even station wagons as mentioned above. The vast majority in this weight category are transporters.

Corresponding to the increasing number of vehicles and the growing driven kilometres, the number of goods vehicles involved in accidents with injured or killed persons increased, too.

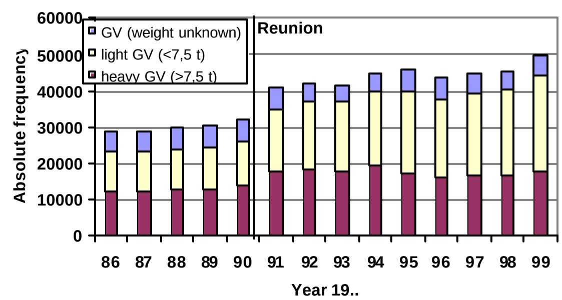

Figure 2. Absolute frequency of goods vehicles (GV) involved in accidents with injured or killed persons in Germany from 1986 to 1999 (Source: Federal Statistics, [2]**)**

The figures published in the official statistics allow a comparison of accidents with involvement of vehicles of a weight of less than 7.5 t with those of 7.5 t and more and show basic differences regarding long-term trends of these vehicle categories inside urban area (Figure 3**)** as well as outside urban area (Figure 4).

Inside urban area the number of light goods vehicles (<7.5 t) involved in accidents with injured or killed persons shows a considerable increase in the number of such cases in the long term since the end of the 80ies. On the one hand this could be explained by the rise of registered transporters which dominate this vehicle weight category. On the other hand their use inside urban area for the distribution of goods is exactly a main field of work for transporters. Outside urban area there is a greater share of heavy goods vehicles (≥7.5 t) which are operating more on long distances. So it is obvious that heavy goods vehicles (≥7.5 t) are dominating on motorways, Figure 5. The heavy goods vehicles (≥7.5 t) involved in accidents with injured or killed persons are showing a small increase in the course of the years, which can be explained by the fact that the driven kilometres have increased in the same period.

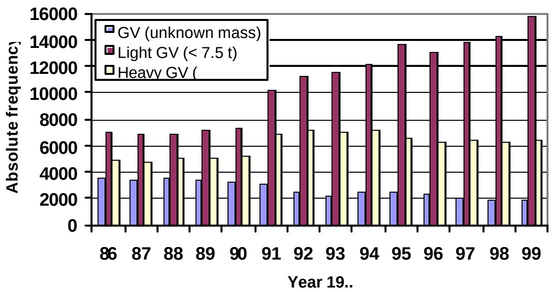

Figure 3. Absolute frequency of goods vehicles (GV) involved in accidents with injured or killed persons in Germany inside urban area from 1986 to 1999 (Source: Federal Statistics, [2]**)**

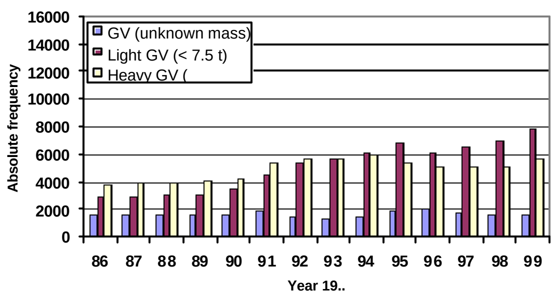

Figure 4. Absolute frequency of goods vehicles (GV) involved in accidents with injured or killed persons outside urban area from 1986 to 1999 (Source: Federal Statistics, [2]**)**

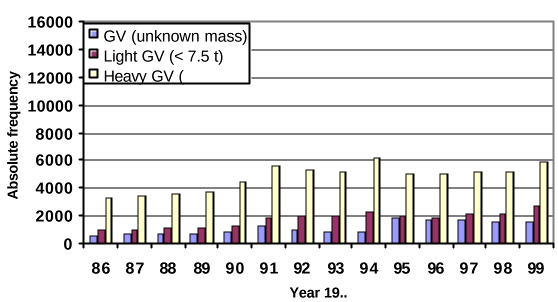

Figure 5. Absolute frequency of goods vehicles (GV) involved in accidents with injured or killed persons on motorways from 1986 to 1999 (Source: Federal Statistics, [2]**)**

Referring to the figures of the first year after the reunion (1991 = 100 %), an increase of about 60 % for light goods vehicles (<7.5 t) involved in accidents with injured or killed persons can be realized for 1999 whereas the figures of heavy goods vehicles (≥7.5 t) have remained approximately constant, Figure 6. The number of cars involved in accidents with injured or killed persons has also remained approximately constant since the reunion. Caused by the increasing figures of goods vehicles involved in accidents with a gross vehicle weight of less than 7.5 t, there is an increasing trend for all goods vehicles, too.

Related to the year 1991 the figure of cars involved in accidents with injured or killed persons on motorways in 1999 is reduced to 85.8 %, Table 1. For heavy goods vehicles (≥7.5 t) this ratio is 92.5 %. On rural roads (without motorways) it is 102.3 % for cars and 93.8 % for heavy trucks (≥7.5 t). Light goods vehicles (<7.5 t) show a high increase for both figures: on motorways up to 114.4 % and on rural roads (without motorways) up to 153.5 %. This means an increase of involved light goods vehicles (<7.5 t) in the above-mentioned rural road accidents of about 50 %. For accidents with injured or killed persons inside urban area the ratios went down to 98.9 % for cars and 91.9 % for heavy trucks (≥7.5 t) and raised up to 139.9 % for light goods vehicles (<7.5 t) in the same period.

For the time series of goods vehicles involved in accidents with injured or killed persons, separated by the categories of gross vehicle weights (<7.5 t resp. ≥7.5 t) and by the location type from 1986 up to 1999, see Figures 3, 4 and 5. It is obvious again that the increase of involved light goods vehicles (<7.5 t) especially on rural roads and inside urban area was higher than that of involved heavy goods vehicles (≥7.5 t) since 1992.

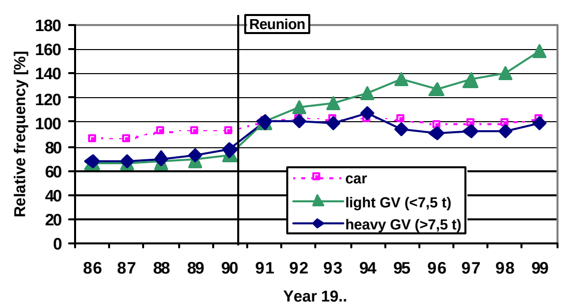

Figure 6. Time series of goods vehicles (GV) and cars involved in accidents with injured or killed persons, standardized to the year 1991 (Source: Federal Statistics)

Table 1 Ratios 1999/1991 for goods vehicles (GV) and cars involved in accidents with injured and killed persons (values of the year 1991 correspond to 100)

	GV <7,5t	GV ≥7,5 t	Car
Urban area	139.9 %	91.9 %	98.9 %
Rural area without motorways	153.5 %	93.8 %	102.3 %
Motorway	114.4 %	92.5 %	85.8 %

ACCIDENT ANALYSIS

The clear increase in the number of accidents with involved light goods vehicles (<7.5 t), which can also be put down to the increase of traffic and accident involvement of transporters. Therefore DEKRA’s accident research unit decided to analyse the accidents of this vehicle group in depth. Up to now 97 accidents involving 100 transporters have been determined in a study. These accident investigations are based on reports made by DEKRA experts all over Germany. These reports are containing an accident reconstruction of the way the accident happened and descriptions of the involved vehicles. The accident research unit utilizes besides the report other supplementary documents and information of the police reports. The DEKRA accident research also collaborates with medical doctors to investigate, describe and classify injuries.

The analysed transporter accidents are from the middle and late nineties, Figure 7. In more than half of the cases (60 %) they happened in rural area, Figure 8. In contrast to this, the accidents with injured or killed persons involving light goods vehicles (<7.5 t) as described in the federal statistics occur more often inside urban area. This is exemplarily shown with data from 1999 in the same diagram (Figure 8). The difference is mainly caused by the fact that the average of the accidents of the DEKRA stock is more severe than of those in the statistics. This is justified by the accident reconstruction order which is given to the DEKRA expert. The appropriateness of the means must be fulfilled, so the order is being given more often in case of more severe than in case of less severe accidents. So the DEKRA stock gives predominantly a view of the more severe accident scene rural.

As collision opponent of transporters, in the DEKRA stock passenger cars come first with almost half of the cases (49 %), Figure 9. In 22 % of the accidents with transporters no other vehicles are involved. In 10 % transporters collide with trucks.

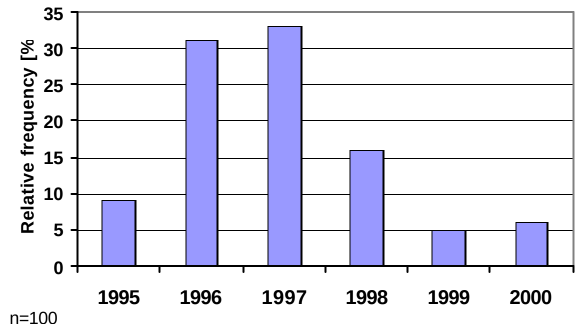

Figure 7. Years of the analysed accidents involving transporters (Source: DEKRA)

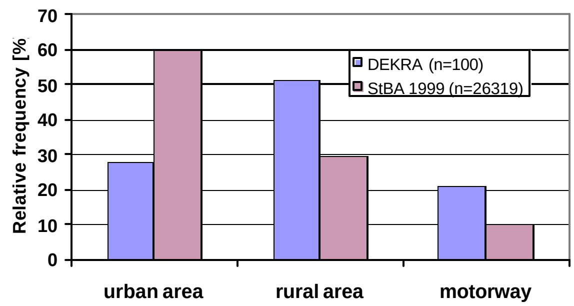

Figure 8. Accident location of 100 involved transporters (DEKRA) and of 26.319 accidents involving light goods vehicles (< 7.5 t) (Source: StBA = Federal statistics)

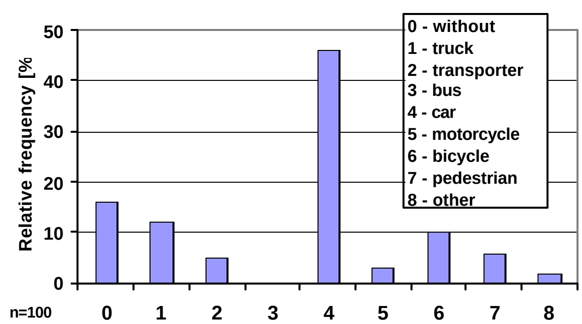

Figure 9. Crash opponents of transporters (Source: DEKRA)

In the DEKRA stock accidents with transporters happen equally on straight roads, at junctions (crossroads) and in bends, Figure 10. As a comparison to this, the distribution of a corresponding sample of 618 in accidents involved cars is shown in the same diagram. These cars are from another DEKRA stock with the same distribution of the accident location type. It is conspicuous that accidents with transporters happen more often on straight roads than those with cars.

The speeds driven by the transporters just before the accident happened cover the whole range of values which are existing in road traffic, Figure 11. It is remarkable that about every ninth transporter used a speed of more than 105 kph.

The speeds of transporters at the moment of the collision are a little lower than those of passenger cars with the same location (in urban area, in rural area without motorways and on motorways), Figure 12. Impact speeds of more than 90 kph e. g. occur with the passenger cars in 21 % and with the transporters in 15 % of the cases.

Three of ten transporter drivers (30 %) braked before the collision, Figure 13. Nearly every fourth driver (23 %) was doing an evading manoeuvre or has just finished an evading manoeuvre. Swerving or drifting before collision was recognized in 14 %. In the cases mentioned last, there would be a potential for electronic stability program (ESP).

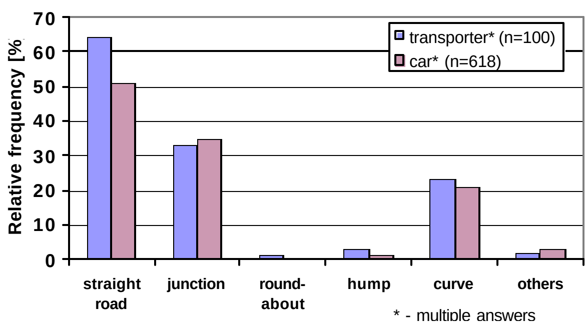

Figure 10. Road characteristics of 100 transporter accidents, compared to 618 car accidents (Source: DEKRA

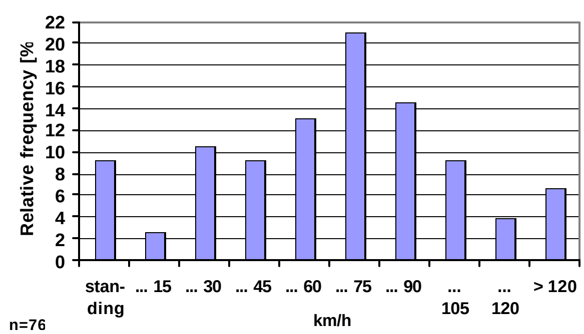

Figure 11. Speeds of transporters just before accident (Source: DEKRA)

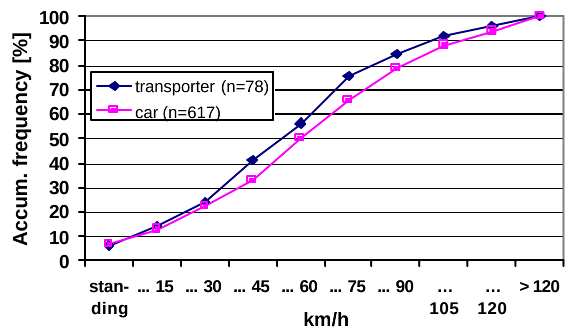

Figure 12. Cumulated impact speeds of transporters and passenger cars (Source: DEKRA)

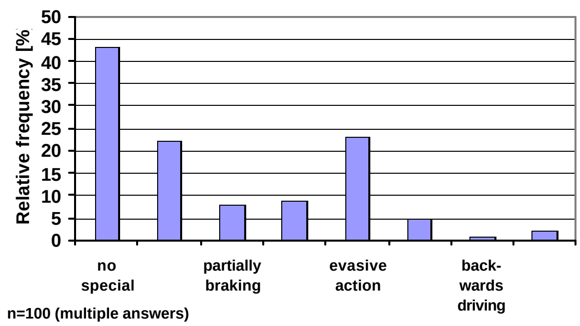

Figure 13. Pre-crash behaviour of transporter drivers (Source: DEKRA)

The different accident situations of transporters are shown in Figure 14. The most frequent accident situations are frontal crashes with oncoming traffic and single vehicle accidents. Of special interest for the secondary safety are accidents where occupants of transporters suffer severe or fatal injuries. By comparing this group with all transporter accidents of the DEKRA stock, special details of this so-called “serious transporter accidents” become visible. The comparison of all 100 accident involved transporters, Figure 15, with the 43 transporters with severe or fatal injured occupants, Figure 16, shows that single accidents and accidents with trucks are resulting mostly in severe or fatal injuries for the transporter occupants. Collisions with passenger cars, on the contrary, have particularly serious consequences for the transporter occupants in only 40 % of the cases.

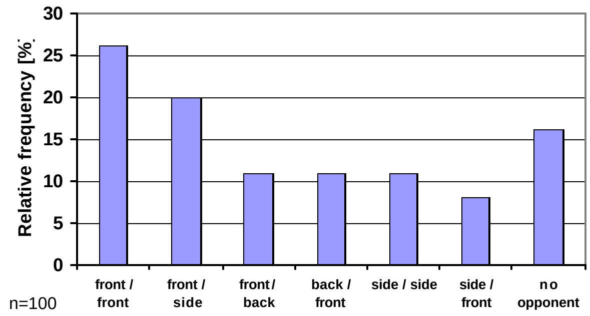

Figure 14. Constellations of transporter accidents (Source: DEKRA)

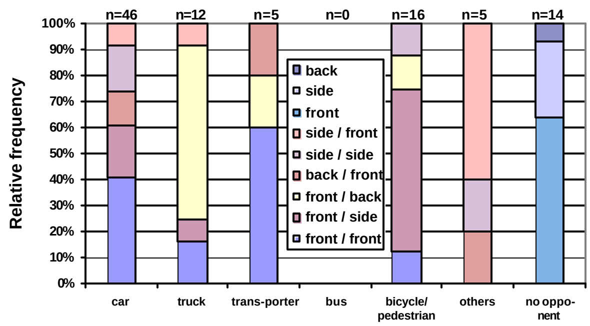

Figure 15. Impact constellations of transporter accidents according to the opposing vehicle (Source: DEKRA)

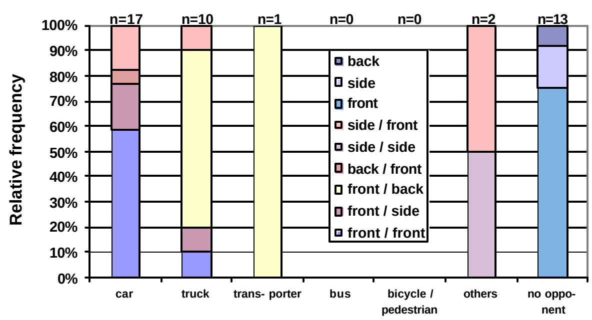

Figure 16. Impact constellations of accidents with severe or fatal injured transporter occupants according to other involved vehicles (Source: DEKRA)

In general, more than two of five (42 %) of the transporter occupants were severely or fatally injured in the analysed accidents, Figure 17.

If more transporter occupants used their safety belt, the number of them who are severely injured or killed would noticeably decrease. Although almost all transporters were equipped with safety belts (98 %), it was only in 21 % of the accident involved transporters surely ascertainable that the occupants used their belts, Figure 18. It is to fear that in fact most of the cases with unknown belt use the belt was not used.

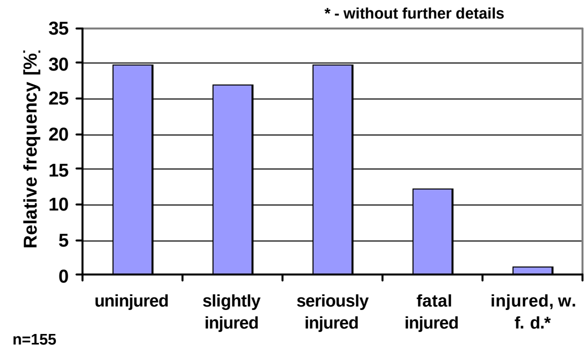

Figure 17. Consequences of accidents for transporter occupants (Source: DEKRA)

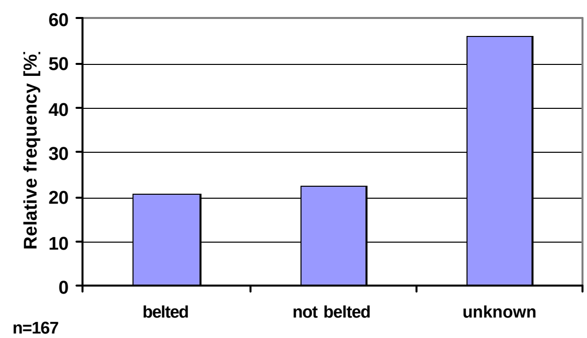

Figure 18. Rate of belt wearing of transporter occupants (Source: DEKRA)

A traffic analysis of 375 vehicles with a gross vehicle weight of less than 8 t, investigated in 1999 on all kinds of roads, came to the similar result of a 19 % seat belt use rate [4]. The low rate of belt wearing is alarming because transporters drive and collide at almost the same speeds as passenger cars, as shown above.

ACCIDENT SITUATIONS OF TRANSPORTERS

Based on Figure 15 and Figure 16 the clearly defined accident situations can be deduced. Collisions between transporters and cars are much more frequent than all the other constellations. Nearly in every second transporter accident a car is the opponent. This corresponds to the road traffic situation with cars being the most frequent motorized traffic participants.

Two other accident situations worth mentioning are those with trucks and the single accidents of transporters. Accidents with trucks as opponent are critical for transporter occupants because of the disadvantageous mass ratio for the transporter and the compatibility problems to the truck. Part of the accident consequences are large intrusions into the cabin with accompanying severe injuries. Single accidents do also often have the problem of large intrusions. Here they result for example from impacts on trees.

The three just mentioned accident situations are important for the passive safety of transporter occupants. Another situation is important for the so-called unprotected road users: pedestrians and bicyclists. This is also very important because of the high share of accidents involving light goods vehicles (<7.5 t) inside urban area. One special problem is the head contact area on the front of the transporter. The different shape of the transporter requires special developments for pedestrian protection [5]. With the relative high bonnet of the transporter the impact area of the head is around the front edge of the bonnet.

Crashes of transporter with car

The cumulative frequency of the impact speeds of the 38 accidents with involved transporters colliding with cars is shown in Figure 19. Here the cars are a little bit faster than the transporters. An impact speed of 60 kph covers 52 % of the cars and 62 % of the transporters.

Regarding the impact direction of the car relative to the transporter, it is visible that the majority of the cars impacted frontally (61 %), 20 % impacted from the left-hand side, 13 % from the rear and 6 % from the right-hand side, Figure 15 and Figure 20.

The main situation is a frontal transporter impact with the front of an oncoming car. This happened in every fourth of all analysed 97 accidents. The mean impact speed of the transporter is roughly 45 kph and that of the car is about 60 kph.

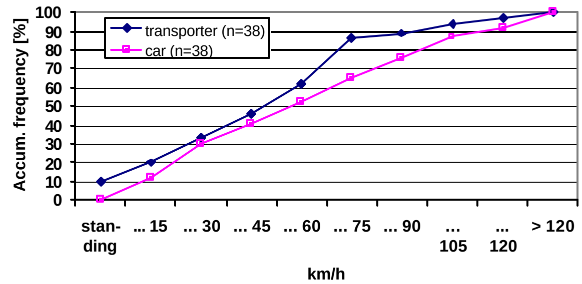

Figure 19. Impact speeds of transporters and passenger cars

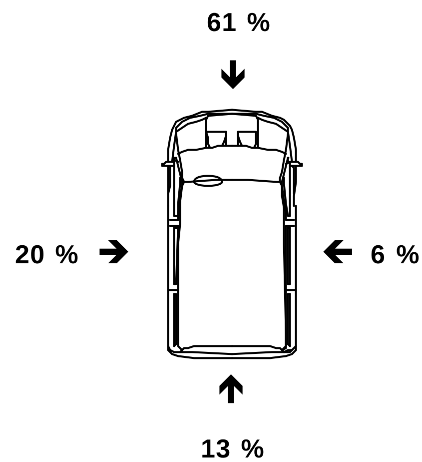

Figure 20. General impact direction relative to the transporter in 38 accidents involving transporters and cars

The following example gives some impressions. A transporter was colliding with a speed of 41 kph against a car which drove at 78 kph. The overlapping ratio of the transporter was 80 %. The damage to the transporter is shown in Figure 21. Figure 22 shows the damage of the car.

Figure 21 Damage to transporter caused by frontal collision with a car (see Figure 22)

The technical reconstruction came to EES = 30 kph for the transporter and EES = 50 kph for the car. The deformation severity of the transporter can also be classified by using the collision deformation classification (CDC), [6]. The column 7 describes the deformation extent which is the value 5 for transporter and the value 6 for the passenger car.

Transporter and car were occupied only by the driver, both occupants were belted. The transporter driver was slightly injured (AIS 1). He got only some contusions. The car driver was injured severely (no further details available).

Figure 22. Damages to the opponent of the transporter (see Figure 21)

Crashes of transporter with a truck

Amongst the analysed 97 accidents were 12 cases with the transporter crashing against a truck. The impact speeds of the transporters ranged from 30 up to more than 120 kph. The mean value is in the classification group 30 to 45 kph. The trucks collided with speeds between 0 and 90 kph. The mean value is in the classification group 75 to 90 kph. In 11 cases the transporter was impacted at its front, in one case at the left side (see Figure 15). There were no cases where a truck hits on the right side and no cases where it hits on the back of the transporter.

An example shows the consequences of an accident with the transporter impacting frontally against the rear end of a truck. The similar accident situation happened in eight of the 12 cases where a transporter collided with a truck. In the example shown in Figure 23 the transporter collided with a speed between 125 and 130 kph (results of reconstruction) with the back of a semitrailer which was driving at 80 kph.

Figure 24 shows the damage to the transporter. The damage to the semitrailer is shown in Figure 25. The accident reconstruction came to an EES value between 35 and 40 kph for the transporter. Delta-v was calculated in a range from 12 to 19 kph for the transporter and 1 up to 3 kph for the truck.

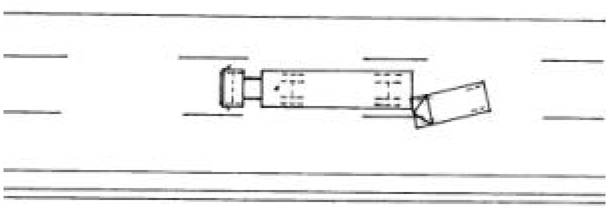

Figure 23. Sketch of the impact situation

Figure 24. Damages to the transporter after collision with the back of a semitrailer (see figure 25)

The transporter was only occupied with the driver. The police classified the transporter driver as severely injured (stay in hospital, no further information available). The truck driver did not get any injury.

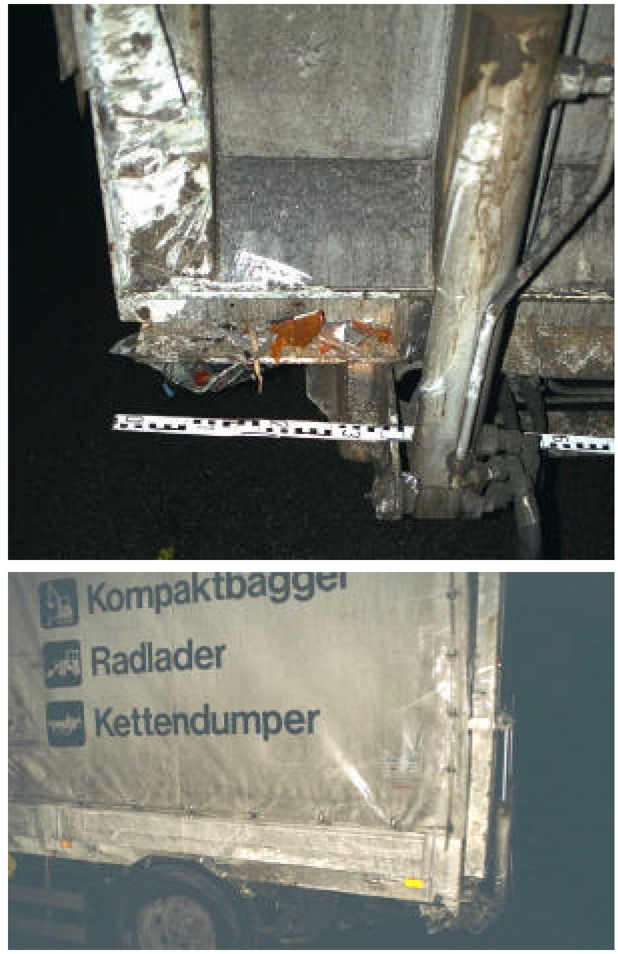

Figure 25 Damages to the opponent (tractor with semitrailer) of a transporter (see Figure 24)

Single accident of a transporter

The mean frontal impact speed in a single accident is roughly 75 kph. In a typical single accident the driver's cab has got a serious degree of damage, which can sometimes be caused by a rollover. In the example case a transporter first slided upon the wet road and the bordering meadow and then collided with a tree. Afterwards it had a rollover. The three occupants were not belted. They were ejected and killed, Figure 26.

Accident of a transporter with a bicyclist

In the case shown in Figure 27 an adult cyclist collided with the front of a transporter. The transporter was coming from its left side and was crashing with a speed of 54 kph. The head of the cyclist hit the windscreen of the transporter. The driver of the transporter remained uninjured while the bicyclist was severely injured.

Figure 26. Damages to the transporter after single accident caused by collision with tree and rollover

SUMMARY AND CONCLUSIONS

In Germany the growing number of accidents with involved trucks is dominated by the growing number of involved light trucks (<7.5 t). Based on the analyzed sample it is not detectable that the light trucks which are also called transporters have a higher risk to be involved in an accident than other traffic members. The increasing share can be explained by the increasing number of registered light trucks. The higher number is followed by a higher kilometrage of transporters.

Figure 27. Damages to the transporter and bicycle

The transporter accidents happen most frequently (two of three accidents) inside urban area. This is corresponding to the delivery traffic which is the original use of transporters. Inside urban area the secondary safety is very important for unprotected road users such as pedestrians or bicyclists. They are the most common group of traffic members inside urban area.

For occupants of transporters the secondary safety is important in case of three relevant accident groups. The most frequent of these dangerous accident groups is a collision between transporter and passenger car. This group can also cause injuries for the transporter occupants. The second one is the collision versus a heavy truck. Here the same problems which are well known from the analysis of car versus truck collisions are occurring. This depends on mass and form aggressiveness. The third dangerous group is the single accident of transporters. Of high risk is to collide with a fixed obstacle like a tree or a wall. The other high risk is the rollover where unbelted occupants could be ejected.

The development of transporters requires nowadays besides the consideration of points like comfort and economy also the secondary safety of this vehicle category. This includes for example several crash tests, special pedestrian protection or safety features like airbag.

The belt usage in transporters is somewhat higher than in heavy trucks (≥7.5t), but in relation to passenger cars it is too low. For a better passive safety inside transporters the percentage of belted transporter occupants must be much higher. Only belted occupants can participate properly from supplementary protection which is provided by airbags in modern transporters.

In the analysed accidents it was found that cargo safety was not a main problem. The existing number of cases do not allow to make in-depth analysis of this problem. Nevertheless it can be a problem for the occupants of transporters. Sometimes a braking manoeuvre can cause injuries coming from load inside the transporter. There are cargo shift systems available on the market which can avoid a lot of dangerous situations caused by unsaved load [7].

The points shown in this presentation are results of the first analysed 97 accidents with involved 100 transporters. This small sample is only able to give a first view to the accident situation of transporters. To validate the shown results and to make possible a more detailed analysis the number of cases collected by DEKRA will grow in the future. This will allow to describe transporter accidents in a more detailed way.

The expected kilometrage of transporters and box-type trucks will keep growing in the future as it did in the last decade. So the significance of transporter accidents and the knowledge about it will become more and more important.

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