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Pre-dominant Collision Types in Real Accidents and Comparison to International Safety Standards and Euro NCAP

Pre-dominant Collision Types in Real Accidents and Comparison to International Safety Standards and Euro NCAP

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1 Accident trends in Germany

1.1 Accident and fatality figures

The accident situation in Germany is characterised by a significant decline in the numbers of fatalities [1] and near constancy in the number of accidents registered by police (**Figure 1**), despite an increase in the number of registered vehicles on the roads as well as in the amounts of driving being done.

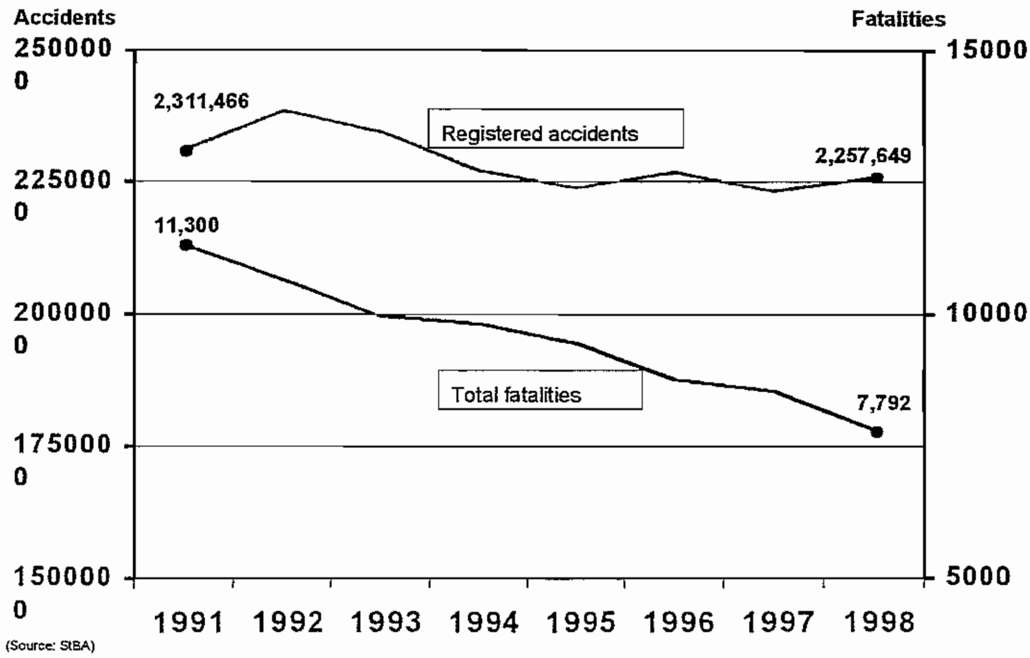
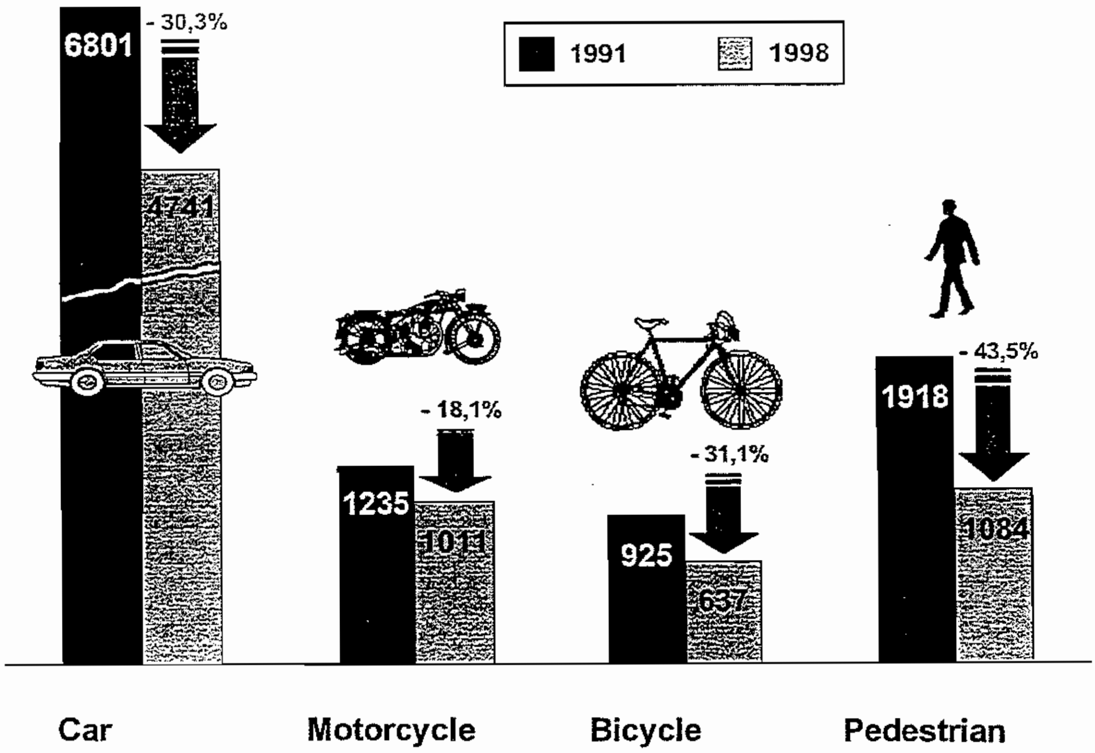


Figure 1: *Road accidents and fatalities registered by the police in Germany*

The trend being seen in road accidents is more a result of the increase in passive safety (reduction of the effects of accidents) than of the avoidance of accidents (active safety).

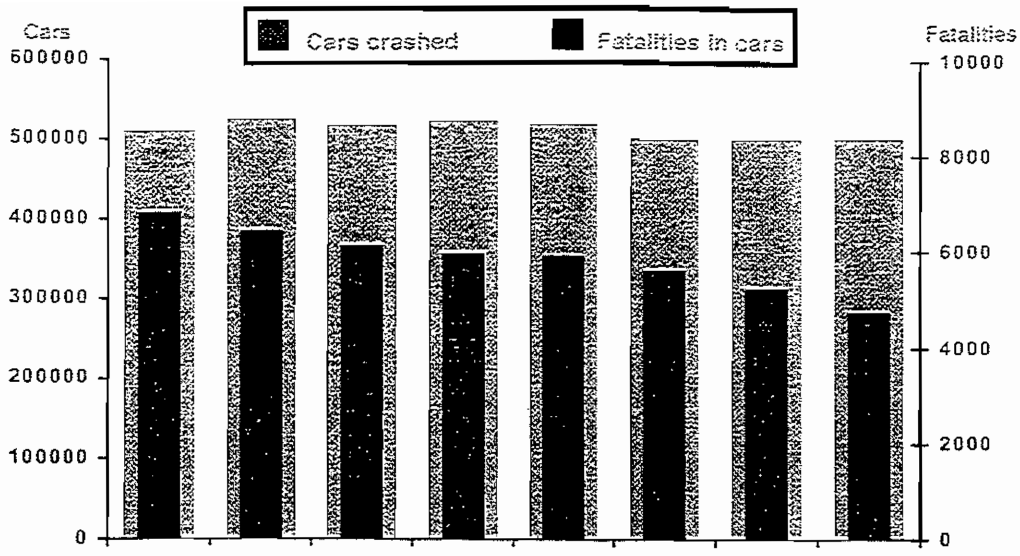
The declining number of persons killed in traffic accidents – expressed in absolute numbers – can be attributed primarily to the decline in the number of persons killed while riding in cars (**Figure 2**).



(Source: StBA)

Figure 2: *Fatalities in road accidents by the type of traffic involved*

In 1991 a total of 6,801 people were killed in cars; in 1998, on the other hand, this figure was „only„ 4,741. The fatality figures have also declined significantly for unprotected traffic participants such as pedestrians, cyclists, motorcyclists and their passengers; the largest relative decline in fatalities, 43.5%, was noted with regard to pedestrians.



(Source: StBA)

	1991	1992	1993	1994	1995	1996	1997	1998
Fatalities passengers per 1,000 car crashes	13.3	12.2	11.8	11.4	11.4	11.2	10.4	9.4

Figure 3: *Cars in accidents involving passenger injuries and fatalities*

The risk of being fatally injured in a car is depicted in **Figure 3**.

In 1991 13.3 passengers were killed per 1,000 cars in accidents involving injuries; in 1998 it was only 9.4. Despite this very positive and pleasing trend, fatalities among car passengers still account for around 60% of all fatalities in road accidents.

Looking ahead to the future, it can be said that the number of fatalities among passengers in cars is going to continue to decline; a hundred percent of all new cars are now equipped with front-seat airbags, but market saturation is currently still only at around 35%; as such, we can expect to see a further decline in the number of drivers and passengers killed in the years to come as a result of the rising percentage of cars fitted with airbags.

We will also have to reckon with the introduction of electronic drive control systems in the cars of the future (e.g. ESP) and the question will arise as to whether, in addition to the expected reduction in the number of serious accidents, it will be possible to determine an effect in the direction of accident avoidance in general.

1.2 Accidents with and without the involvement of other parties

In assessing the importance of certain accident constellations and collision types attention needs to be given to the completely different structures of accidents involving one car alone and collisions involving more than one car. In the case of accidents in which injuries to persons occurred the accident type "car/car" clearly predominated with around 105,500 collisions (**Figure 4**); in the case of accidents in which fatalities occurred, on the other hand, accidents involving just one car predominated by far in 1998 with 1,898 cases.

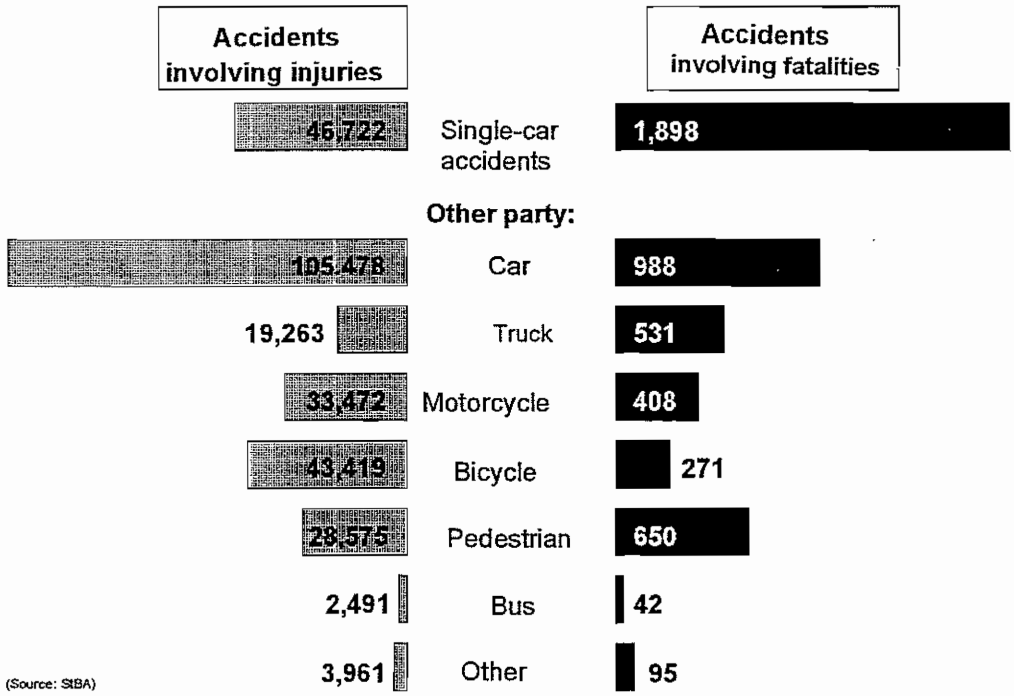


Figure 4: *Other parties in accidents with cars involving injuries and fatalities (1998)*

In accidents involving one car the safety criteria are twice as important as they are in car/car collisions and this needs to be taken into account in the evaluation of crash test results.

Figure 4 shows that with 650 fatal accidents a large measure of importance attaches to car/pedestrian accidents and to collisions between cars and trucks (531 accidents involving fatalities).

Depending on the nature of the other party or the type of accident involved, the risk of being killed is greatest in accidents involving just one car by itself; the ratio of accidents involving fatalities to accidents involving injuries is as follows:

- single-car accidents 4.1 %
- car/truck accidents 2.8 %
- car/car accidents 0.9 %

Accordingly, single-car accidents are around four times as dangerous to passengers as car/car collisions. As such, there can be no compromises with regard to passenger self-protection. However, self-protection measures must not be at the expense of partner protection, since partner protection is going to continue to play an important role in connection with the new „vehicle mix„ (current vehicle population + light vehicles + such things as „sport utility vans„).
Car/truck accidents constitute a special case in the context of car safety, since the severity of accidents and injuries depends to a large extent on partner protection on the part of the truck, a factor which is often still insufficient.

2 Collision types in car crashes

In the framework of GDV accident research activity data has been built up in recent years on some 15,000 car/car accidents and around 1,000 single-car accidents involving injuries [2]. Out of this material 831 car/car accidents involving severe injuries (MAIS 3+) [3] and 524 single-car accidents (MAIS 3+) were selected for detailed analysis. There are also other bodies of data such as car/pedestrian accidents (1,383 cases). The following observations are based on this data.
In GDV accident research so-called "collision types" are used for the classification of accidents describing the relative positions of the vehicles in the case of car/car accidents; or in the case of single-car accidents the type of object collided with and the impacted area of the vehicle.

2.1 Car/car collisions

Figure 5 shows the distribution of collision types in car/car accidents involving injuries (all degrees of injury; „FS 90„) and in car/car accidents involving severe injuries (MAIS 3+; „RESIKO„).

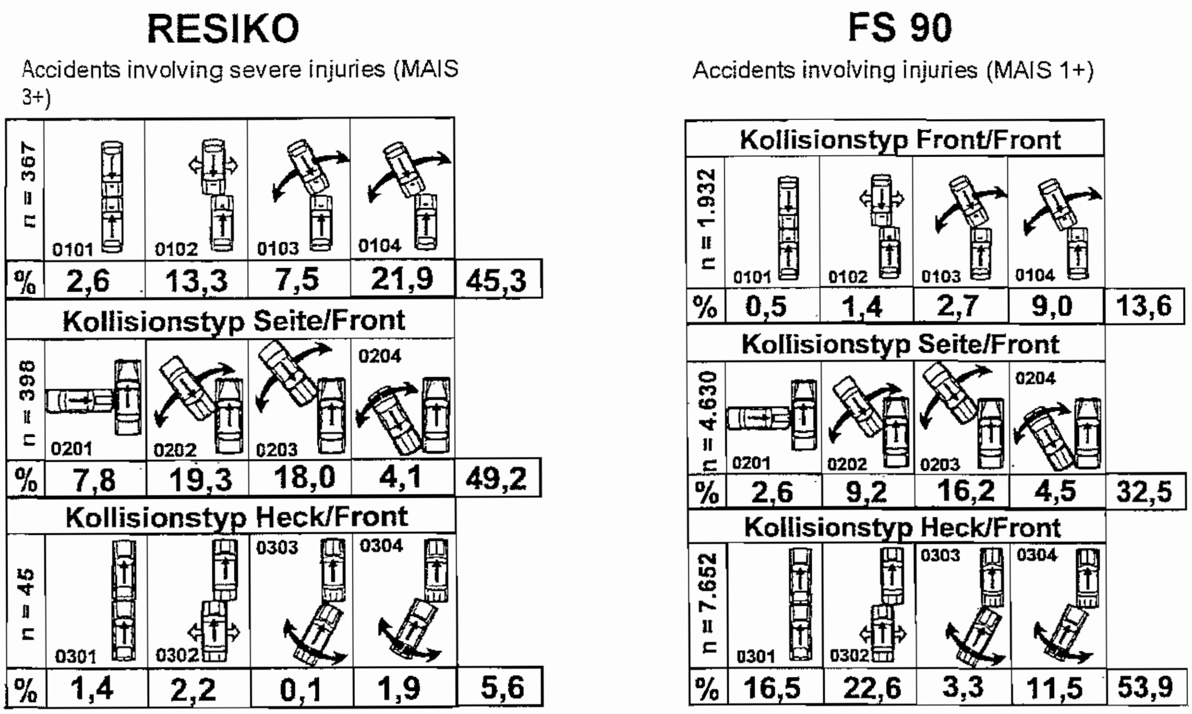


Figure 5: *Distribution of collision types in car/car accidents involving injuries (FS 90 [2]) and car/car accidents involving severe injuries (RESIKO [4])*

In the case of car/car collisions with all degrees of injury rear-end collisions predominate by far with 53.9 %. This type of accident is characterised by the frequent occurrence of neck injuries, beginning in a range of speed change of up to 15 km/h (**Figure 6**).

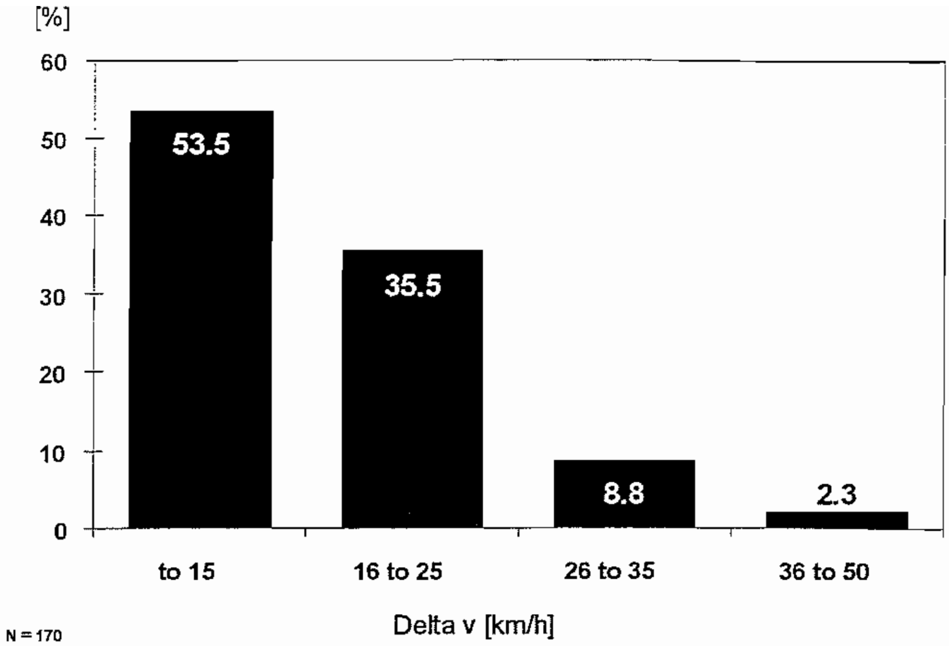


Figure 6: *Frequency of neck injuries in relation to speed change delta v*

In volunteer experiments carried out by GDV causes of injury and kinematic mechanisms were analysed. In corresponding seat/headrest tests with dummies clear quality differences were shown in new cars. About a 30% reduction in the risk of neck injury can be expected by improving seats and headrests. As such, it should be urgently demanded that seats and headrests be subjected to a standard testing procedure; a proposal for raising the quality standards of seats/headrests was formulated by GDV together with other institutes.

On the other hand, rear-end collisions hardly play any role at all in connection with severe or fatal accidents („RESIKO„) (see Figure 5); the priority here lies with side-impact collisions now that the risk of injury in connection with frontal collisions has been greatly reduced by means of a number of safety measures including optimisation of front-end structures, reduction of intrusion, optimisation of restraint systems and supplementary protection through airbags. It goes without saying that the Euro-NCAP tests, involving collisions at 64 km/h against a deformable barrier, have helped to promote this development.

An EES analysis of all non-angular frontal collisions in the RESIKO data showed that only 5% of the EES figures were over 55 km/h (**Figure 7**).

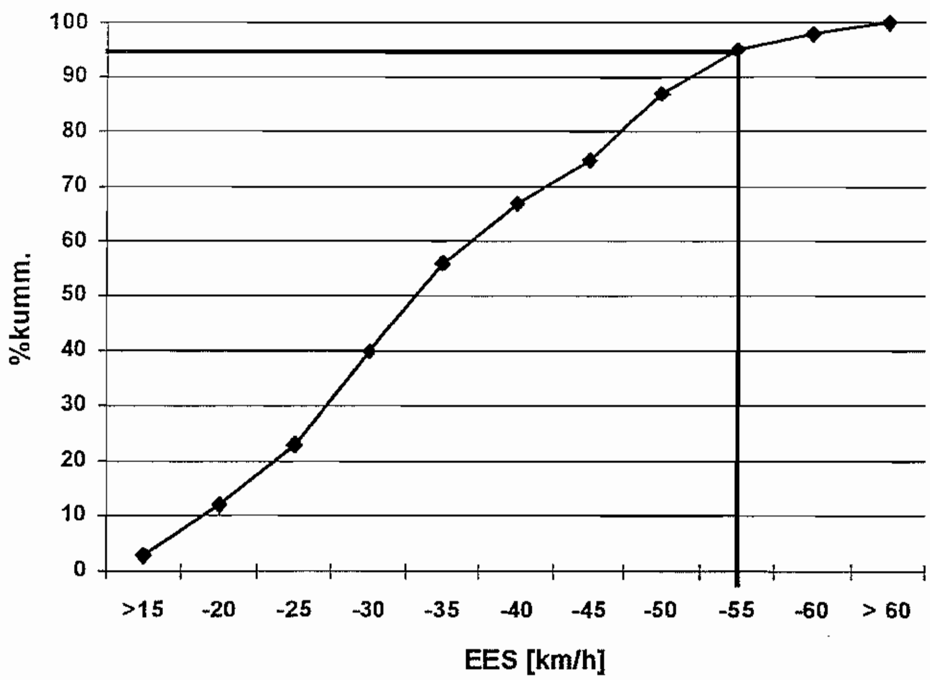


Figure 7: *Distribution of EES in car/car frontal collisions in which severe injuries occurred*
(N = 96)

Taking into account the characteristics of the EuroNCAP barrier, 55 km/h corresponds to a test speed of around 64 km/h against the deformable barrier for a middle class car. The currently used test speed of 64 km/h covers approximately 95 % of real-world frontal collisions involving severe injuries. As a result of a constant test speed, independent of the weight involved, considerable differences occur between heavy and light vehicles in the relative amount of energy absorbed by the deformable barrier in each case. It will need to be discussed whether instead of the present standard EEVC barrier different barrier types should be used for the various weight categories or whether a three-part barrier with different degrees of rigidity is enough.

It was noticeable in the analysis of side collisions that fewer accidents at intersections were involved; instead, the most serious side-impact collisions were a result of accidents in which vehicles swerved sideways and there was a side collision with an approaching vehicle. With ESP it would be possible, on the one hand, to reduce the numbers of these accidents and, on the other, to change collision characteristics such that vehicles would collide with each other **frontally** and, in doing so, provide greater protective potential than in the case of a side collision. This shows that systems for increasing active safety can also have a positive effect on passive safety [8].

2.2 Collision types in the case of single-car accidents

Also in the case of single-car accidents side collisions have a higher degree of importance than frontal collisions – nearly half of the single-car accidents in which fatalities occurred involved a side collision (**Figure 8**).

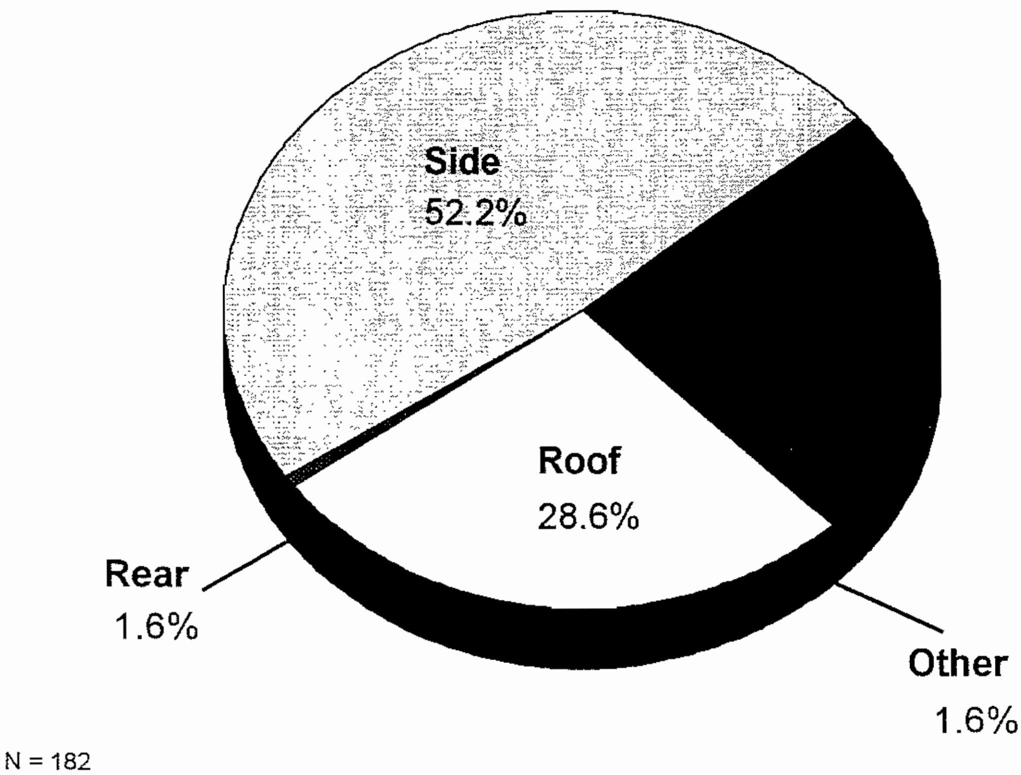


Figure 8: *Main areas of damage in single-car accidents in which fatalities occur*

These side collisions are primarily the result of the vehicle swerving and then slamming sideways at high speed into a tree or a pole (**Figure 9**).

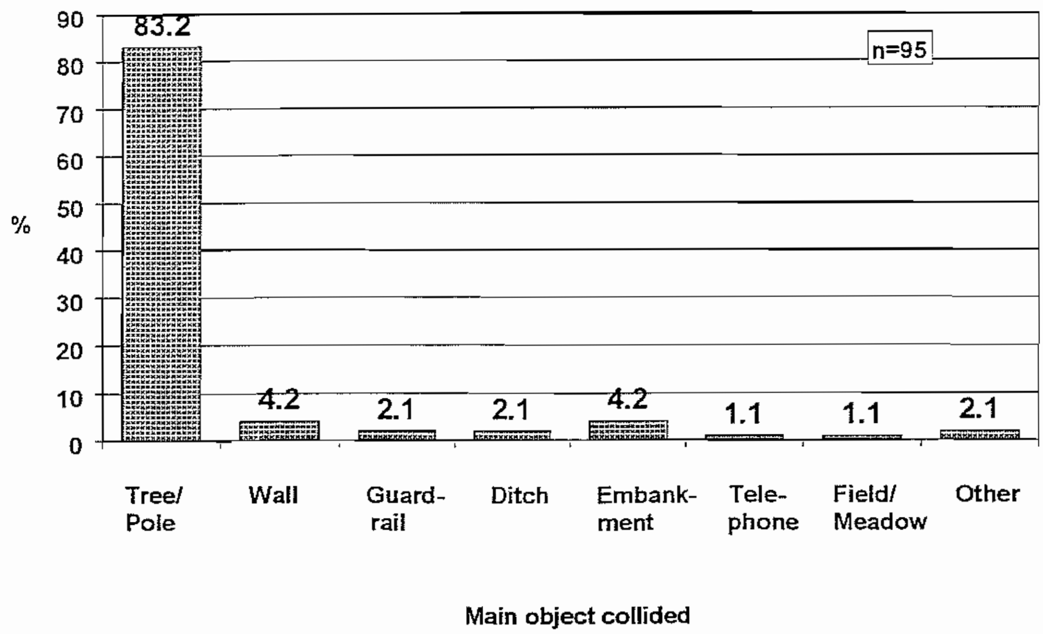


Figure 9: *Main object collided with in single-car side collisions in which at least one fatality occurred*

For this reason a side impact with a pole should be included in the future as an additional test criterion; the function of side-impact airbags in the head area could also be tested in this connection.

The second most frequent scenario in single-car accidents in which fatalities occur is a collision in which the roof gets hit; frontal collisions follow in third place.

2.3 Roll-over

A type of accident whose importance continues to be underestimated is when a car rolls over. In the case of car/car collisions involving injuries [2] the occurrence of roll-overs is relatively rare (just under 1%); by contrast, around 45% of all single-car accidents [2] involved the car rolling over.

When vehicles leave the road they are often travelling at a relatively high longitudinal speed. As they leave the road and move down a sloping embankment they begin a spiral motion, rotating around their linear axis.

Speed at beginning of roll	50 - 140	Ø= 109
Direction of roll	to the left to the right	47% 53%
Height of fall	0.5 - 8	Ø= 2.8
Impact surface	Meadow, Asphalt Tree Other	47% 10% 10% 2%
Main impact surface	Roof Side	40% 60%

Figure 10: *Essential parameters for single-car accidents in which the car rolls over; safety of drivers ensured, MAIS 2+; (N = 52)*

Figure 10 shows the key parameters for accidents in which the car rolls over.

For a test in which a car is to be rolled it is important that the vehicle have a longitudinal speed of at least 70 km/h and execute spiral movement.

2.4 Integrated assessment

In order to describe the requirements for the safety of cars in general an integrated assessment of the relative importance of car collision types must be carried out. This assessment is to be made by weighting the results of representative accident studies for a given area, e.g. car/car accidents or single-car accidents, in accordance with their relative importance and projecting this onto the overall national statistics. Details on „integrated assessment„ are described in [2]. In the following, reference is made exclusively to the risk of fatal injuries.

The ranked list of collision types given in **Figure 11** is based on the collision frequencies already described (100 % = all fatally injured persons in car/car and single-car accidents).

1.		Side collision in the area of the forward door **25.9 - 30,5%**
2.		Full frontal collision **17.7 - 22,1%**
3.		Full roof impact after rolling over **14.8 - 17,5%**
4.		Offset frontal collision **13.2 - 14,2%**
5.		Large-area side collision **9.4 - 11.4%**

Figure 11: *Ranked list of collision types, determined on the basis of the „integrated assessment„ of car accidents (indication of upper and lower limits)*

The importance of side collisions on a limited-sized area of the passenger compartment becomes clear. This importance can be attributed primarily to the high percentage of collisions of this kind in single-car accidents.

Full frontal collisions follow in second place on the basis of the integrated assessment of car/car and single-car accidents.

The very considerable importance of accidents in which a car rolls over and takes a massive impact on the roof is strongly determined in its ranking by the relatively high percentage of passengers who do not have their seat belts fastened. If this type of accident only involved passengers who had their seat belts fastened, it would drop down to position 5. Nonetheless a roll-over test, such as described in chapter 2.3, should be part and parcel of the „type approval„ procedure.

Offset frontal collisions do not have the same importance in the overall assessment of car accidents in which fatalities occur as other types of car/car collisions; amongst serious car-car collisions (MAIS 3+) this type of collision would have a frequency of 35 %. The high level of importance attributed to the offset crash test in the international safety standards is thus justified.

3 Compatibility

3.1 Weight conflict

The subject of „compatibility„ is characterised by a constant conflict between self-protection and partner protection. This is shown most clearly in connection with the what is probably the most important factor, i.e. vehicle weight. While the passengers of a car which is very heavy are exposed to a relatively low level of danger of injury (**Figure 12**) this weight causes a higher level of damage to the other car involved in an accident and correspondingly more severe injuries to the other passengers.

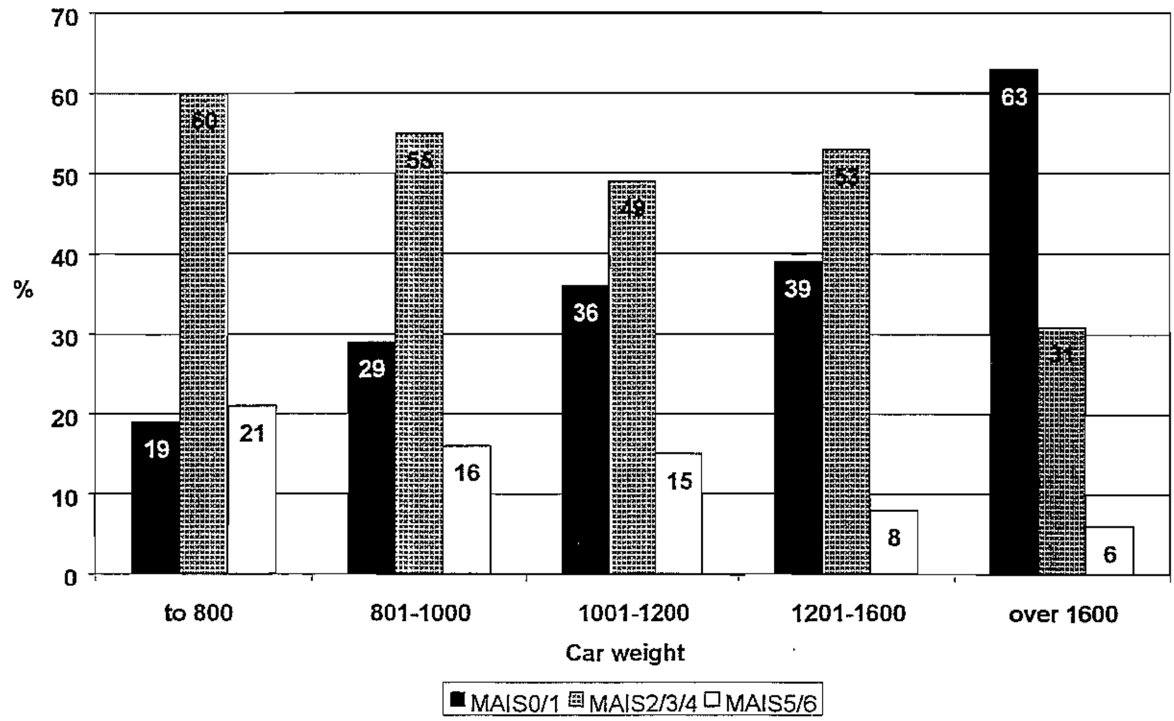


Figure 12: *Severity of passenger injuries in relation to vehicle weight*

The greater the difference in weight between the two vehicles involved in the accident the more dramatic this effect becomes.

In a weight ratio range ($m_{Fzg.1}$ / $m_{Fzg.2}$) from 0.8 to 1.2 nearly balanced masses can be assumed. On this basis a weight aggressivity problem must be assumed in approximately 30 % of real-world frontal collisions (**Figure 13**). However, these figures should be viewed more as a lower limit.

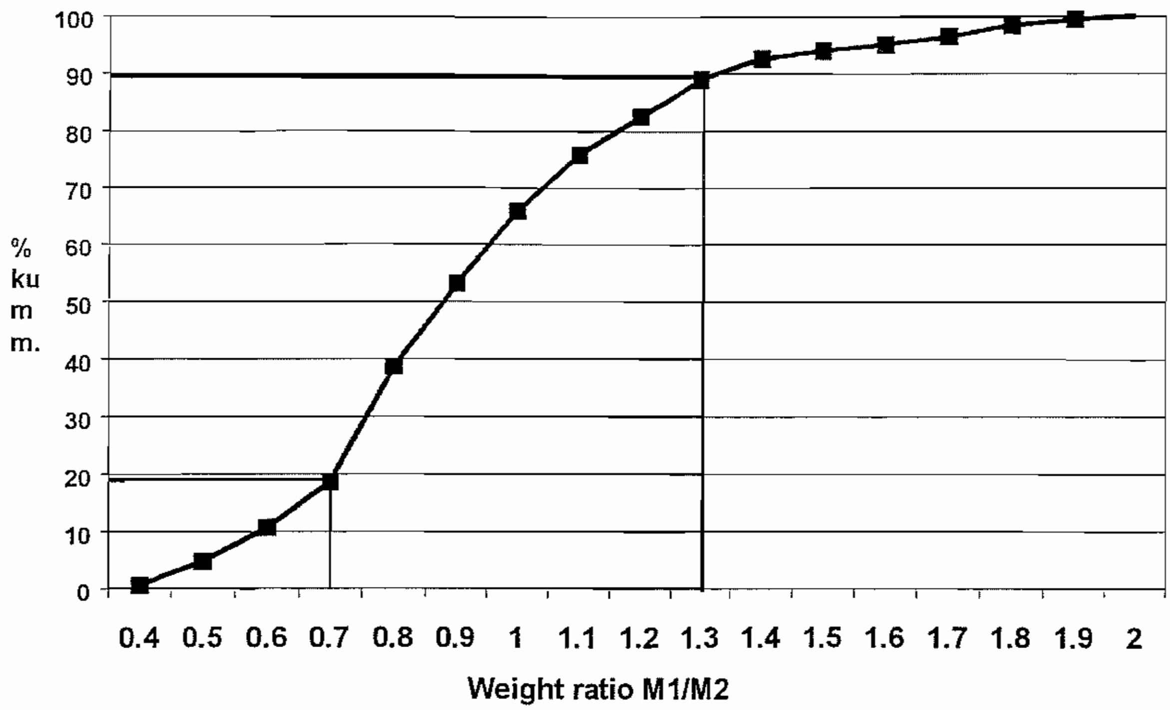


Figure 13: *Vehicle weight ratio ($m_{Fzg.1}/m_{Fzg.2}$) in car/car frontal collisions*

The alarming growth in the numbers of so-called off-road vehicles, on the one hand, and the strongly expanding market for very small towncars, on the other, throws the subject of future compatibility and weight aggressivity into sharp focus.

3.2 Form aggressivity, overrun/underrun

In addition to weight there is also a recognisable compatibility conflict in the area of front-end design or form aggressivity. In real-world car/car accidents the least amount of damage is seen in cars when energy-absorbing structural elements such as subframe carriers are located at the same height (**Figure 14**).

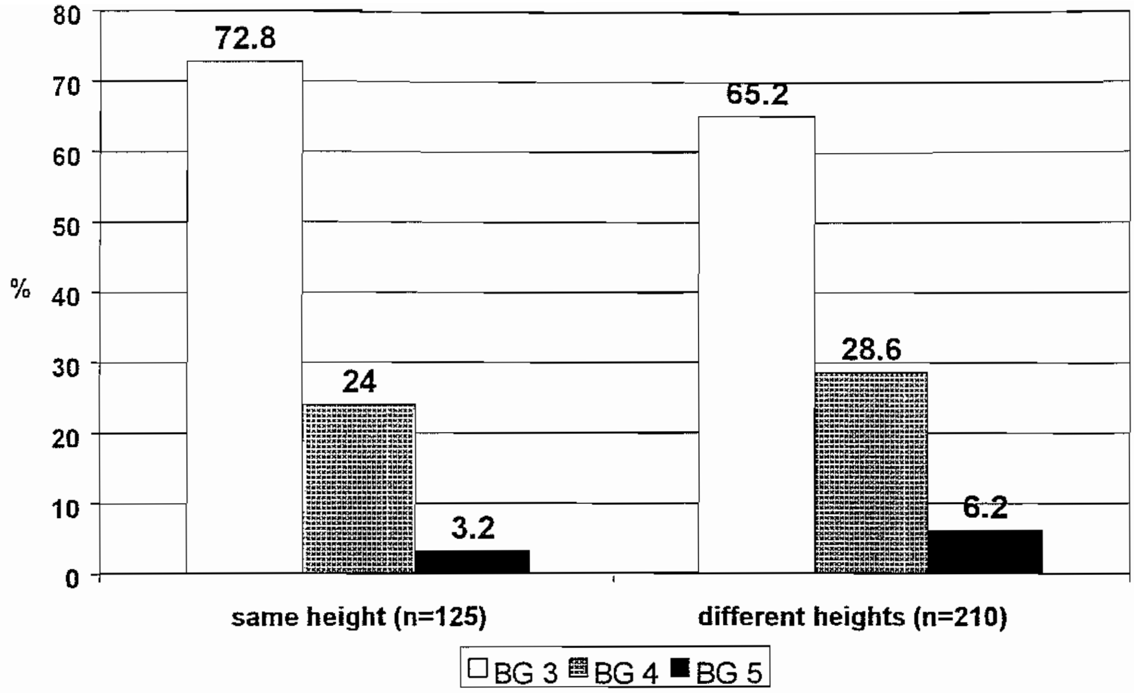


Figure 14: *Degree of damage to vehicles in relation to subframe carrier constellation*

If the so-called „fork effect„ occurs in connection with a frontal collision or an overrun/underrun situation (i.e. the energy-absorbing zones are not in the same horizontal or vertical planes) then much greater amounts of damage are found in the cars.

It should be noted here that in a real-world accident scenario the height of the subframe carrier is exposed to dynamic influences. Both the braking process and the way a car is loaded can have critical effects here.

Proposals as to how the front-end structures of a car might be designed more compatibly are contained in [7]: A homogeneous front-end design in the form of a „frontal impact plate„ (**Figure 15**) with good vertical and horizontal compatibility would make possible an even distribution of impact forces in the event of a frontal collision.

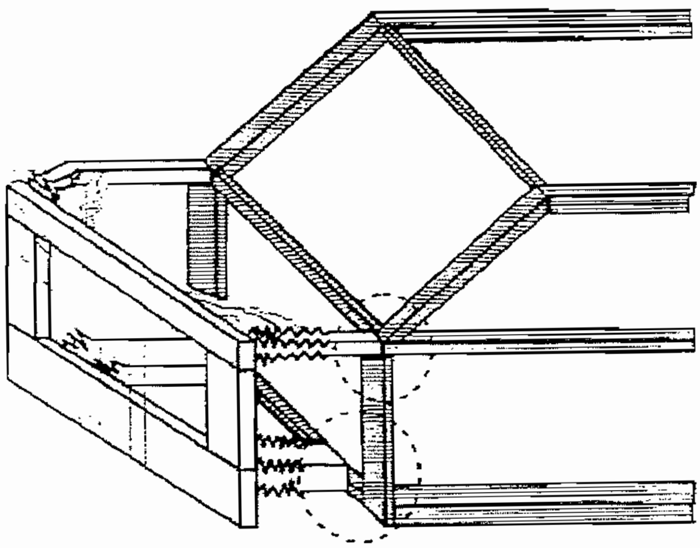


Figure 15: *Example of a frontal impact plate [7]*

This design proposal would not only minimise the fork effect and other dynamic effects in a collision, it would also make possible almost optimum effectiveness of subframe carriers and crumple zones.

The results given here, some of which stem from ongoing EU projects, show how important a compatibility test is for the assessment of vehicle safety; in future it needs to become an additional assessment criterion for Euro-NCAP.

4 Accidents involving pedestrians

4.1 Accident data

The number of pedestrians killed in road accidents in Germany has declined considerably in recent years (minus 43.5 % from 1991 to 1998, see Figure 2); nonetheless greater attention will need to be given to pedestrian safety in future.
In the framework of the "Vehicle Safety 90" programme a new database was built up containing (as of mid-1999) 1,185 car/pedestrian accidents in which injuries and fatalities occurred; the database shows good agreement with official statistics, as can be seen in **Figure 16** with regard to the age distribution of pedestrian fatalities.

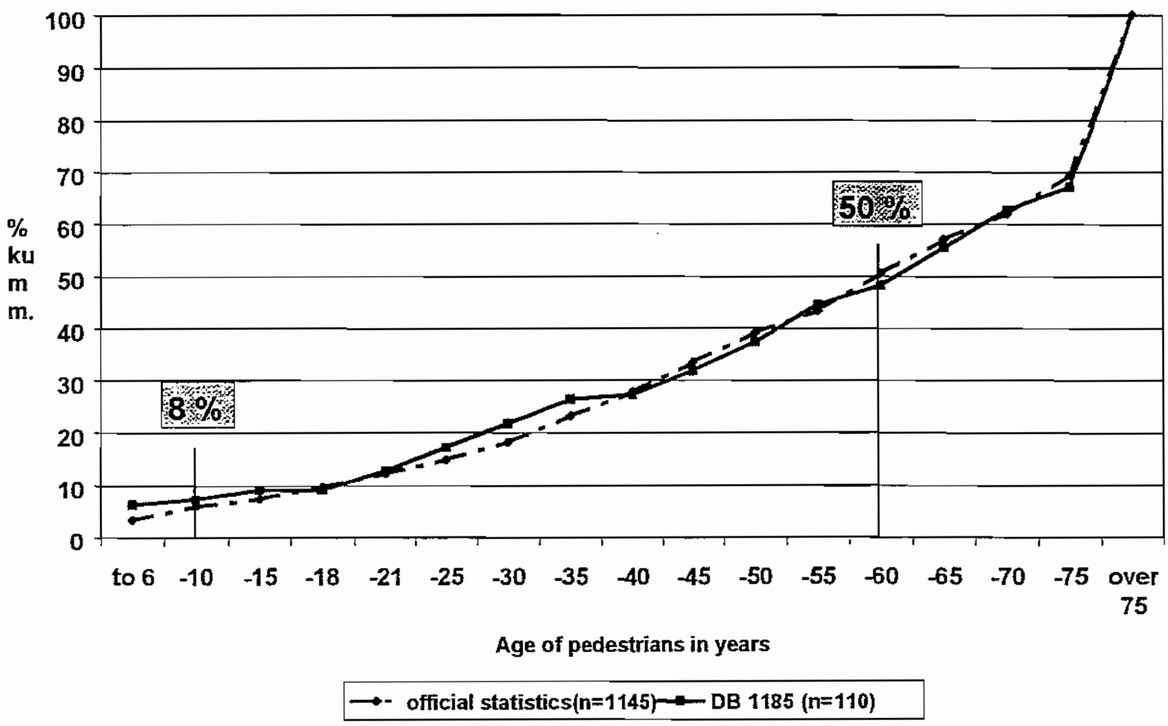


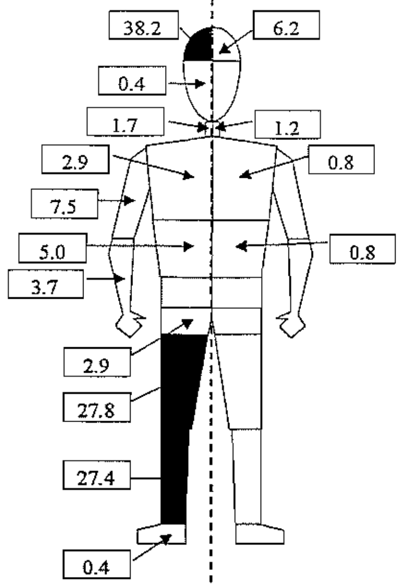
Figure 16: *Comparison of the age distribution of pedestrians killed (official statistics and GDV database).*

The graphs show that children (up to the age of 10) account for about 8 % of those killed and thus that older pedestrians are killed much more frequently. Every second fatally injured pedestrian in the GDV data material was at least 60 years old. This is not only a result of a higher level of pedestrian activity, it is also a result of the greater vulnerability of this age group. The percentages for the different types of injuries are given in **Figure 17**.

Injured parts of the body in pedestrians up to the age of 10
all collision types

AIS 2+

Head	38.2
Upper leg	27.8
Unterschenkel	27.4
Upper arm	7.5
Abdomen	5.0



AIS 4+

Head	6.2
Neck	1.2
Thorax	0.8
Abdomen	0.8

<10
10-20
20-30
>30

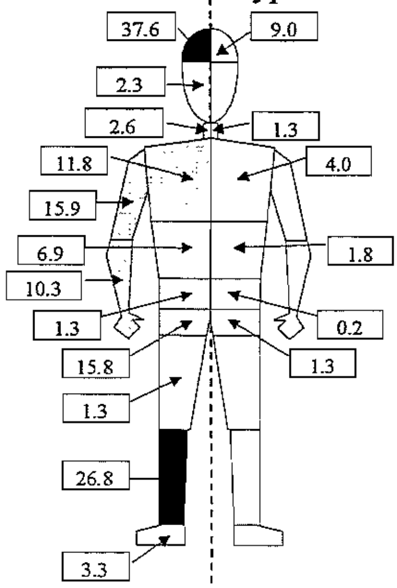
All figures in percent

1185 database
n=214

Injured parts of the body in pedestrians older than 10
all collision types

AIS 2+

Head	37.6
Upper leg	26.8
Upper arm	15.9
Pelvis	15.8
Thorax	11.8



AIS 4+

Head	9.0
Thorax	4.0
Abdomen	1.8
Neck	1.3
Pelvis	1.3

<10
10-20
20-30
>30

All figures in percent

1185 data base
n=944

Figure 17: *Injury statistics for pedestrians up to the age of 10 and over the age of 10*

The danger of suffering a MAIS 4+ injury is much greater among older pedestrians than in the age group up to 10. In the case of head injuries the percentage is nearly half again as much, in the case of injuries to the thorax region it is greater by a factor of 5. However, the greatest difference in the injury statistics between children and adult pedestrians is to be found in the AIS 2+ injuries. While only 1.3 % of those over 10 suffered leg injuries, in the case of children it was 27.8%, nearly one out of every three. It is clear that pedestrian accidents involving children need to be viewed separately, given that they are not comparable to adults with regard to kinematic sequences of events during accidents and, as such, with regard to resultant injuries.

In order to increase the number of cases describing typical injury patterns, the indicated database was expanded in the framework of two special studies by around 100 cases for each of the two categories involving car/pedestrian accidents and accidents with "modern-design short-front cars" (e.g. Mazda 121, Renault Clio) in which fatalities occurred.

4.2 Injury statistics

Accidents in which severe or fatal in juries (MAIS 4+) occur, more frequently involve frontal impacts, as shown in **Figure 18**.

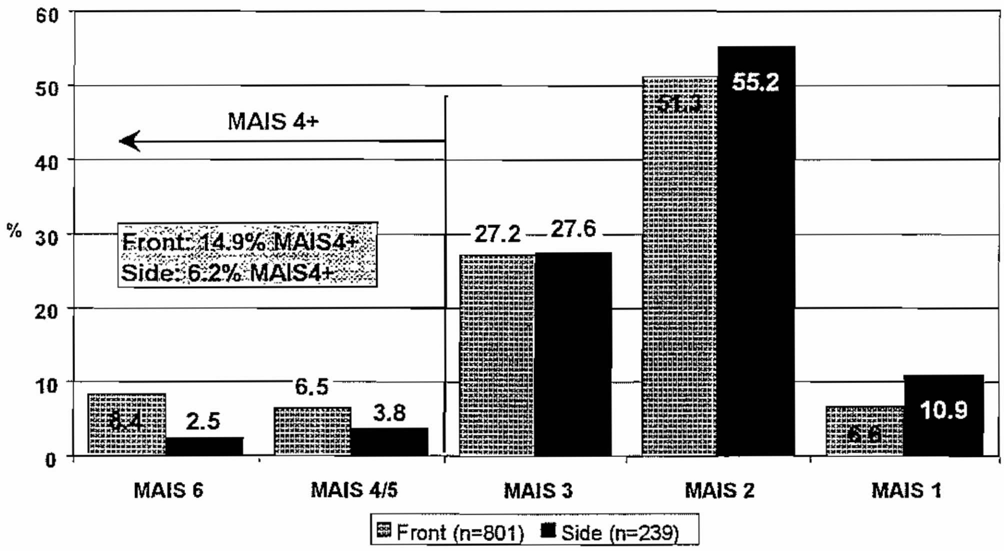


Figure 18: *Initial impact surface compared with degree of injury to pedestrians*

In the case of frontal-impact collisions MAIS4+ injuries occur 2.5 times more frequently than in the case of side-impact collisions.

This fact does not relativise the dangers of side-impact accidents, however, since, as **Figure 19** shows, one out of every three of the children up to the age of 10 contained in the data was impacted by the side of a car. This means that this age group is involved in a third of all side-impact accidents.

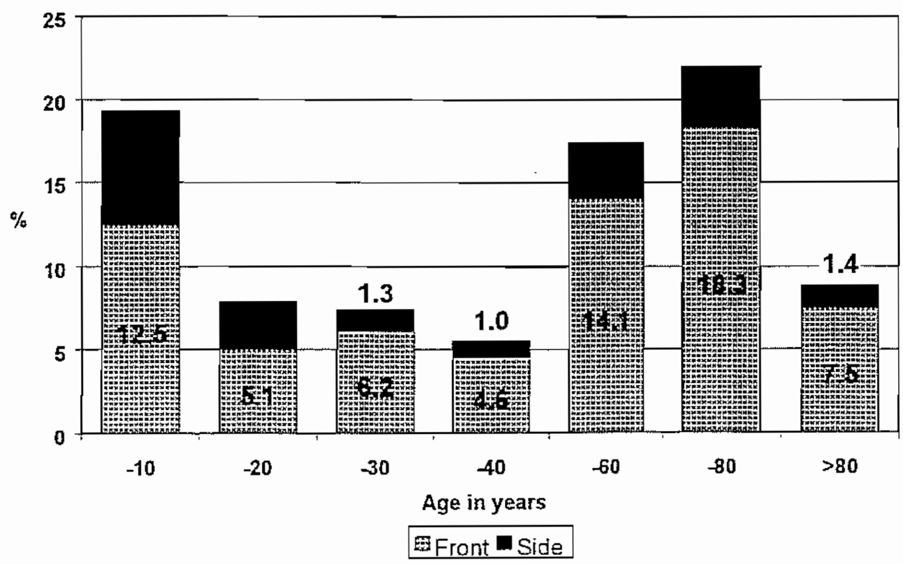


Figure 19: *Initial impact surface in relation to age of pedestrian*

The frontal collision types were divided into six typical kinematic sequences, which were evaluated in interdisciplinary co-operation by engineers with regard to damage characteristically done to the vehicles involved and by physicians with regard to injury mechanisms.

Needless to say, the kinematic sequence of events pedestrians go through during collisions as well as the resulting points of impact with the vehicles are of crucial importance in describing the injuries characteristically suffered in car/pedestrian accidents. **Figure 20** shows six kinematic groups into which the data material was divided.

Group 1 (n=189)

1st impact	front
2nd impact	no further impact
3rd impact	no further impact

Group 2 (n=254)

1st impact	front
2nd impact	bonnet
3rd impact	no further impact

Group 3.1 (n=114)

1st impact	front
2nd impact	bonnet
3rd impact	windscreen

Group 3.2 (n=10)

1st impact	front
2nd impact	bonnet
3rd impact	A-pillar / windscreen frame

Group 4.1 (n=114)

1st impact	front
2nd impact	windscreen
3rd impact	windscreen / bonnet / no further impact

Gruppe 4.2 (n=24)

1st impact	front
2nd impact	A-pillar / windscreen frame
3rd impact	windscreen / bonnet / no further impact

Figure 20: *Categorisation of frontal-impact accidents in accordance with the kinematic sequence of events pedestrians go through*

Clear differences emerged in frequencies of occurrence and the resultant severity of injuries in the different impact categories. While groups 1 and 2 contain by far the largest absolute numbers of cases, the most serious injuries (MAIS 4+) occurred most frequently in the groups 3.1, 3.2 and 4.2 (**Figure 21**).

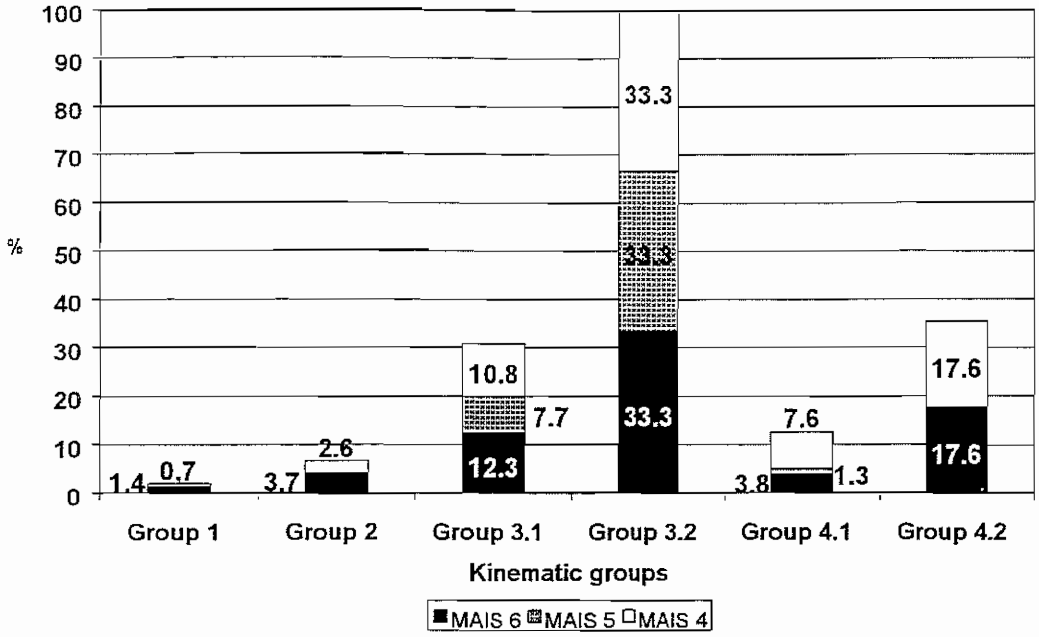


Figure 21: *MAIS4+ injuries of pedestrians in the kinematic groups, collision speed < 50 km/h*

The high percentage of MAIS4+ injuries in the groups 3.1, 3.2 and 4.2 (**Figure 22**) is clearly attributable to the head impacting with hard components of the vehicle such the windscreen, particularly its frame, as well as the A-pillar.

AIS 2+	Group					
	1	2	3.1	3.2	4.1	4.2
Head	30.7	35.0	65.8	90.0	53.5	60.7
Thorax	3.2	8.7	18.4	30.0	16.7	25.0
Pelvis	6.9	14.2	25.4	30.0	14.9	29.1
Upper leg	13.2	13.0	14.0	20.0	10.5	8.3
Lower leg	46.0	37.8	68.4	50.0	61.4	70.8

AIS 4+	Group					
	1	2	3.1	3.2	4.1	4.2
Head	2.7	9.1	32.4	70.0	16.7	37.5
Thorax	0.0	2.0	12.3	30.0	7.0	16.7
Pelvis	0.0	0.8	3.5	10.0	1.8	4.2

Figure 22: *Frequency of individual injuries in the different kinematic groups*

It is also conspicuous that children up to the age of 10 are present in the very dangerous kinematic groups 3 and 4 in a total of only 5 cases. Since no injuries greater than AIS 4 are registered here, no particular severity of injuries is noted in the kinematic groups 3 and 4 for children up to the age of 10.

The situation is different in the kinematic groups 1 and 2. The involvement of children is about 25% in both. Head injuries are predominant here, although in only 9 cases (8.6%) was the degree of injury MAIS 4 or above. It also needs to be taken into account here that in kinematic group 2 1/3 and in group 1, 2/3 of the injuries suffered by the children in question were due to impacting hard on the road surface.

This is of course primarily a result of the sequence of events. In group 1, for instance, there was only a single contact with the front of the car.

For adults this figure is also very high, 20-34%. But in this case injuries caused by impacting with the cars in question play a much greater role. The greatest threat is that of being injured in the lower leg area as a result of bumper impact, accounting for up to 45% of the cases on record. In kinematic group 2, in which initial contact is with the bonnet of the car, one out of every six pedestrians suffered hip injuries as result of colliding with the bonnet.

Although AIS4+ injuries are extremely rare in kinematic groups 1 and 2, the potential for injury must not be underestimated. The recovery process in connection with injuries to the hips or extremities is very demanding in terms of time and costs. Permanent injuries are no rarity here either in the two kinematic groups with the largest number of recorded cases.

4.3 Predominant characteristics of car/pedestrian accidents

The accident data shows that the bumper and bonnet areas are of primary importance in this connection. In any kinematic impact they cause enormous damage to the lower extremities and hips, injuries which are rarely life-threatening but take an extremely long time to recover from and treatment of which is very expensive. By far the most serious injuries occur in connection with the head impacting against the windscreen, the windscreen frame, or the A-pillars.

Children up to the age of 10 are typically involved almost exclusively in impact categories in which no lift-up onto the bonnet occurs. After initial impact with the front of the car they are knocked down and frequently are not injured until they hit the road surface. Given the size of children's bodies, a hard impact with the windscreen or the windscreen frame is unlikely. In car/pedestrian accidents with children of this age group the injuries recorded are comparatively light. This should not detract attention from the potential danger of this kind of accident, but this is not where the main problem lies.

An optimisation of protection against these danger areas would be of major benefit both for children and adults and is, as such, a matter of extreme urgency.

5 Conclusions for international safety standards

5.1 Expansion of European crash test standards

The offset test against a deformable barrier, an integral part of the EU crash test programme, corresponds to about 75 % of all car/car frontal collisions resulting in severe injuries and, as such, is an indispensable reference in the testing of front-end structures and the risks associated with intrusion in frontal collisions.

For the testing of restraint systems an additional crash test against a rigid wall with 100 % coverage and at 50 km/h should be required as a reference test. Making up around 19% of car/car accidents and one-car accidents in which fatalities occur, this type of crash is sufficiently important in the overall accident picture.

Integrated assessment of the impact areas on cars has shown a previously underestimated importance of the single-car accident in which the car rolls over. For this reason a roll-over test at an initial speed of around 70 km/h and characterised by a spiralling motion should be included in future EU safety standards.

Side collisions are of extraordinary importance in all car crashes involving injuries, particularly in single-car crashes against rigid, pole-like objects. For this reason a side-impact crash test at 35 km/h against a pole in the forward door area should also be required, among other things to test the protective effect of side-impact airbags in the head area.

The tests prescribed in the type approval procedure should give greater attention in future to the risks of rear-end collisions. In general a low-speed rear-end test in the form of a sled test should be required for the entire seat/headrest system with delta v = 15 km/h. A corresponding proposal for a test procedure was submitted by GDV.

5.2 Conclusions for Euro-NCAP

In the framework of the project „Quality Criteria for the Safety Assessment of Cars Based on Real-World Crashes„, which is being funded by the European Commission's Directorate-General VII, one of the focuses will be a comparison of safety ratings taken from real accidents with results of Euro-NCAP tests. Results of prospective tests (Euro-NCAP) cannot be compared directly with retrospective safety ratings, but in this project it is nonetheless to be determined in tests carried out on an international basis whether we at least have equal vehicle rankings. One problem will doubtless be the short-term availability of correspondingly large numbers of cases based on real-world accidents, given that Euro-NCAP tests are carried out exclusively with new cars.

Initial comparative studies from Australia [5, 6] show that results obtained from the 40 % offset test correlate fairly well with those taken from real accidents. The work carried out in the framework of the indicated EU project will show the extent to which these results can be transferred to the European context.

A key requirement for the further development of the EuroNCAP test is the measurement of aggressivity. The ideal case would doubtless be given if vehicle aggressivity could be measured by means of an appropriate barrier design in a 64 km/h test with 40% coverage. Based on the information available to us at the present time it cannot yet be determined definitively whether the same barrier with three force/direction-registering elements (**Figure 23**) will satisfy the test criteria for occupant safety as well as those for aggressivity or whether two different types of barriers will be needed.

Independent of this question, in future we will need to ensure that the stricter rigidity criteria desired for occupant safety are not satisfied at the cost of compatibility. A vehicle can only be rated as safe if the criteria both for partner protection as well as for self-protection are satisfied. The additional „compatibility„ factor will mean having to revalue the Euro-NCAP test areas, thus increasing the urgency of a scientifically confirmed integrated assessment of the various Euro-NCAP tests to form an understandable overall safety rating.

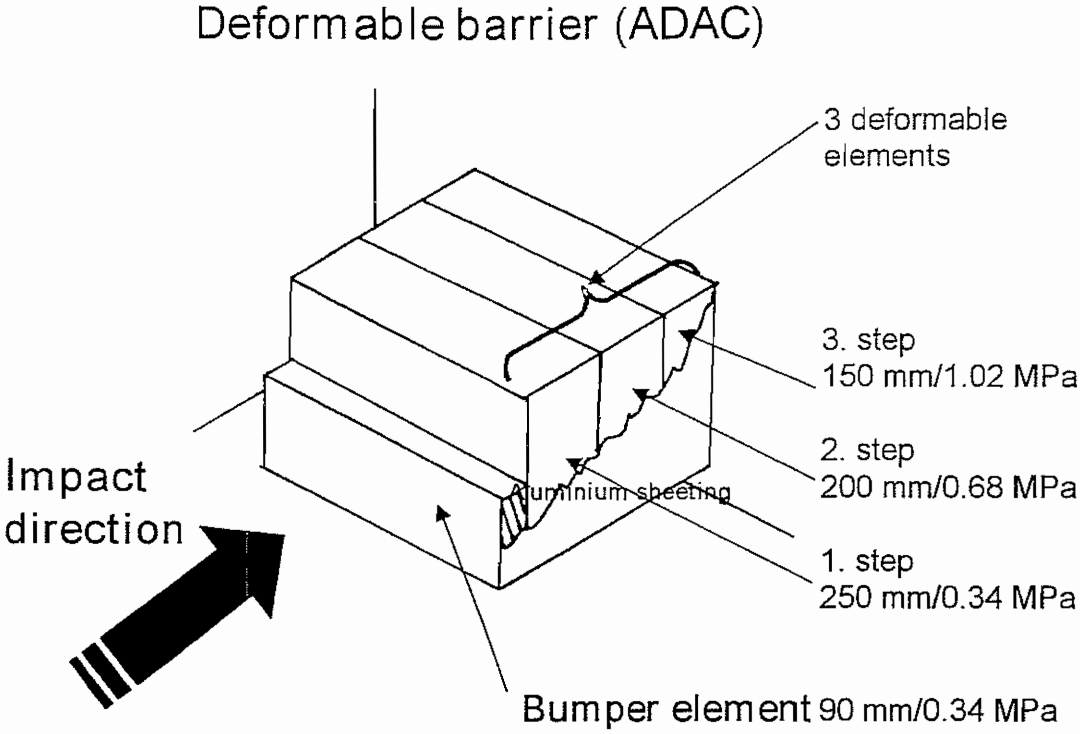


Figure 23: *Example of a three-part deformable barrier for determination of vehicle aggressivity*

The procedure [9] developed by the Technical University of Berlin at the request of the Federal Highway Research Institute (BASt) could serve as the basis for a scientific evaluation. The objective here must be to provide information for consumers, but also to ensure transparency for vehicle manufacturers as well as scientific objectivity. Finally, this work should be carried out with the goal in mind of achieving worldwide harmonisation that would include America and Australia among other countries.

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