NEW DEVELOPMENTS IN RETROSPECTIVE DATA BASES OF SERIOUS CAR CRASHES AND CAR COLLISIONS WITH PEDESTRIANS AND MOTORCYCLISTS. - THE RESEARCH ACTIVITIES OF THE GERMAN INSURERS (GDV)

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ABSTRACT

The German Insurance Association (GDV) has continued and completed the accident research program „Vehicle Safety 90".
Based on a data base of 15,000 car-to-car crashes, about 1,000 car crashes with serious injuries (MAIS3+) have been analyzed in depth. The results are presented, especially analysis regarding collision types and injury criteria. On the basis of a comprehensive injury description, using AIS, ISS and Scales showing long term disability, social economic cost factors are outlined which show the requirements of further injury reduction strategies.

Parallel to the research program „Vehicle Safety 90 – **VS90**" two other data bases have been completed. Accident material of 600 motorcycle-to-car crashes shows both the accident circumstances as well as the crash characteristics and the injury pattern of motorcyclists.
A representative data base of 1,200 car-to-pedestrian accidents will be finished by mid 1998. The collision types and crash/injury characteristics are the focal areas of this research program.
These data bases are described in their structure and the accident parameters covered, the focal results concerning collision types, crash and injury data are outlined, which form the basis for continued analysis within GDV research.
Finally, proposals for data bases of the next research period „Vehicle Safety 2000" will be made which should assist a continued and intensified international cooperation.

INTRODUCTION

Effective protective measures require a thorough knowledge of the accident scene.
This guiding principle of the German Insurers' accident research illustrates the aim of the Institute for Vehicle Safety in Munich.
The systematic research into all details of the accident sequence are presented on the following pages with the help of information from insurers' accident records, police reports and experts' opinions as well as some findings developed from them.

THE BASIS OF THE DATA

Accident research in Germany, and internationally, is divided up into three essential areas of analysis.

- The retrospective analysis of traffic accidents using accident records was the starting point for constructive accident research. The in-depth analysis at the scene of the accident, too, which also relates to data <u>after</u> the real-life accident, partially belongs to this area.

- Experimental simulations represent the second branch of accident research which involves applying the findings of automotive engineering and/or the testing of safety elements on and in the car.

- Mathematical simulation of accident sequences is regarded as the third aspect of accident research.

Without the retrospective preparatory work, however, the basis for experiments and for mathematical models would also be incomplete. In addition, the results of this work reflect the details of the real-life accident, and it is precisely here that it must be repeatedly pointed out that only the accident itself can furnish information on the consequences for the persons involved in it. It is particularly mathematically simulated results that offer at best a framework, which, however, is again and again broken through by real-life events.

The methods of collecting data

Data on accident sequences have been collected continuously by the German insurers since 1969.
This information on accidents is the basis of every data base. By means of coding into characters that the

computer can understand a number of 100 to 350 data fields are made available per accident.

But where do these details of the accident come from?

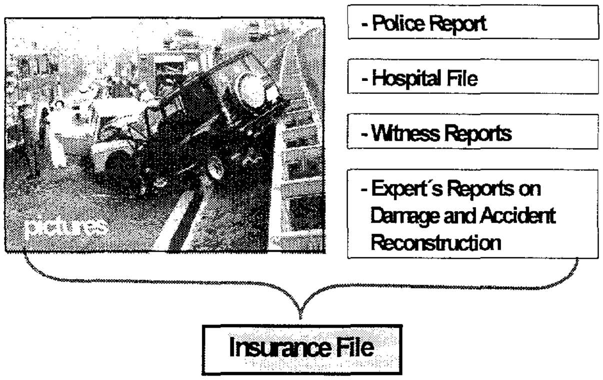


Fig. 1: Data sources for Insurance Files

Here the first decisive advantage of the German Insurers' accident research can be seen, namely access to all of the insurers' claims files relating to the accident.
In Germany the claims files of the insurers provide a valuable basis for accident research, as they contain extensive documentation which is compiled when claims are settled and is systematically expanded during retrospective examination by the Institute's engineers and medical experts.
In most cases an insurance file contains the accident sequence on the basis of the police report, as well as the expert's opinion on damage to the vehicle and the hospital report on injuries to the persons involved. In the case of serious accidents these data are supplemented by reconstructions of the accident sequence and an indication of the speeds.

Compared with collecting data at the scene of the accident, a significant advantage for the work can be recognized here, since nearly every information is available in one file and only has to be coded.
The disadvantage is in the delay between when the accident occurred and the evaluation, as before all the documents have come together in the file, about one year has passed. A further delay may result if some claims have still not been settled and the file is still in the hands of the court, especially in the case of serious accidents.

These disadvantages - on the one hand, in the case of retrospective accident research the delay in time and, on the other, in on-scene analysis the problem of combining all data sources - can, under certain circumstances, be eliminated in the foreseeable future if it turns out to be possible to harmonize the activities of the German insurers with the new efforts to extend the inquiry into the accident at the scene of the accident.
This approach to an interdisciplinary accident research could eliminate, at a stroke, the problems that will become more and more complex in the future.

In summary, if accident research should solve the more and more complicated question of traffic safety in future, there is no alternative to a multi-phased collection of accident data.

The limitations of data bases

The second step, after collecting the data, is to examine the plausibility of the data.
It is no secret that mistakes are made when information is transferred - firstly, when assessing, for example, a detail of the accident, and, secondly, by typing errors.

In most data bases these cases cannot be corrected, as it is no longer possible to access the original information.

In the case of the Institute for vehicle safety in Munich it is possible to specifically access the file once again and thus to integrate the missing information.

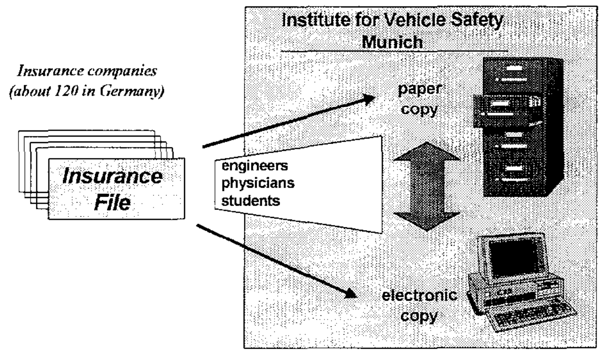


Fig. 2: data acquisition

But in the case of the new problems which crop up, for example, during the evaluation this kind of "redundant" data base has also proved successful. In this case the information can be specifically accessed a second time by looking into the physical file and the data base can be expanded.
This direct access to the records - also, for example, to copy special photos - is an important advantage of the independent accident research of the German Insurers.

In cases in which data from outside data sources are worked on, for example in the case of the official collection of accident data or of data bases that have been purchased, the user is faced with a series of numbers which supplies him with information in coded form. But it will never be possible to reconstruct whether the number of a data field really corresponds to the information about the accident.

Previous accident research of the Institute for Vehicle Safety

Beginning in 1969, there followed in 1974, 1980 and the last time in 1990 large scale analyses /1,2,3,4/ which founded the basis for the accident research of the Institute for Vehicle Safety, formerly known as "Büro für Kfz-Technik" in Munich.

The latest generation of this kind of data (VS90) contains 15,000 car/car accidents as well as 1,000 single-car accidents. The full report is available on request at the Institute for Vehicle Safety.

Apart from these large quantities of data, which on account of the information density are necessarily limited, in recent years special data bases have been built up which contain fewer accidents but more data.

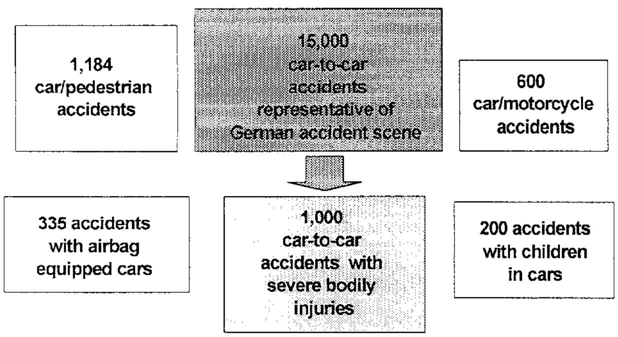


Fig. 3: Data bases of the Institute of Vehicle Safety

Examples of this are 600 motorcycle to car accidents, 1184 car/pedestrian accidents, datasets of accidents in which injury severities exceeded MAIS 3, data about accidents involving children in cars/5,6,7/ and special accidents in which an airbag /8,9,10/ was deployed.

Accident studies of the risk behavior of young drivers or accidents on highways with fatalities also belong to this group of special evaluations /11/.
Medical information, too, for example, on the problems of cervical vertebral column (CVC) injuries, are stored by doctors in the Institute's data bases and are available for evaluation/12/.
All the studies mentioned are listed in the literature.

DATA BASES AND THE RESULTS
Car/car collisions - VS90

With the so-called "Vehicle Safety 90 - VS90" a representative data base of 15.000 accidents has been created. In this "basic analysis", about 100 accident parameters are defined and differentiated according to the factors "man, vehicle, environment"

The accidents considered reflected the accident scene in Germany of all accidents in which bodily injury occurred in one of the vehicles involved.

One of the basic results was the clear distinction of the collision-type as a function of accident severity

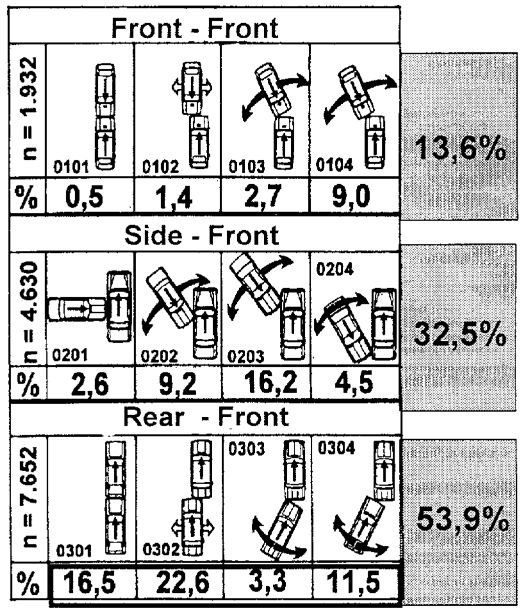


Fig. 4: The distribution of collision-types in the German accident scene

Frontal collisions with 13.6% and side-collisions with 32.5% are also part of the material but as the entire accident scene is characterized by minor accidents, it is the rear-end collisions which are directly connected with the problems of CVC injuries, that dominate in this representative material.

CVC Injuries

In these accidents, injuries to the back of the neck (cervical vertebral column) are the most common type of injury. However, the importance of injuries to the cervical vertebral column is still underestimated, regarding their high social and economic costs.

Approximately 2 billion marks are spent in Germany every year on these injuries. Up to now there are no uniform strategies, either in the diagnosis or treatment of injuries to the cervical vertebral column.
In 12,200 of the total of 15,000 car/car accidents studied (81%), at least one of the occupants complained about CVC pain. CVC distortions (AIS 1) even if they are only declared therefore represent a mass problem in dealing with insurance claims.

61.3% of CVC injuries can be traced to a rear-end collision. The injuries to more than 1,000 people were examined in detail [13]. This analysis showed that the occupants of lightweight cars (up to 800 kg) were more likely to incur CVC injuries than the occupants of medium-heavy cars. Women in general suffered more frequently (79%) from minor CVC injuries than did men (55%) The biomechanical explanation for this tendency is that women have a weaker CVC muscular system.

The headrest is still a "forgotten safety system". Field research and observations have shown that in at least 40% of cars, and possibly as many as 73%, the headrest is incorrectly positioned, i.e. too low. The same conclusion was reached by a basic research project at the Allianz Zentrum für Technik [14].

Accidents with severe injuries – “RESIKO”

After the large scale study VS90 the files where again analyzed but now with the aim of concentrating on accidents in which severe or fatal injuries occurred. In addition, the data-density was raised to about three times more data fields than in the VS90.
This new study was called RE.SI.KO /15/ which stands for the German title “Retrospektive Sicherheitsanalyse von Pkw-Kollisionen mit Schwerverletzten”
In these accidents the shortcomings of passive safety systems are shown up. The limits of feasible safety have not yet been reached, only it will become more and more difficult to find improvements which are not already covered by existing safety elements such as the belt and the airbag.
RE.SI.KO. is aimed at resolving this problem and indicating further possibilities of improving safety.

Angled Front Collisions and Side-Collisions

As the severity of accidents increases, the collision types shift from the rear-end collision to the front and, in particular, to the angled front and side collision.

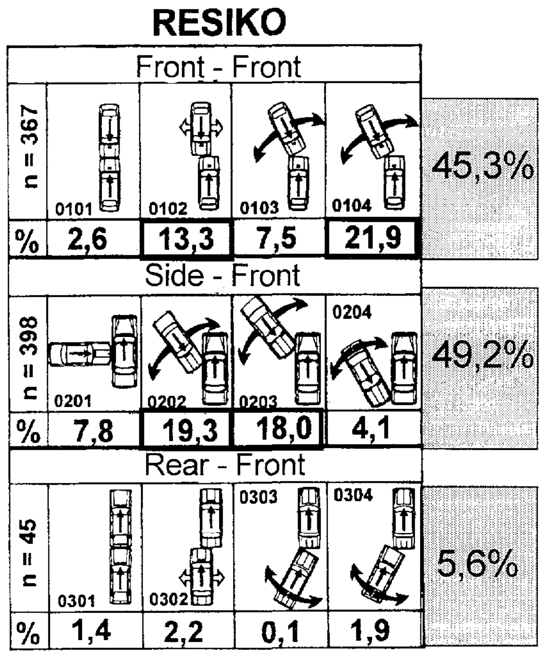


Fig. 5: Collision types in accidents with severe and fatal injuries

Frontal collisions with complete or partial overlap are the subject of constant discussion because of NCAP, EU-NCAP and, in Germany, the numerous crashtests of the motoring magazines.

In addition, our work in the future must address the problems of the angled frontal accidents as well as side collisions.

Angled frontal collisions indicate points of impact for the occupants, e.g. the A-pillar, which at the present time possess only limited passive safety elements. For this reason research activities are being focused on further work to optimize the side airbag or the interaction of frontal and side airbags and as well the design of padding in the vehicle's interior.

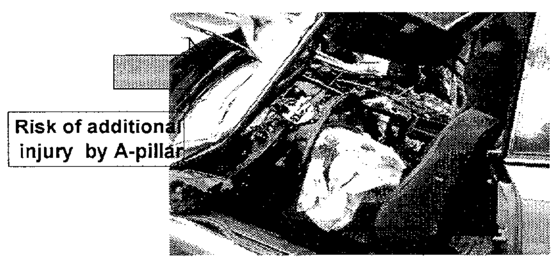


Fig. 6: Risk in angled front-collisions

Side collisions are a further main area on which to concentrate efforts to develop further passive safety.
This also becomes clear by means of a sophisticated presentation of the evaluation of accident severity *according* to the *fundamental* accident situations. It can then be seen that single car accidents and car-to-car accidents are mainly responsible for the high proportion of fatal injuries in cars.

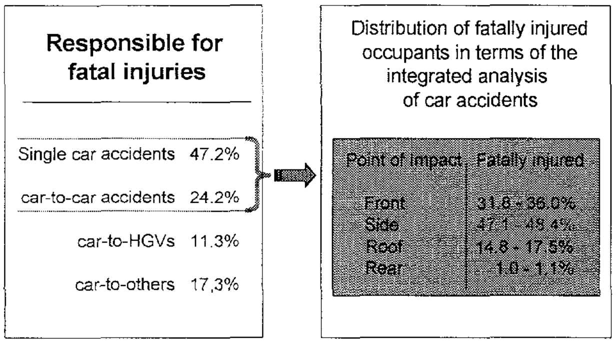
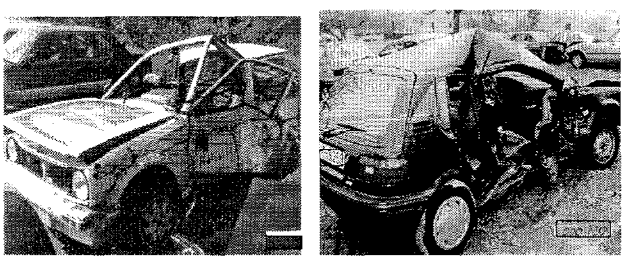


Fig. 7: "Integrated Analysis of Car Accidents"

This so-called integrated evaluation is achieved by projecting the results of representative accident studies, based on a section of the overall accident database (e.g. car/car accidents), onto the overall national statistics.
The study also showed that it is not only sufficient to look at the impact on the driver's side but it is also necessary to concentrate on impact against the other side although sufficient safety space between the occupant and the opponent exists.



43% of all fatally injured drivers die due to an impact on the drivers side — As many as 17% of all killed drivers die due to an impact on the other side

Fig. 8: Side Collisions

The injury pattern of the occupant at the struck-side show that injuries to the thorax, with 12.1%, followed by head-injuries, with 8%, dominate the list of AIS 4+ injuries.
If looking at AIS 2+ injuries the injuries to the pelvis with 32.7%, are significant higher than in all other collision types.

At the non-struck-side the injuries concentrate on the head and thorax but also on neck injuries when only severe injuries are focused on.

Injuries to different body regions

The survey of the injury pattern was completed by an in-depth investigation of the different collision types and body regions. To clarify the difference between the frequency of injuries and the severity of injuries two samples where compared for each collision-type. One sample contained all AIS 2+ injuries the other all AIS 4+ injuries.

For all variations of collisions the head is still the most involved body region with 28.5%. The second position is represented by injuries to the thorax with 24.6%. As in this analysis all collision types are combined all other body regions like the lower arm (10.9%), pelvis (10.3%) show a relatively constant distribution.
This changes if the different collision types are focused.

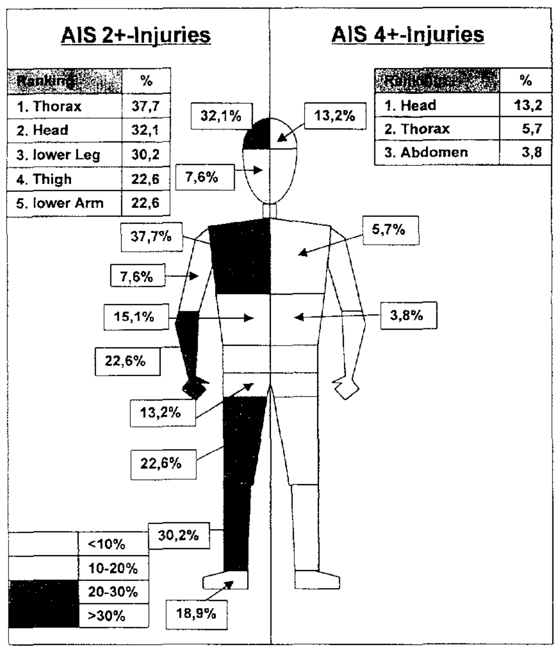


Fig.9: The distribution of injuries in frontal collisions with partial overlap

In frontal collisions with partial overlap it can be seen that nearly every body region has a higher risk than the average contribution.
As in these cases only occupants have been inspected who where belted and without an airbag the injury

contribution will change when accidents with airbags are included.

The following figure shows all frontal collisions. This result is taken from a special airbag investigation where the injuries of a certain accident severity is displayed once for drivers with belt and airbag and once for drivers who where belted only.

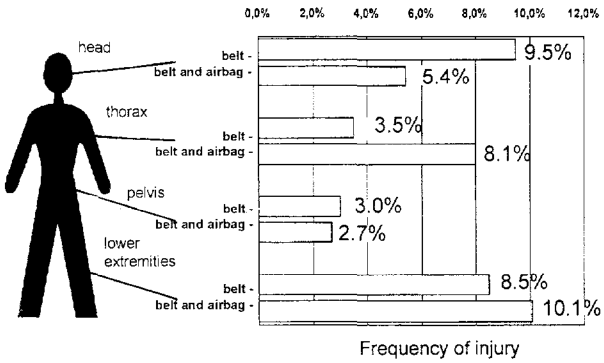


Fig. 10: Injury patterns for restrained drivers in frontal collisions of comparable accident severity

It clearly shows the reduction of injuries to the head but on the other hand an increase of injuries to the thorax. This increase of thorax injuries could be related to the higher age of the drivers in the airbag group but also to the lack of beltforce limiters.
The injuries to the lower extremities in this comparison become number one in ranking. This does not mean that the airbag has an influence on the frequency of these injuries but it shows that the injuries to the lower extremities become more obvious.

If the areas of the foot, lower leg and femur are combined there is a clear indication of a safety deficit. Optimizing the legroom and preventing the intrusion of parts of the engine into the passenger cell are two areas of research which hold out the promise of improvement.
An improved dummy design in the region of the lower extremities is necessary if the loading is to be researched realistically.

Injury costs

The RESIKO study also analyzed the injury costs depending on the type of collision. By means of the injury cost scale (ICS) it was possible to look at the average costs per body region.
The following results are calculated only for injured occupants. Calculations for killed persons have been incorporated.

For the entire accident material 1685 belted persons were inspected. The costs where calculated applying the definitions of the German "Berufsgenossenschaft" and set in relation to the appearance in all accidents and in special collision types.

One of the results concentrates on the injuries to the lower extremities. These injuries have been neglected in the past because of the dominance of the head injuries. Now, as the effect of the airbag is perceptible in decreasing head injuries, injuries to the lower extremities have to be studied greater in detail.
In figure 11 three different samples are compared. All accidents, all frontal collisions and only those frontal collisions where a partial overlap took place.
As it shows, the highest costs arise when the car is partially hit and that in those cases the costs double, especially for the lower extremities.

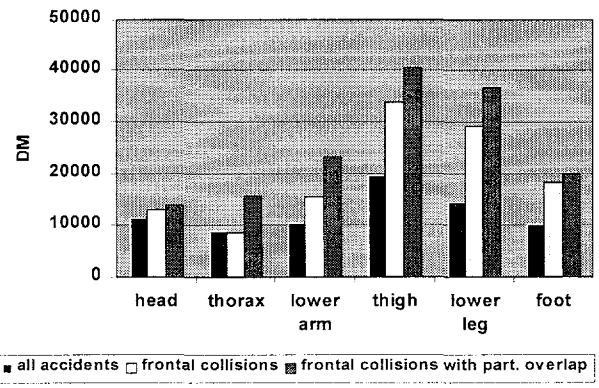


Fig. 11: Injury costs for different collision types

In future these injuries of the lower extremities will provide a lot of scientific potential to improve secondary safety in cars.

The problems of driving dynamics

Further results of the study of the accidents in which serious and fatal injuries occurred focus on problems of controlling the vehicle.
The material offers the possibility for analyzing both active and passive safety.
About 30% of all accidents between two cars resulting in fatalities take place at crossroads or junctions. The rest, about three-quarters of all fatal collisions, are the result of driver error on straight roads, in bends and when overtaking.

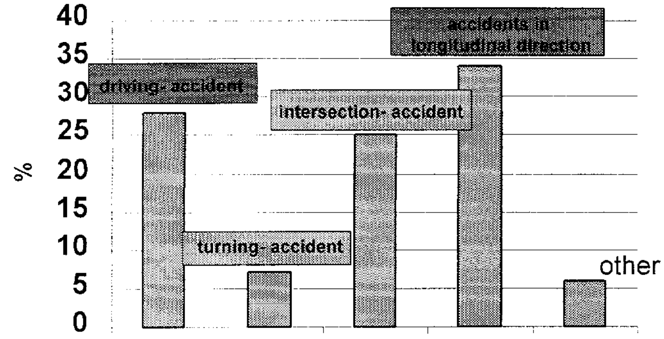


fig. 12: Distribution of accident types in severe car-to-car collisions

The "driving accident", which is presented as the loss of control over the vehicle as a result of speeding in bends, faulty reactions by the driver and overestimating one's own driving ability, is ideally suitable as a field for developing new vehicle systems like driver assistance systems.

In Germany the development of such driving stabilization systems can be clearly observed.
Two findings can be derived from this.

Throughout the world there are no uniform tests to examine questions of active safety, and, the possibilities of improving active safety or driving dynamics like ABS, ESP and other driver assistance systems has to be intensively promoted. Activities have been started by the German VDA.

In accidents with serious bodily injury that have been studied this weak spot showed up quite clearly.
Besides the vehicle-specific improvements, however, the human being and the road also have to be included if accidents resulting from driving dynamics are to be overcome. Driver training, further instruction and appropriate ways of addressing driving errors have to be optimized.
Road instabilities, such as, for example, sunken road shoulders, are further parameters which, when a vehicle starts to swerve, counteract any rapid correction by the driver.
Before the potential of passive safety becomes effective, all the possibilities of active safety should be exhausted to avoid the accident in the first place.

CAR/MOTORCYCLE COLLISIONS

Besides the problems of car safety the data bases of the German automobile insurers also offers information on two wheeler accidents such as motorcycle and moped driver.
As an unprotected road-user the driver of a motorized two-wheel vehicle is exposed to higher risks. Numerous studies have dealt with this type of accident and the consequences.

The German Insurers' motorcycle data base first made it possible for a description of the accident according to the definition of the ISO standard 12232/13/ to be developed for this type of collision.

Collision type

The collision type, i.e. the way in which the two vehicles involved in the accident collide, constitutes the central starting point for assessing passive safety. It is precisely in the case of the motor cycle accident that so many trajectories arise depending on the collision type that a single examination can never describe all the possible injury patterns.
In the following comments the variations of collision types depending on the different ways they occurred and the consequences of the accidents for the motor cycle accident are described and evaluated.
The code prescribed in the ISO Standard is used as a definition of the collision type. The impact point on the accident opponent, on the motor cycle and the angle of the longitudinal axis result in a three-digit number.
These three digits can, when considered individually, also give the first indications of the critical points of the accident.
Fig. 13 shows the contact point on the accident opponent

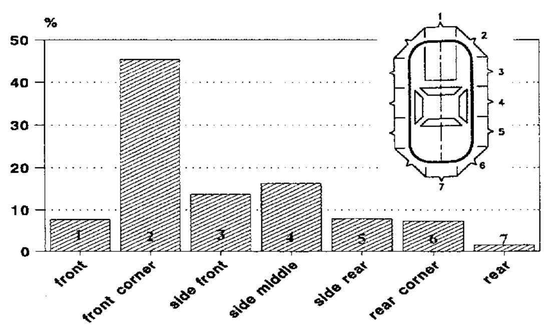


Fig. 13: Contact point on the car in collisions with motocycles

The front corner is obviously by far the most frequent point of contact on the car.
A distribution presented in the next Figure results from the contact points on the motor cycle.
As expected, the front of the motor cycle dominates with about 60%.

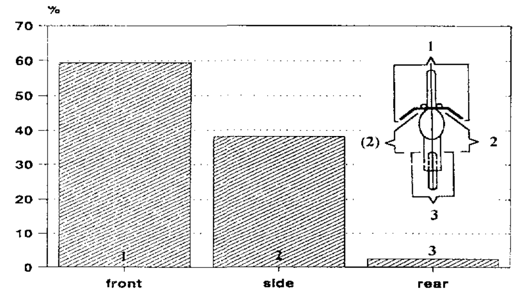


Fig.14: Contact point on the motor cycle in collisions with a car

Rear collisions, i.e. accidents in which the motor cycle is struck from behind, are rare.

The angle of the longitudinal axis of the vehicles involved is laid down as the third feature of the collision type. The distribution of the individual angle areas is shown in Fig. 15.

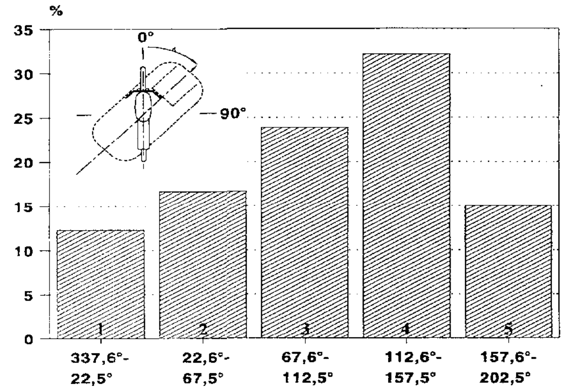


Fig. 15: Angles of the longitudinal axes to one another in car/motorcycle collisions

The opposing angled impact and the roughly perpendicular, about 90°-collision can be observed most frequently in the accidents.

Accident avoidance

What is new in this area is an analysis of the accidents in which a collision occurred between a car and a motorcycle, and only those cases were considered in which the motorcyclist was not responsible for the accident.

If the motorcyclist exceeds the critical speed in a bend or disregards the right of way, then this is an obvious error. It is quite different if the collision seems to take the motorcyclist by surprise. Unfortunately the proportion of these accidents is very high in Germany. Two-thirds of all collisions with a car fall into this group.
500 accidents of this kind were therefore stored in a new data base, and indications of how such accidents can, under certain circumstances, be recognized in advance and avoided were sought.

Cars ignoring the right of way at intersections was the most frequent accident type, namely 42%. This is followed by a car turning into a side street, motor cycle is overtaking and turning round by car.

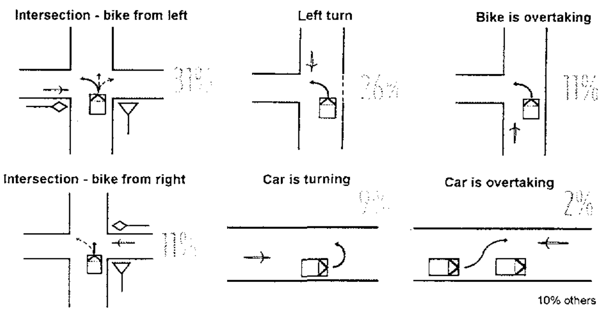


Fig 16: Accident types in collisions where the motorcycle driver was not guilty

For these main areas in the accident scene three rules of conduct were set up the aim of which is to make the motorcyclist sensitive to accident-prone situations.
Firstly, it is important not to take one's own right of way for granted. If under certain circumstances one risks a bump in the car, a motorcyclist suffers a more or less serious injury in almost all accidents. So the first rule is to distrust one's own right of way in unclear situations.
It is not always easy to recognize a one-track vehicle, i.e. there is a tendency to overlook a motorcyclist or in many cases his speed is wrongly estimated. He should therefore not simply assume that he has been noticed. Especially in situations in which car drivers do not react to an approaching motorcyclist such aids as the horn can attract attention.
This leads to the third rule, namely the motorcyclist should react in good time as soon as he has realized that the situation is unclear. In many cases it was observed that the motorcyclist had enough time to reduce his speed or to make himself noticed. But at a certain point

it is too late, and the accident sequence can no longer be averted.

The findings of this motorcycle study were published in a brochure last year in cooperation with the Institute for Motorcycle Safety, and so far about 20,000 copies have been distributed. In addition, driving schools and private persons can order a video[1] on this subject.

CAR/PEDESTRIAN COLLISIONS

A data base on pedestrian accidents was completed in the spring of 1998. It comprises 1,185 collisions between a car and a pedestrian. Trifling accidents were left out, and only those accidents were entered in which the pedestrian at least required in-patient hospital treatment. Directly comparable data from official statistics are not available for these accidents.

This data base was created in two stages. After 348 accidents, the data was sifted, and then, after completion, compared with the entire database.
The background to this method of proceeding was to check the statistical stability from a certain number of cases beginning after about 350 accidents.
The data were collected at random and presented in the following table of the most important circumstances surrounding the accidents. The deviation of the individual collections is visible. Some parameters show good agreement. In the case of some information about, for example, the involvement of alcohol, the error span is 4% in total.

	348 cases %	1185 cases %	Diff.	%
Accident location				
Built-up areas	89,9	88,9	1,00	1,11
Crossing	25,3	20,1	5,20	20,55
Junction	17,5	21,6	-4,10	-23,43
Straight road	39,9	38,3	1,60	4,01
Weather				
Rain	21,8	20,9	0,90	4,13
Clear	49,2	46,8	2,40	4,88
Daylight	57,0	55,0	2,00	3,51
Traffic regulation				
none	56,3	53,3	3,00	5,33
Pedestrian crossing	20,8	20,1	0,70	3,37
Causes of accident - car				
speeding	18,3	18,4	-0,10	-0,55
Causes of accident - pedestrian				
Alcohol	14,2	10,1	4,10	28,87

Fig17.: Comparison of various datafields in different data sizes

Since, as already mentioned, there are no comparable groups of these accidents from the official statistics or from any study, the figures of the larger collection must be regarded as representative.
Case numbers of around 350 cases from this comparison cannot be considered adequately representative.

The results of the study will be published around the end of 1998. The following features can be identified in advance.

When an accident occurs between a car and a pedestrian it was the pedestrian's fault in one third of the cases.

The collision speeds of the cars are within a range in which improvements are still possible. In 58.4% of all pedestrian accidents the impact speed was below 30 kph. If the speeds are considered in cases in which the car driver was at fault, the proportion of this group was 65.6%.

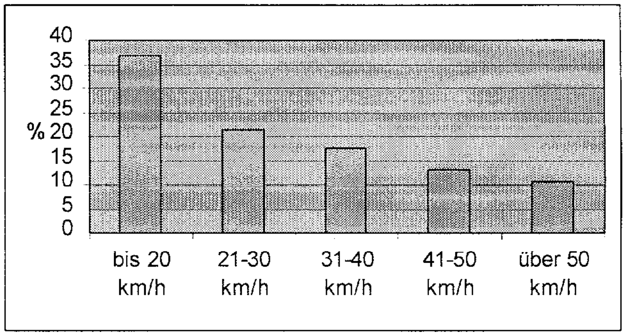


Fig. 18: Collision speed of the car in car-pedestrian accidents

With systematic measures it must be possible to optimize the vehicles front for this speed range.
This can be achieved by influencing the motion path and by avoiding hard vehicle parts in the area of contact.

The main body regions which are injured are the knee,/lower leg and head each with 19% occurrence. 50% of the killed pedestrians died due to a head injury.

Age groups at risk are children up to the age of 9 (18.8%) and pedestrians over 50 years old (49%).

In general, the problems of pedestrian accidents still provide an abundance of leads for further improving safety. The main areas of technical measures as well as training and educating adults have to be addressed.

[1] To order at GDV München

Summary - The aims of the German Insurers' accident research

The evaluation of data bases has become an indispensable part of accident research. But foreseeable developments show that gathering data is becoming more and more complicated, because, on the one hand, the quality of the data makes ever higher demands, but, on the other, it is becoming increasingly difficult to get at the data at all. Data protection and administrative problems are not diminishing.
The way out of this dilemma is to be found in the search for new ways of acquiring data.
Information only from insurance files will no longer meet the demand for more details of the accident.
On-the-spot accident research, in-depth analyses as well as closer cooperation with the police, fire brigade and authorities can help here.

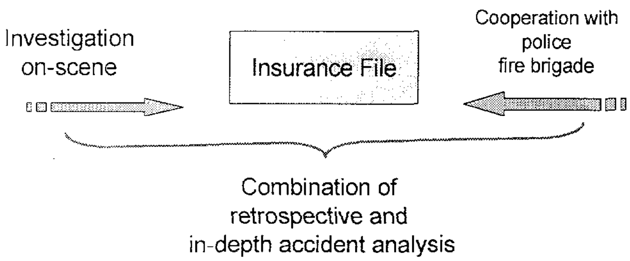


Fig. 19: Future accident research

Thus the basis of the German Insurers can be realistically expanded and continued, and we face the challenges of the future with confidence.

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