

ACTIVE SAFETY SYSTEMS CHANGE ACCIDENT ENVIRONMENT OF VEHICLES SIGNIFICANTLY - A CHALLENGE FOR VEHICLE DESIGN

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ABSTRACT:

ESP, the Electronic Stabilization Program, was offered by Volkswagen and AUDI, because predictions showed a high potential for injury mitigation through accident avoidance. This encouraged both companies, to offer ESP for most of their vehicles, beginning with the Audi A2/A3 and VW Golf. Adding ESP would make the vehicles more expensive. The decision to offer ESP was a courageous one, especially in the A2/A3 and Golf segments where price was and is a major consideration for customers. So it was clear that the accident performance of vehicles equipped with ESP had to be very carefully and thoroughly studied by Volkswagen and AUDI accident research teams.

The result of this research exceeded expectations. The accident research teams had to increase their projections with every new study. Today, it can be stated that ESP is the most effective safety measure after the safety belt, even more effective than the airbags.

The main figures are: ESP, provided by Volkswagen and AUDI, can prevent 80% of all skidding accidents. This means that ESP has a high potential to prevent roll-over accidents. There is an additional potential of ESP, because it will change pole-side-impact into pole-frontal-accidents. This is still a dangerous accident, but much less dangerous than pole-side-impacts. If only the avoidance effect of ESP is taken into account, it can be stated from accident experience (not projections) that more than 80% of all skidding accidents can be prevented by ESP. This is a new dimension, if compared with passive safety. While a passive safety measure can prevent injuries, ESP prevents

the accident from occurring. The driver does not realize that he just avoided a situation, that might have been fatal without ESP. In Germany, this finding would mean that 35% of all vehicle occupant fatalities could be prevented: Not just reduced to minor injuries, but actually prevented. Secondary effects of injury mitigation, as mentioned before not taken into account. So 35% is a lower limit of the expected effect.

These findings show that the future development of vehicle safety will be driven by accident avoidance much more than by injury mitigation. Rating systems of passenger vehicles should take this into account. Regulation, compliance testing, and rating systems like the different international NCAP organisations should also take this into account.

Accident avoidance is always the better solution. Future development should reflect this widely accepted philosophy. NCAP-ratings should make sure that a „best pick“ is really a best pick based primarily on accident avoidance and not just with respect to injury mitigation.

INTRODUCTION

Vehicle safety during all stages of product development and production has always been common practice at Volkswagen. Accident research in combination with the development of products that offer high levels of passive and active safety has a high priority in this process.

Since passive safety has been the focus of vehicle development in the past, remarkable progress has taken place in this field that has led to a high standard of performance in passenger vehicles. Vehicle designs have brought about dramatic decreases in the injury risk to vehicle occupants.

Over the last several years, advances in electronics have increased the feasibility of vehicle systems that help the driver to prevent accidents. Early examples of such systems are ABS (Antilock Braking System) – in more recent vehicles, ESP (Electronic Stabilization Program) can be seen as the most notable example of such active safety measures. In contrast to passive safety measures, such systems do more than just reduce the overall risk of injury. They influence accident diversity and thus change the requirements for future safety developments.

To gain more knowledge about those changes, the VW group operates teams of experts, consisting of engineers, physicians and psychologists to analyse accidents involving recent VW vehicles. Accident reconstruction provides initial information regarding the probable cause of the accident.

In addition to these activities, representative accident data from several national and international sources is analysed in depth to gain a better appreciation of the incidence of potentially critical situations.

Several studies from various groups involved with traffic safety have proven the benefits of ESP in preventing accidents. Thus, as a result of the increasing size of the portion of the vehicle fleet equipped with ESP, the distribution of different accident types will change significantly in the years to come. Brake assist systems (BAS) are a further example of features that will influence real-world accident scenarios. Comparable effects can be expected from other active safety systems expected to be introduced in passenger vehicles over the coming years.

These changes in accident scenarios give reason to re-think recent test configurations and new test-methods that are currently under discussion. Accident research will have to answer the question,

if current methods are able to handle future tasks and bring about an increase traffic safety.

This paper will offer an overview of, how the benefits of these new systems must be taken into account during the discussion of future regulations and consumer testing. ESP performance will bring about positive changes which can already be observed in Germany. This should be a starting point of a general discussion regarding future goals.

GIDAS ACCIDENT DATA

The analyses in this paper are based on data supplied by GIDAS (German In Depth Accident Study). The advantages of this database are two-fold: (1) the number of cases is high enough to provide statistically significant results, and (2) each case is documented in great detail, permitting in-depth-analyses where required.

GIDAS is a unique project involving the German government and the motor vehicle industry. The cornerstone of the GIDAS-project was laid in 1973 and based on the recognition that official statistics were not sufficient to answer important questions that arise during accident research. For this reason, the German Federal Highway Research Institute (“Bundesanstalt für Straßenwesen”, BASt) initiated a project, in which interdisciplinary teams analysed highway accidents from a scientific perspective – independent of the objectives and needs of law enforcement. The project underwent an important change in 1985, when the choice of the accidents for detailed analysis began to follow a random sampling plan.

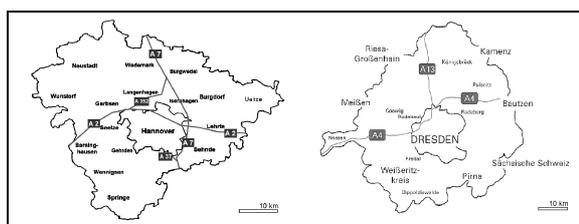


Figure 1. GIDAS Research Areas in Dresden and Hanover.

A second major improvement took place in 1999 when GIDAS was expanded to include cooperation with BASt and the German Association for Automotive Technology Research (“Forschungsvereinigung Automobiltechnik e.V.”, FAT). For this purpose, a second team was established at the Technical University of Dresden. Currently, the sampling criteria are as follows:

- road accident

- accident site in Hanover City and County or Dresden City and County
- accident occurs when a team is on duty
- at least one person in accident injured, regardless of severity

The data collected is entered in a hierarchical database. Depending on the type of accident, each case is described by a total of 500 to 3,000 variables, e. g. accident type and environmental conditions (record Umwelt), vehicle-type, mass, drive train and the type of road it was on (record Fzg), the age, size, hours on the road and injury data for all persons involved (record Persdat and Verlob). Each accident is reconstructed in detail including the pre-collision-phase. Available information includes initial vehicle and impact speed, deceleration as well as the collision sequence.

This database is representative of German national accident statistics, whereby severe cases are slightly over-represented. The database that Volkswagen accesses currently contains as many as 19,300 cases, involving 34,400 vehicles and 49,500 people, 26,700 of which were injured.

SINGLE CASE ANALYSIS AT VW-GROUP-ACCIDENT-RESEARCH

The Volkswagen Group formed one brand research teams at AUDI in Ingolstadt and another at VW in Wolfsburg. One reason to initiate brand accident investigation was the lack of accident data for newer vehicles. Figure 2 shows the phase-in of new models into the GIDAS database. Statistical analysis of accidents with newest models can only be performed if the number of cases in the database is sufficient to provide reliable results. The example of the VW-Golf, one of the top sellers in the German market, shows that this process takes about 5 years.

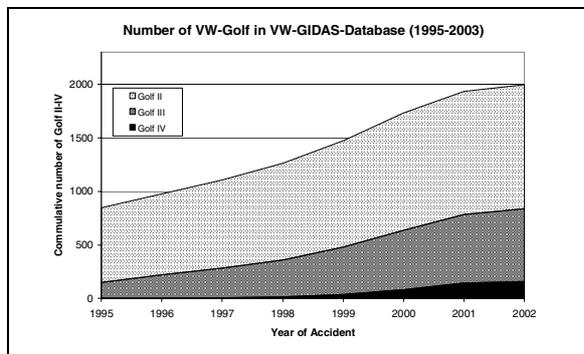


Figure 2: Number of VWGolf Models in GIDASData

This leadtime means that the potential for technical improvements based on real-world accident data would be delayed by at least 5 years. These teams consist of engineers, physicians and psychologists. The multi-disciplinary nature of the teams permits a comprehensive understanding of the accidents investigated. These accident investigations also include a technical analysis of vehicle structure and suspension as well as a complete reconstruction of the accident sequence, including the medical analysis of injuries and the injury causing factors as well as a detailed understanding of accident causation through physical and psychological analysis of the accident scene and in-depth interviews with the persons involved. The basic elements of such accident research are shown in figure 3.

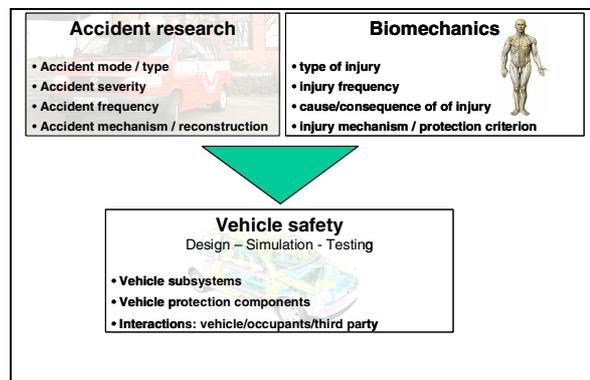


Figure 3. Accident Research at Audi and Volkswagen

To help guarantee the best data quality both teams are on call 24 hours a day, seven days a week to allow an timely on-scene investigation and documentaion of evidence and debris.

LATERAL AND FRONTAL POLE COLLISIONS

In 2002 in Germany approximately 25% of all passenger car fatalities were attributable to pole impacts (2002: 1577 deaths, 9636 severe injuries). The majority of this accident type shows a stereotypical course of events in which the driver first loses control of the vehicle and after skidding with the vehicle rotating around the z axis a lateral pole/tree collision follows at the side of the road. The cause of the “loss of control” is often driver inattention.

The consequences of such accidents are dramatic as indicated by the incidence fatalities. From a technical perspective, the side structure of any passenger vehicle must be viewed as that part of a passenger vehicle having the smallest deformation space, as much as vehicles width is necessarily limited. Only limited deformable structures with a

limited capacity to absorb impact energy can be provided. Figure 4 shows a comparison between the deformation space available in frontal and lateral structures of a passenger vehicles.

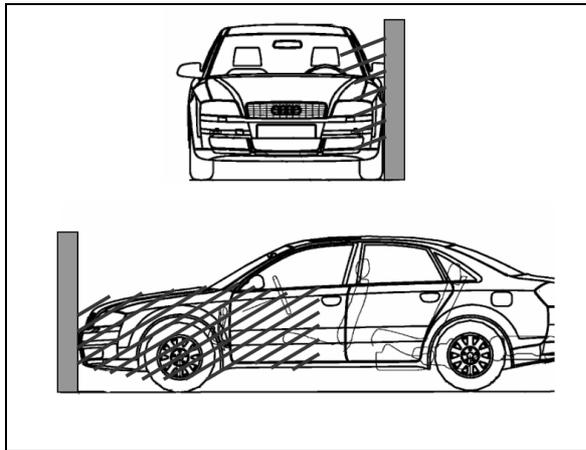


Figure 4. Deformable Areas in frontal and lateral Collisions.

In lateral pole collisions, the distance between occupant and impacting pole is less than 30cm. It is within the narrow confines of this space in which energy absorption and moderate occupant acceleration combined with sufficient survival space to be accomplished in order to minimize the risk of injury. This conflict between energy absorption through deformation and survival space is easier to resolve in frontal impacts where more than 1m space is left between the bumper and the occupant's head. So much more structure can be used to optimize the deceleration process. In frontal impact situations considerably more deformable structure can manage a significant part of the impact energy. In addition, restraint systems optimize occupants kinematics and help to absorb additional energy.

Despite these physical limitations, this collision type has been the focus of vehicle design for many years, in order to decrease the injury risk of lateral collisions. These efforts resulted in remarkable increases in levels of vehicle safety by improving lateral strength together with the introduction of additional safety equipment such as side airbags in the thorax region and curtain airbags. Consumer testing and legislation helped to encourage these improvements with which an optimized level of passive safety has been achieved.

It must be noted that this accident type represents a challenge for safety design. Figure 5 depicts the risk of head injury in lateral and frontal pole impacts.

Both tests were performed with the same vehicle type. In the frontal impact test a Hybrid III-Dummy was used, in the lateral test a EuroSID side impact dummy was selected.

Figure 5 shows head acceleration over time in a 29km/h 90° lateral pole impact and a 35 km/h full frontal pole impact. Considering the amount of kinetic energy involved, the frontal impact can be seen as the more severe event because the impact velocity is significantly higher than the speed in the lateral configuration. Two physical characteristics highlight the difference between these accident types:

- given the lower impact energy, the peak head acceleration is significantly higher than in the frontal impact.
- the time between impact and peak acceleration is much shorter than in frontal impacts.

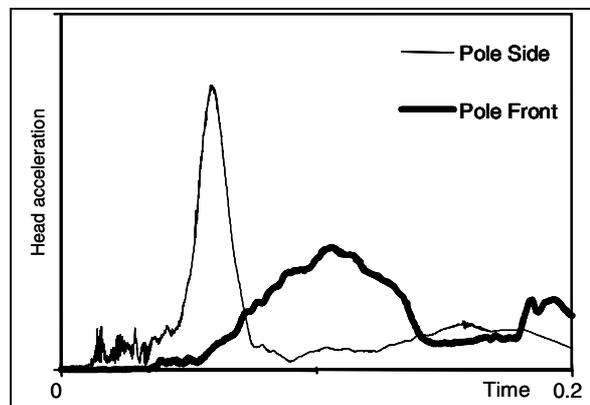


Figure 5. Head Acceleration in Pole to Side and Frontal Pole Collisions.

The first characteristic results from a direct contact of the occupants head with the impacting pole. In this particular example a head airbag was between head and pole which reduced occupant injury risk. The risk of injury associated with such contacts can only be mitigated if the vehicle is equipped with airbags that help protect the head.

The second characteristic indicates that the time to deploy side airbags is very short in comparison with the time available for a front airbag to deploy.

In a frontal pole test at 35km/h, the vehicle is moderately deformed and experiences moderate deceleration. With the exception of the lower extremities, occupants usually do not have contact with vehicle structures. The restraint system (airbag, safety belt, knee padding) can decelerate the passenger over a longer distance than side structures can in side impacts.

Figures 6 and 7 show the deformation of the test vehicle in the frontal impact test. At maximum crush the compartment is completely intact. Figures 8-10 show the vehicle structure in the lateral test configuration. The deformation is more severe. The intrusion into the compartment indicates a comparatively high risk of injury for occupants within the impact area.



Figure 6. First Contact between the Frontal Structure and the Pole.



Figure 7. Maximum Deformation of the Frontal Structure.

In a side impact with a pole at 29km/h the occupant on the struck side is in a free flight with 29km/h against a rigid obstacle. Considering that the door structure cannot be completely crushed, the distance remaining for occupant deceleration is approximately 0.1-0.15m (pelvis, abdomen, chest) and a little bit more for the head. The restraint systems (airbag, padding) have only this small distance available in which to absorb the occupant's kinetic energy. The deceleration phase must be complete within 40-50ms. Up to 40ms the vehicle has moved approximately 0,3m. The deformation phase ends 0.15s after initial contact with an intrusion of appr. 0.5m.

The severity of these side pole impacts and their risk for the occupants is evident. The ability of passive safety measures to reduce this risk is limited by the lack of space as mentioned above.

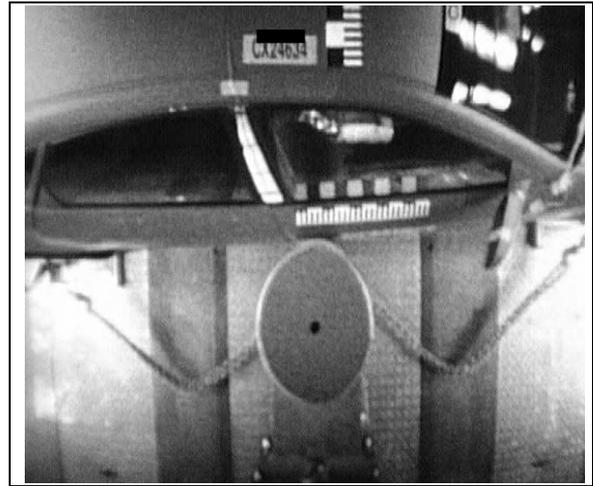


Figure 8. First Contact between the Pole and the Door

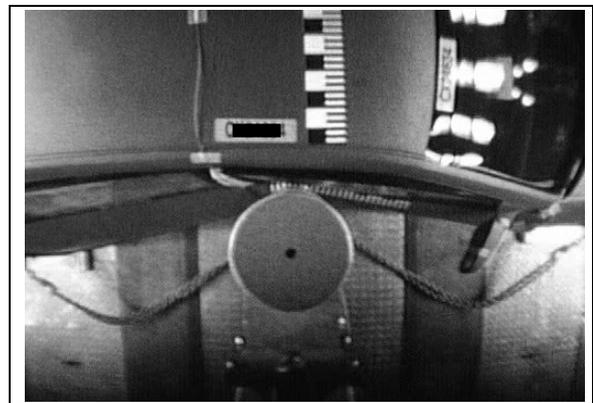


Figure 9. End of Occupants Deceleration.



Figure 10. Maximum Intrusion in the Pole Test

INFLUENCE OF ESP ON ACCIDENT DIVERSITY

In Germany the number of fatalities decreased dramatically during the last decade as shown in figure 11. This continuing trend is strongly influenced by efforts to increase traffic safety by improving the passive safety of passenger vehicles.

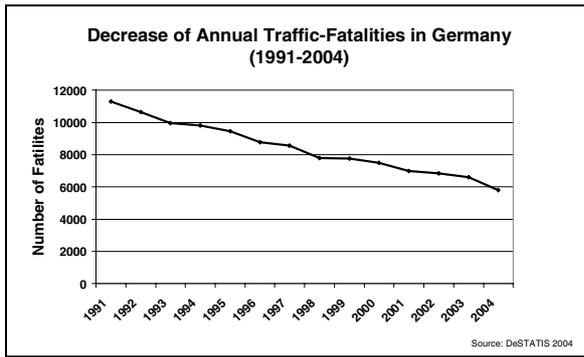


Figure 11. Decrease in Traffic-Fatalities in Germany 1991-2004.

The latest prognosis for fatalities in 2004 in Germany indicates a reduction of approximately 13% as compared to 2003. The absolute number of fatally injured passenger vehicle occupants decreased from 3774 in 2003 to approximately 3300 in 2004. The number of all accidents during this period did not change significantly indicating that technical measures in passenger vehicles can take credit for a significant share of this trend.

After ESP emerged in 1995 as a optional feature in larger and more expensive vehicles, VW decided in 1998 to make ESP available for a majority of its models. Thus ESP is becoming a standard feature in a large number of vehicles in the companies' model lines. This increasing numbers of ESP-equipped vehicles within the fleet in several European markets is shown in Chart 12. The highest share of ESP in new vehicles can be observed in Germany where about 64% of all passenger vehicles sold in 2004 were equipped with ESP.

It is important to note that the influence of ESP is just beginning to become apparent in accident statistics. New vehicles with ESP represent only a small share of the entire fleet in which ESP is still comparatively rare. This is also true for the side impact head airbags passive safety systems. Thus typical accident configurations addressed by ESP will remain quite relevant in the next years to come.

ESP must be viewed as an initial step for the transition from passive to active safety in passenger vehicles. Several industry and insurance studies and analyses by highway administration institutes have already demonstrated the apparent remarkable ability of ESP to reduce the incidence of fatalities in "loss of control" accident situations. The efficiency of the system was stated to be about 50% with respect to the reduction of severe accidents

and up to 80% in reducing accidents in which skidding was the initiating event.

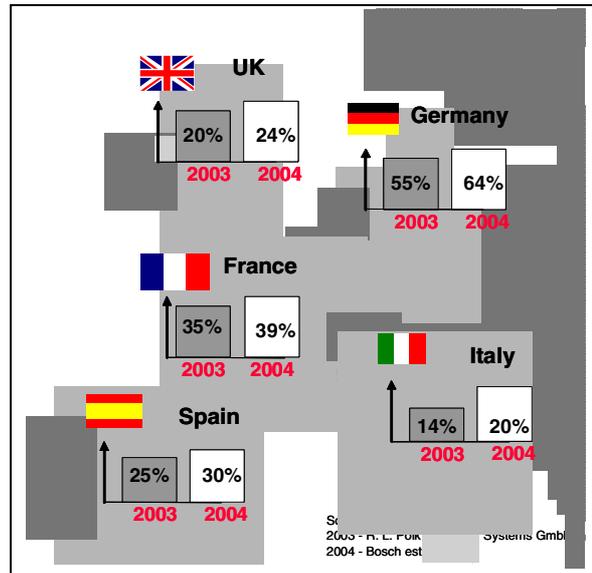


Figure 12. Equipment Rates for ESP in Europe as estimated by Robert Bosch AG.



Figure 13. Influence of ESP on Skidding.

These estimates are confirmed by a retrospective analysis of real-world accident data. The first estimates of the effectiveness of ESP were performed by VW in 1998. These findings were exceeded dramatically by field observations after system introduction.

The beneficial effect of ESP appears to have been verified. The next step must be to quantify its influence and then to project this on the universe of accidents to be expected in the future.

Figure 14 shows the diversity of passenger vehicle accidents in rural areas by accident type when only accidents with injuries to occupants of passenger vehicles of at least MAIS 4+ are considered. The analysis is based on VW-GIDAS data. The chart indicates that in Germany "Leaving the Road" is

the most dangerous accident category that is, responsible for more than 50% of all severe injuries in rural areas.

This results include accidents involving specific infrastructural characteristics of German rural roads that are often lined with trees. In many of these “Leaving the Road” accidents, the initial event led to a pole impact with the consequences described above.

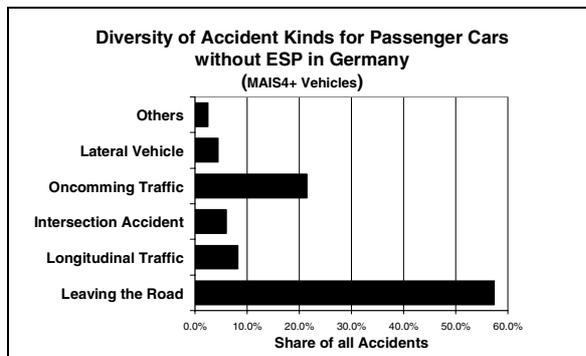


Figure 14. Diversity of Rural Accidents for Vehicles without ESP and MAIS4+ Injured Occupant.

Assuming that ESP is able to prevent 80% of all accidents initiated by skidding, the equivalent of “Loss of Control,” the diversity of the accident universe would change dramatically. Figure 15 depicts the results of a calculation which shows this diversity, if all passenger vehicles were equipped with ESP. To point out the overall effect of ESP, the denominator was the same as in figure 13. Thus the change in the percentage of a particular accident type can directly be interpreted as the potential of ESP to prevent these accidents.

As expected, the predominant influence of ESP can be observed in “Leaving the Road” accidents. But all other kinds of accidents were also influenced.

The potential in absolute terms is shown in detail in figure 16. ESP, according to this analysis, is able to prevent accidents in all different kinds. The resulting reduction of all MAIS4+ accidents is about 40%, thereby confirming the results of other studies.

Taking the frequency of the different accident types into account, collisions with oncoming vehicles are the second most accident type and significantly influenced by ESP. These collisions often result in lateral collisions with oncoming vehicles when the passenger vehicle goes into a skid.

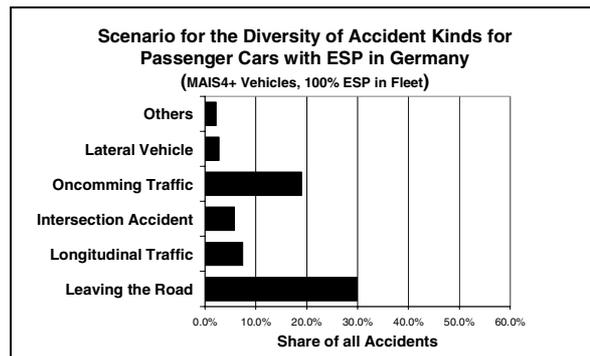


Figure 15. Resulting Scenario for MAIS4+ Accidents if the German Fleet is Equipped 100% with ESP

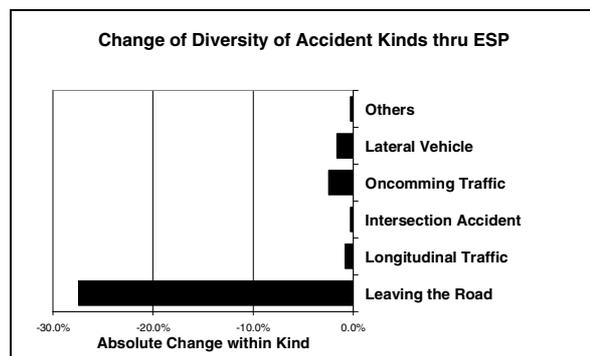


Figure 16. Changes of Accident Diversity through ESP.

A further question to be answered is whether ESP will also influence the diversity of collision opponents for passenger vehicles. These changes would directly influence the performance parameters related to vehicle design. Figure 17 shows the same type of diagram as figure 14 with the diversity of the collision opponents in the initial collisions. Accidents involving passenger vehicles in rural areas in which occupants were injured with a severity of at least MAIS 4+ were analysed.

The chart provides the reason why pole impacts were the focus of passive safety measures in the past and are still being discussed in the context of improved passenger vehicle safety. Nearly 40% of all accidents in Germany in which passenger vehicle occupants sustain severe injuries MAIS 4+ must be attributed to pole impacts.

But does this Chart reflect the safety level of modern passenger vehicles? It does not. The data is derived from a fleet in which both recent active and passive safety systems, such as ESP and side impact head airbags are still a rarely installed.

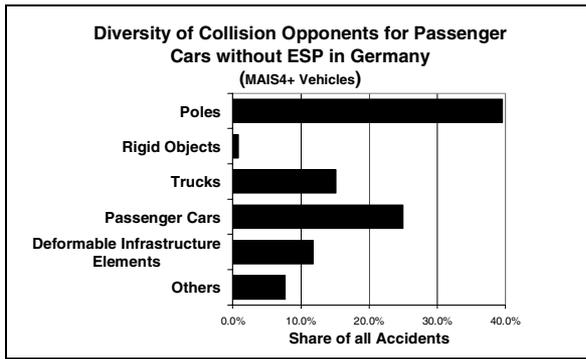


Figure 17. Collision Opponents of Passenger Vehicles in Accidents with MAIS4+ Injuries to Vehicle Occupants.

Figure 18 shows the calculation assuming a 100% ESP equipment rate within the entire fleet. The proportion of pole impacts decreases significantly. The technical effect of ESP reduces the yaw angle of the vehicle by producing an opposing momentum via the brakes. Therefore it can be assumed that the pole impacts prevented must be principally lateral collision configurations, because these collisions are most likely to occur in ESP-relevant situations.

A detailed analysis of the data confirms this assumption. Lateral pole impacts are reduced by approximately 70% based on this scenario, while frontal impacts are reduced by approximately 30%. The proportion of lateral pole impacts decreases from 56% of all pole impacts to 39% of the remaining pole impacts. More than 50% of all pole impacts would have been completely prevented if ESP were installed in the entire fleet.

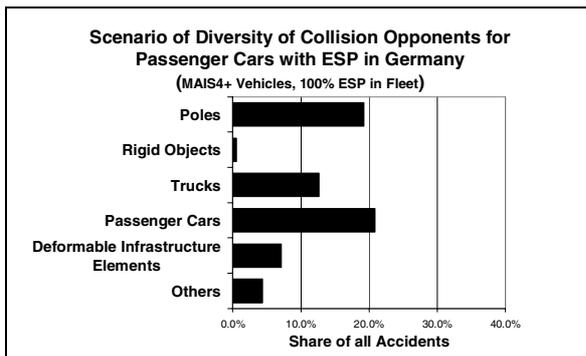


Figure 18. Resulting Scenario for MAIS4+ Accidents if ESP is installed in the Fleet by 100%.

The remaining pole impacts are dominated by frontal collision configurations in which recent vehicles are able to offer optimized passive safety levels to protect vehicle occupants.

Furthermore figure 19 shows the overall effect of ESP, which by preventing skidding, will, of course, influence all other collision constellations and opponents. Combined with the findings from figure 16 that shows a significant effect on collisions with oncoming vehicles, the reduction of collisions with other motor vehicles shown in figure 19 can be interpreted as a reduction of another severe accident configuration: side collision with oncoming vehicles. These accidents are less frequent as compared to pole impacts but they are of comparable severity. Thus ESP can be viewed as a system that focuses on the severest accidents and contributes significantly to their prevention.

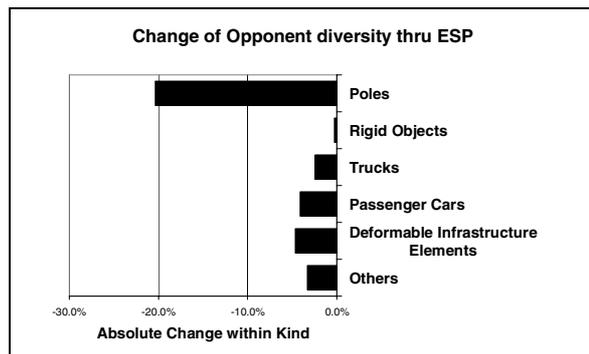


Figure 19. Changes of Opponent Diversity with ESP.

ESP AND PASSIVE SAFETY MEASURES

To underline the significant benefit that ESP can have on vehicle safety, a comparison is made between the effect of ESP and the effect of safety belts, structure and airbags. For this reason, 4 scenarios were defined and evaluated with the help of GIDAS data:

Scenario	Belted Occupant	Vehicle manufactured 1995 or later	Airbag available	Number of cases in GIDAS
1	No	No	No	Ca. 1 000
2	Yes	No	No	Ca. 13 500
3	Yes	Yes	No	Ca. 630
4	Yes	Yes	Yes	Ca. 1 800

Figure 20. Scenarios to estimate effectiveness of passive safety measures.

These scenarios are used to describe the effectiveness of measures.

Scenario 1 ⇒ 2 Safety belt effectiveness in vehicles manufactured before 1995

Scenario 2 ⇒ 3 Structural enhancement for belted occupants in vehicles manufactured before 1995 and in vehicles manufactured later

Scenario 3 ⇒ 4 Airbag effectiveness in vehicles manufactured in 1995 or later for belted occupants

To compute effectiveness values, injury risk in these scenarios was computed:

RISK REGARDING MAXIMUM AIS OF ALL INJURIES OF PERSON	UNBELTED PASSENGER CAR OCCUPANTS IN CARS MANUFACTURED BEFORE 1995 (NO AIRBAG) SZENARIO 1	BELTED PASSENGER CAR OCCUPANTS IN CARS MANUFACTURED BEFORE 1995 (NO AIRBAG) SZENARIO 2	BELTED PASSENGER CAR OCCUPANTS IN CARS MANUFACTURED 1995 AND LATER (NO AIRBAG) SZENARIO 3	BELTED PASSENGER CAR OCCUPANTS IN CARS EQUIPPED WITH AIRBAG AND MANUFACTURED 1995 AND LATER SZENARIO 4
AIS 0..6	100,00%	100,00%	100,00%	100,00%
AIS 1..6	77,78%	44,21%	38,10%	36,43%
AIS 2..6	35,81%	12,31%	8,10%	7,00%
AIS 3..6	15,58%	4,16%	2,06%	1,59%
AIS 4..6	8,93%	1,82%	0,79%	0,51%

Figure 21. Risk of MAIS-categories within the scenarios.

In all categories, injury risk decreases. The categories AIS 5..6 and AIS 6 were not included, because the number of cases is too small and thus the statistical significance poor. Note that 0.79% of 630 cases (AIS 4..6 in scenario 3) represents 5 cases. The effectiveness is derived from these figures:

EFFECTIVENESS REGARDING MAXIMUM AIS OF ALL INJURIES OF PERSON	UNBELTED TO BELTED OCCUPANTS BEFORE 1995 SZENARIO 1 VERSUS SZENARIO 2	BEFORE 1995 TO AFTER 1994 FOR BELTED OCCUPANTS SZENARIO 2 VERSUS SZENARIO 3	BELTED WITHOUT AIRBAG TO BELTED WITH AIRBAG AFTER 1994 SZENARIO 3 VERSUS SZENARIO 4
	Effectiveness of Belt	Effectiveness of Structure	Effectiveness of Airbag
AIS 1..6	43,2%	13,8%	4,4%
AIS 2..6	65,6%	34,3%	13,5%
AIS 3..6	73,3%	50,3%	22,8%
AIS 4..6	79,6%	56,5%	35,5%

Figure 22. Effectiveness of belt, structural enhancements and airbags.

These figures show a clear picture of the relevance of passive safety measures:

The most important safety measure is the safety belt. Vehicle occupants who do not buckle up live in a much more dangerous world than those who use their safety belts. The second most important safety feature is vehicle structure. In all cases the increased benefit from scenario 2 to scenario 3, relates to the optimized structural behavior of passenger vehicles, manufactured in 1995 and later. Structural effectiveness is less than that of the safety belt, but more than that of the airbag. Airbag effectiveness is still significant, but it is ranked third in this list. The next question is, what about ESP?

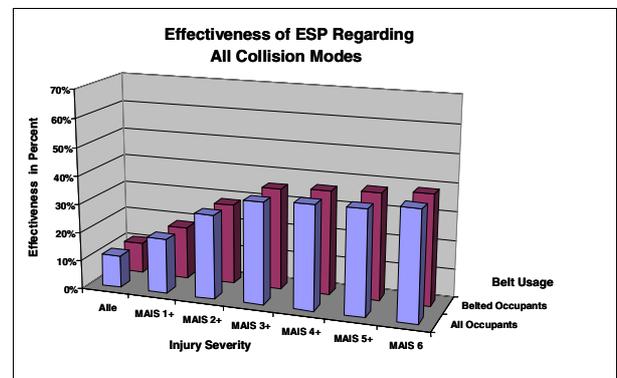


Figure 23. Effectiveness of ESP for occupants with different injury severities.

The effectiveness is nearly the same for belted and for unbelted occupants. The calculation is based on 80% reduction of skidding accidents, as determined by the Volkswagen field study.

Effectiveness of ESP for passenger car occupants				
All collision modes	Belted Occupants	Unbelted occupants	All Occupants	Effectiveness of Airbag
MAIS 0+	10,9%	17,7%	11,4%	0,0%
MAIS 1+	18,4%	22,8%	19,3%	4,4%
MAIS 2+	28,5%	30,4%	29,4%	13,5%
MAIS 3+	35,7%	35,3%	35,6%	22,8%
MAIS 4+	36,7%	35,2%	36,5%	35,5%

Figure 24. Comparison of effectiveness of belt, structural enhancement, airbag and ESP for occupants with different injury severities.

The table clearly answers this question. The effectiveness of ESP is higher than that for the airbag, especially for lower injury severities. The advantage of ESP is that it is independent of restraint use. Crash avoidance is effective for both restrained and unrestrained vehicle occupants. This is not equally true for passive safety measures.

Again, this finding clearly underlines that the level of safety offered by a particular passenger vehicle can only be described properly, if both, passive and active safety measures are taken into account. This computation of ESP effectiveness is conservative and only describes a lower limit of the real effectiveness, because it only takes into account skidding accidents that have been prevented. It is not covered by this calculation that there is a potential of ESP to reduce skidding accident severity by transforming lateral pole impacts into frontal pole impacts. So this computation is still conservative.

To make it very clear, this computation must not be understood questioning the effectiveness of front airbags, on the contrary, these figures show the substantial effectiveness of front-airbags. The message is that ESP is even more effective. As a footnote it should also be noted that enhanced vehicle structures had an even greater effect than front-airbags and ESP. This is often forgotten.

CONCLUSION AND DISCUSSION

ESP is even more effective than airbags.

By ESP, active safety plays the leading role in vehicle safety, more effective than all foreseeable measures of passive safety.

This is the first time that active safety dominates the enhancement of vehicle safety.

It has been shown that there are technical and physical limitations relating to the protection of occupants of passenger vehicles by passive safety measures. Current vehicles have reached a level of passive safety that can only be improved by an inappropriate increase in vehicle weight and associated expense to the customer. Both options lead to other conflicts e.g. fuel consumption.

Active safety measures promise to improve traffic safety by preventing accidents. Ethically they must therefore receive first priority if they have the requisite technical reliability.

The implementation of such systems can have a significant influence on the diversity of accidents as demonstrated by ESP. Thus, views concerning traffic safety must change when the proportion of

such systems in the fleet increases. The latest research results including "In-Depth" accident data indicate that the efficiency of such systems can be predicted. Busch quantifies the effect of different systems in his doctoral thesis [9]. The change of the of the accident mix can be estimated by applying this methodology.

Current discussions on new passive safety test methods do not take these changes into account, e.g. the current discussion on additional lateral pole tests in the US leads in the wrong direction. The accident type sought to be addressed will disappear with the increase in the proportion of the fleet equipped with ESP. The current level of safety is sufficient to assure the functionality of today's passive safety measures. A new test method would interfere with the requirements for those measures and thus increase their cost but the additional benefit to the customer would be marginal. It must be noted that the effects of recently implemented systems both passive e.g. head airbags and active are just starting to influence the accident mix because the current fleet of passenger vehicles is still dominated by vehicles without such systems.

For future advancement of traffic safety all of these factors must be taken into account: ESP is more relevant than front airbag. So a passenger vehicle rating system that neglects ESP or credits it with minor relevance is not reflecting vehicle safety.

New test procedures must focus on the leading injury causing constellations. They must be driven by the objective of optimizing the fleet of cars, currently under production. An uncritical reflection of accident data about older cars will not provide optimum occupant protection for future cars.

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