OPPORTUNITIES FOR A WORLDWIDE COMPATIBILITY EVALUATION -
GERMAN MANUFACTURER'S POSITION PAPER ON CRASH COMPATIBILITY

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ABSTRACT:

The passenger car manufacturers within VDA (German Association of the Automotive Industry) provide a position statement that has the potential to combine research by the American Alliance of Automobile Manufacturers with that of IIHS as well as the efforts of EEVC to constitute a feasible and realistic step for a worldwide compatibility evaluation. This paper provides the technical background of the suggestion. It discusses the relationship between self and partner protection in the current European accident scene and discusses benefits and drawbacks of alternatives currently being discussed in the various groups involved in compatibility research.

Compatibility offers the opportunity to increase safety in a limited manner. However, if it reduces the self-protection of passenger cars, there is the risk that it significantly compromises the currently very positive development of the national road safety figures in Europe.

INTRODUCTION

The main goal of this paper is to provide a first and feasible step towards better compatibility between passenger cars. There are also a couple of drawbacks to be taken into account. But the main message is a positive one: There is a possibility for a feasible first step, and before we create new problems by attempting to solve everything, we should take feasible steps. The first section provides the common position in the VDA, the German Association of the Automotive Industry. In the sections following that, background information is provided.

THE VDA-POSITION ON COMPATIBILITY

- Increased self protection of passenger cars is the main reason for the continuous trend of reduced number of fatalities.
- Potential compatibility improvements must not compromise self protection. Current self protection level shall not be reduced.
- Geometrical alignment provides additional potential to further increase safety in car-to-car collisions, creating load paths between the colliding vehicles. This shall be the primary step for assessing compatibility.
- The geometrical alignment requirement may be based on geometrical measurement as long as no final

applicable dynamic evaluation method is defined. The evaluation of geometrical alignment shall assure that structural engagement and sufficient support is created in the common interaction zone as specified in sections below.

- A dynamic evaluation method may be based on full-width restraint test with load cells assessing forces and/or deformations. The applicable evaluation criteria shall have a strong correlation with improved partner protection without degrading self-protection.
    - The interaction area should be the common zone for structural interaction as specified below.
    - The evaluation should assure that sufficient support is created.
    - In case of force measurement, an upper limitation of force should be avoided due to the draw backs in self protection.
- However, for individual secondary structures (e.g. blocker beams, sub frames), which may not be identified by the full-width restraint test, an optional test or assessment method may be applied.
- If, in the future, new test or assessment procedures are provided, they shall be considered under the objectives of this statement, especially regarding self and partner protection.

Common Zone for Structural Interaction:

1) The presence of structures within a common zone for structural interaction (between 330 and 580 mm of ground clearance) needs to be confirmed for all vehicles including trucks, SUVs/LTVs, Sports Cars and Sedans).
2) Structures above the zone should not be penalised, providing sufficient support is present within the interaction zone.
3) Structures below the zone should be credited, providing sufficient support is present within the interaction zone.

Assessment methods should be defined in accordance to points 1, 2, 3.

This is the original wording of the VDA-position on compatibility.

THE DEVELOPMENT OF VEHICLE SAFETY IN GERMANY AND EUROPE

The comment made in the VDA-Position above – that there is a positive trend in German accident figures – can be easily proven using the data of the German Statistics Office.

Figure 1 shows a clear trend, which has remained fundamentally stable since 1970. Following the oil crises it was initially very pronounced and then, after an increase, it remained relatively stable until re-unification. With the exception of the increase caused by German re-unification, the number of people killed in traffic accidents has decreased by an average of 370 persons every year since 1983. This is a very encouraging development and may result in Germany achieving its goal of reducing the number of traffic fatalities by one half between the years 2000 and 2010.

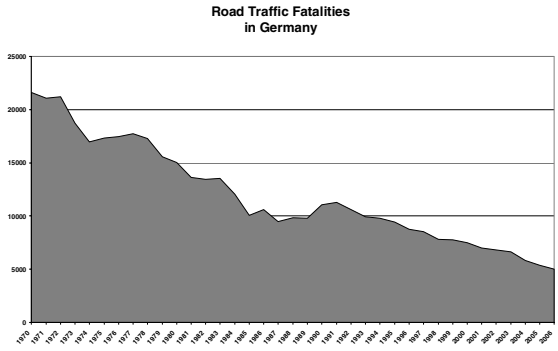

Figure 1. Time history of the number of fatalities in Germany since 1970. The 2006-figure was estimated by BASt in November 2006. (Source IRTAD)

Figure 2 shows that this positive trend affects all road users. Figure 3 presents the same data with a reference year of 1980. This makes the reduction achieved in the individual groups of road users more visible.

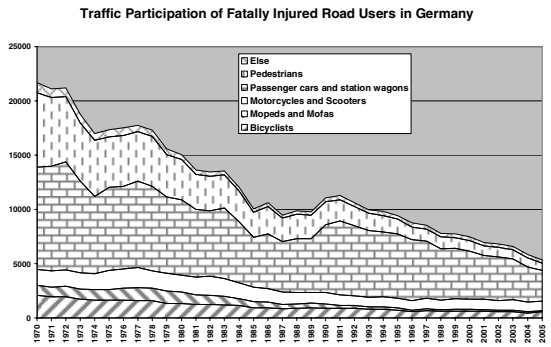

Figure 2. Time history of the number of fatalities in Germany since 1970 for individual groups of road users. (Source IRTAD)

In Figure 3, the results for mopeds and motor-assisted bicycles are especially positive. Due to the unknown total travel distances of mopeds and motor-assisted bicycles, it cannot be directly concluded that there has been an increase in the safety of these vehicles. Nevertheless, the enforcement of helmet use and the low speeds of

these vehicles have a special significance. In 2005, fatalities of moped and motor-assisted bicycle riders had dropped to only 10.1% of the 1980 figure.

The pedestrian category also shows a considerable reduction to 18.4% of the 1980 figure. This trend has continued uninterrupted since 1970.

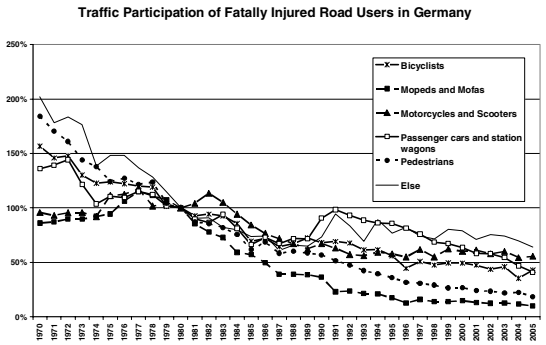

Figure 3. Time history of the number of fatalities in Germany since 1970 for individual groups of road users. 1980 was used as the reference year to enable comparison between the groups. (Source IRTAD)

Passenger car occupants follow as the third group, with a reduction to 41% of the value from 1980. Here, it must be taken into account that the number of fatally injured car occupants in 1991, immediately following re-unification, rose to equal the value from 1980. A very low level had been achieved in 1987. Thus, a more relevant observation is that the car occupant group has in fact achieved a 59% reduction in the period from 1991 until the present.

Bicycles and motorcycles show a less pronounced reduction during the last 15 years.

Nevertheless, it can be summarised that a marked increase in the level of traffic safety, which affects all road users, can be observed in Germany.

Looking at the other EU member states shown in Figure 4, a similar trend may be observed. It would be too complicated to discuss each member country individually, but it is readily apparent that many member countries display a similarly positive trend. The exceptions are Greece and the new European member states.

The effects of the trend can be better observed looking at the reduction expected between the years 2000 and 2010. Figure 5 shows a linear regression of the last 10 years for each country until the year 2010. The expected reduction in traffic deaths compared to the year 2000 is indicated. Only Germany can expect a reduction of more than 50%. Some countries – namely Portugal, Austria and Hungary – are expected to reach over 40%. In total, the 18 EU members for whom IRTAD (International Road Traffic Accident Database) provides data should achieve a reduction of 23%. This is an encouraging number, even if the ambitious goals set by the EU are unlikely to be achieved.

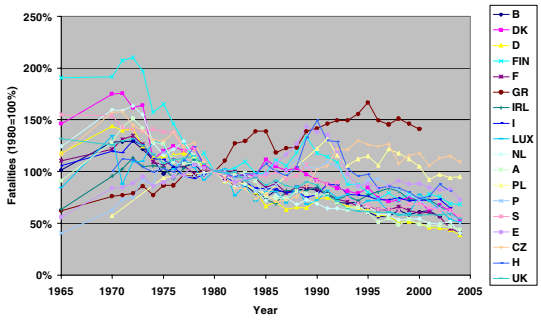

Figure 4. European trend with regard to the number of fatalities in 18 member states of the EU. 1980 was used as the reference year in order to achieve comparable data.

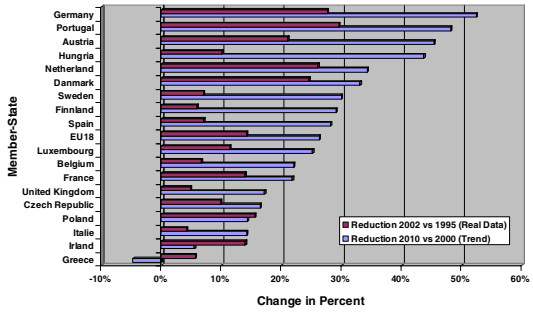

Figure 5. Current change and expected trend seen in 18 major member states of the EU.

Overall, these numbers show that considerable progress has been made in Europe. Steady progress in almost all the member states is especially visible in the last ten years.

This means that caution must be exercised with regard to the modification of safety-relevant regulations. We should do whatever possible to ensure that the positive trend continues.

THE SIGNIFICANCE OF THE COLLISION TYPES FOR BELTED PASSENGER VEHICLE OCCUPANTS

Figure 6 provides an overview of how the collision types are distributed for the various injury classes. The categories are divided as follows:

MAIS 0+ includes all injured and uninjured car occupants involved in GIDAS accidents, and

demonstrates the distribution of collision modes in accidents with injured persons,

MAIS 1+ includes all injured car occupants,

MAIS 2+ to MAIS 4+ include injured car occupants with progressively increasing seriousness of injury,

MAIS 5+ includes car occupants with critical injuries and a low chance of survival,

and finally MAIS 6 includes only the maximally injured car occupants with very little chance of surviving.

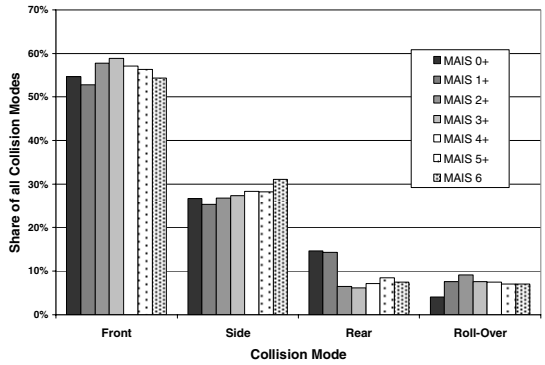

Figure 6. Collision mode distribution for belted occupants of passenger cars, according to GIDAS database. The distribution is shown for all injury severity classes. The relative number of occupants of a particular injury severity is shown in percentage terms for each of the collision modes.

Figure 6 shows that the percentage of frontal collisions, regardless of the severity of injury, is always approximately 55%. Only belted occupants are taken into account. Side collisions follow with 30% and a slightly rising trend. Rear collisions are down to 7 to 8%. Rollovers have also stayed in the same range of about 7 to 8%. They are somewhat under-represented for MAIS 0+ occupants, but no special relevance for rollovers can be deduced from this data.

The effects of previous safety measures cannot be seen in Figure 6, so in the following two figures, the collision mode and injury distributions are considered for older and newer passenger vehicles.

If the MAIS 0+ percentages in Figure 7 and Figure 8 are compared, it can be seen that side collisions have always been less frequent than frontal collisions. However, in vehicles built before 1980, 42% of the MAIS 6 injuries to car occupants resulted from frontal collisions, and 42% resulted from side collisions. This was because the significance of side collisions increased with increasing injury severity. Frontal and side collisions were thus equally represented among the most serious injuries.

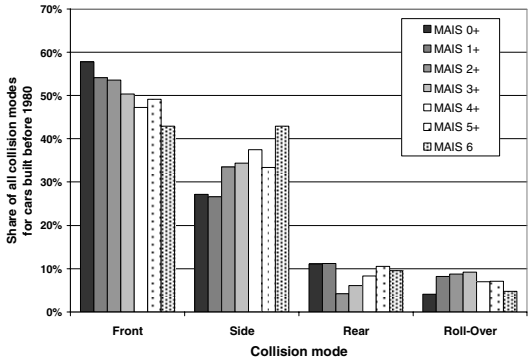

Figure 7. Collision mode distribution for passenger cars built before 1980, according to GIDAS database. The distribution is shown for all injury severity classes. The relative number of occupants of a particular injury severity is shown in percentage terms for each of the collision modes.

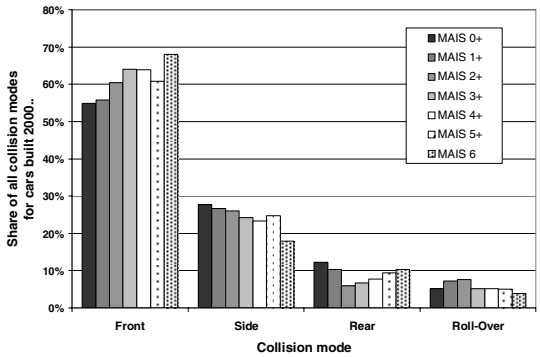

Figure 8. Collision mode distribution for passenger cars built after 2000, according to GIDAS database. The distribution is shown for all injury severity classes. The relative number of occupants of a particular injury severity is shown in percentage terms for each of the collision modes.

For vehicles built after 2000 (Figure 8), the opposite effect is apparent. Today a frontal collision represents a greater danger than a side collision. At higher levels of injury severity, a greater proportion of occupants are involved in frontal collisions.

This illustrates that the measures which were adopted for side protection were more effective than the measures used to address frontal collisions. The distribution of collision types shows that the incidence of severe side collisions has been reduced more than that of frontal collisions. Frontal

collisions must therefore be given a higher priority than they were in the past. The previous section clearly illustrated that the total number of fatal injuries has gone down.

In addition it should be considered that high speed side collisions against narrow objects (e.g. trees or utility poles) with the correspondingly higher injury risk have been significantly reduced due to the introduction of ESC (Electronic Stability Control). This further reduces the number of serious side collisions and points to the fact that it makes sense to prioritise frontal collisions.

THE RELEVANCE OF SELF-PROTECTION AND PARTNER PROTECTION

Europe has a tradition of paying special attention to car-to-car collisions. The high speed frontal offset test described in ECE Regulation R94 (Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a frontal collision) was originally developed to mimic car-to-car collisions with a partial overlapping of the fronts of the vehicles. As the above analysis of the European statistics shows, the test has been effective. Considering the current emphasis being placed on developing a regulation to improve compatibility, it could be presumed that car-to-car collisions represent the greatest risk to car occupants. This is not the case, as studies from many different countries demonstrate. Good examples are the situation in Germany, Italy and France, shown in Figures 9 to 11. For Italy the data for seriously injured persons is lacking, so only two categories can be taken into account.

The message is clear, single vehicle accidents account for a considerable share of injuries and become dominant with regard to fatalities. Therefore self protection is the major key to save lives and protect occupants, while the combination of self and partner protection only decides the outcome of car-to-car accidents.

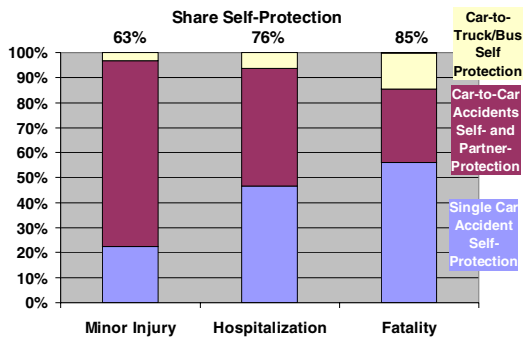

Figure 9. Relevance of self- and partner protection in Germany for different injury severity classes.

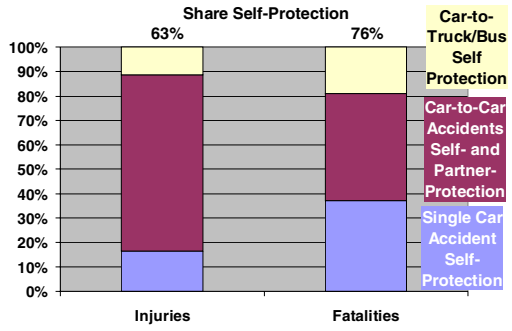

Figure 10. Relevance of self- and partner protection in Italy for different injury severity classes.

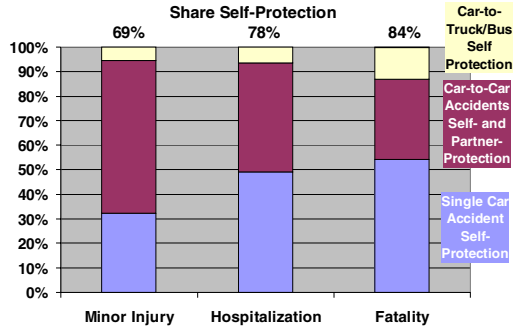

Figure 11. Relevance of self- and partner protection in France for different injury severity classes.

THE DEVELOPMENT OF SELF-PROTECTION AND PARTNER PROTECTION IN GERMANY

Many accident researchers expected that the significant increase in self-protection would have a negative effect on partner protection. This was supported by a spectacular crash test performed by a German test institution, in which a very old vehicle was crashed against a new version of the same vehicle. However, it can easily be seen that, statistically speaking, such an extreme combination is relatively rare. Older vehicles are rapidly disappearing from the vehicle fleet and being replaced by modern cars. It also makes no sense to avoid safety improvements for the future by looking at outdated vehicles that are about to be phased out of the vehicle fleet.

Therefore, the GIDAS database was examined to see how deformation behaviour and the severity of injuries have developed with respect to vehicle build year. During this process, it was consciously taken into account that a new vehicle involved in a collision in 2005 collides with a different fleet to a vehicle built in 1985 involved in a collision in 1990. In other words, the vehicles built in different years were analysed with regard to vehicles that they actually crashed into. A car occupant is only

interested in the level of risk he is subjecting himself to when he buys a car and drives in current traffic conditions. The results are as clear as those shown in the IRTAD data for all of Europe and Germany in particular.

Figure 12 shows that modern vehicles undergo large deformations much more seldom than older vehicles. Assuming that impact speed has not decreased for current vehicles compared to older vehicles, the stiffness of the vehicle fleet must have increased.

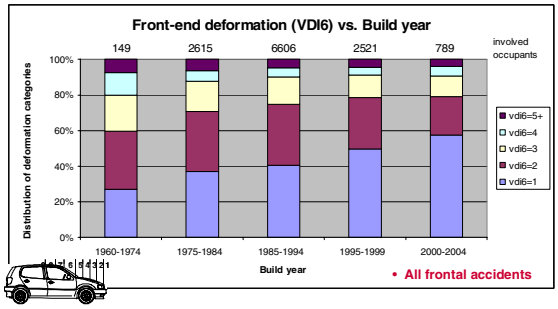

Figure 12. Front end deformation in frontal accidents described by Vehicle Deformation Index VDI6 versus build year. This implicitly describes the effect of structural measures that have been implemented into the vehicle fleet in recent decades.

Figure 13 examines the injuries that people in these vehicles have suffered and it is evident that injuries have been reduced to a similar extent. Figure 14 includes only the upper 20% from Figure 13 to more clearly show that the number of seriously injured occupants has been reduced by half. Especially impressive are the improvements for occupants who suffered MAIS 2 or higher. In vehicles built before 1975 their share was over 20%. In contrast to this, for vehicles built in the current decade it is only 6%. The same also applies to critically injured car occupants.

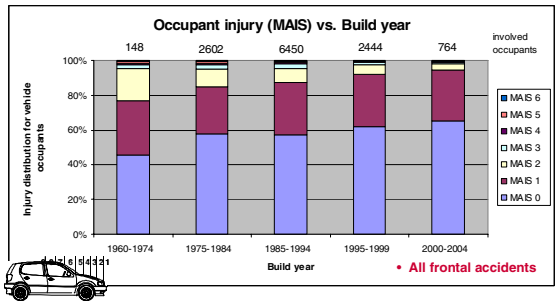

Figure 13. Decrease of injury severity versus build year for belted occupants in frontal collisions.

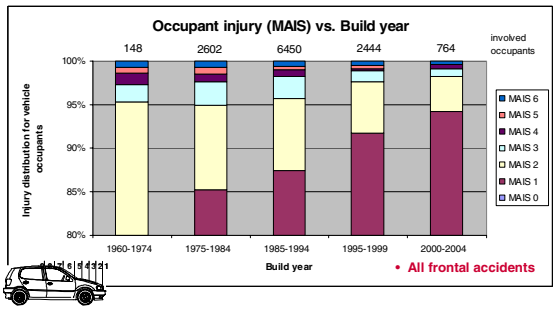

Figure 14. Same graph as Figure 13, but with y-axis limited to 80..100% to show the effect on the most severely injured occupants.

Only belted occupants were taken into account throughout the study, so the higher belt-wearing rate in recent years has no influence on the result.

So far these results are not surprising and fit into the overall pattern which was developed from observing European countries using the IRTAD database.

The following figures evaluate the crash events from the partner protection prospective by looking at the collision partner. This way, it can be investigated how a vehicle of a particular build year affects other vehicles in a collision.

Figure 15 shows the crush depth in the opposing (target) vehicle over the build years of the impacting (bullet) vehicle. This demonstrates that, on average, the depth of intrusions in the collision partner of a newer car is less than those caused by an older bullet vehicle. Or in other words, partner protection with regard to structural deformation has improved. Keeping in mind that the average front end stiffness of the vehicle fleet has increased, the reduction of crush depth in the opponent vehicles can be attributed to the fact that the share of modern cars in the vehicle fleet has over-compensated for the increase of front end stiffness.

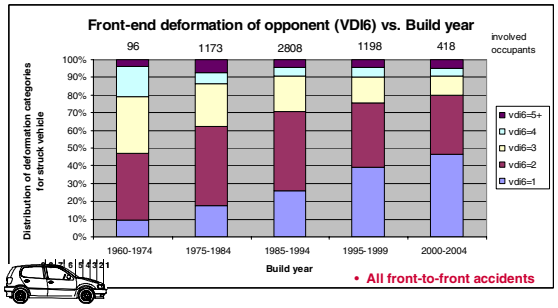

Figure 15. Like Figure 12: Front end deformation in frontal accidents described by Vehicle Deformation Index VDI6 versus build year. But now the deformation of the opponent of the car under consideration is analysed.

Figure 16 and Figure 17 look at the injuries caused in the opponent vehicle with respect to the build year of the impacting vehicle. Here the same pattern is apparent. The injuries in the opponent vehicle have not increased; modern vehicles cause fewer and lesser injuries in the vehicles that they collide with. If the vehicles from 1995 to 1999 are compared with the vehicles from 2000 to 2004 in Figure 16, a slight increase can be seen. Due to the low number of cases, this should not be given too much significance. Therefore, in Figure 17 these two groups are combined. A clear improvement can be seen for the enlarged group. The slight deviation from this trend visible in Figure 16 will be the object of further investigation in the future.

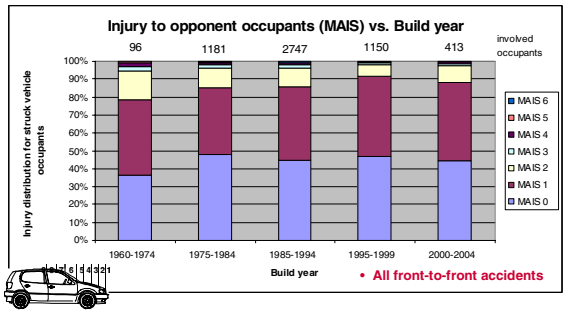

Figure 16. Decrease of injury severity versus build year in frontal accidents for belted occupants of opponent car. This is the partner protection view point, analysing the degree of compatibility in vehicle fleet versus time.

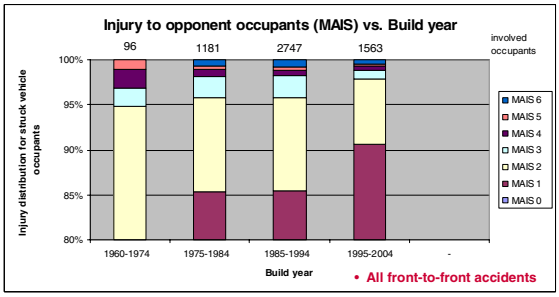

Figure 17. Same graph as Figure 16, but with y-axis limited to 80..100% to show the effect on the most severely injured occupants. To achieve sufficient sample sizes, the latest cars were put in one group.

Overall, it is clear that vehicle development in the past decade has gone in the right direction with regard to both self-protection and partner protection. So far the current regulations have had a positive effect on both self and partner protection.

However, the path of self-protection cannot be stretched out indefinitely by continually increasing test speeds. In this way the results for vehicles from 2000 to 2004 can also be understood as a warning signal. At present, the authors are not in a position to prove the plausibility and statistical tenability of the results for vehicles from 2000 to 2004 using the available numbers.

In any case, it may be concluded that proposals for new test procedures or even for the replacement of Regulation ECE R94 must first demonstrate that the modified procedures will continue the positive trend which have been achieved under the conditions of ECE R94.

FRONTAL COLLISIONS: A BRIEF REVIEW OF THE DEVELOPMENT OF TEST BARRIERS

Test barriers can be considered to come in three relatively discreet forms: rigid barriers, barriers with limited deformation and barriers with unlimited deformation. Naturally, no barrier can be truly unlimited, but if enough depth is provided to prevent bottoming out, the barrier can be considered from the car's point of view to be unlimited. This section will consider the development of these barriers for European offset crash tests.

EEVC developed a limited deformation barrier in the 1980s, which consisted of a relatively small deformation element in front of a rigid wall (Figure 18). This barrier, with a 40 % offset and 56 km/h collision velocity, was a compromise solution representing partly a rigid object collision and partly a 50 km/h, 50 % offset car-to-car collision. Although not completely representative of either collision type, this barrier creates a realistic acceleration pulse and deformation pattern, and ensures significant deformation of the vehicle structures through bottoming out. It entered into regulation in the mid 1990s and is also used in EuroNCAP testing.

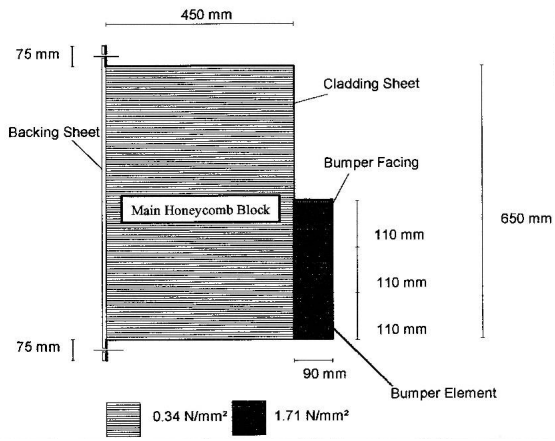

Figure 18. ECE-R94-barrier.

During this time, auto motor und sport, an auto magazine based in Stuttgart, performed tests with a rigid offset barrier. Although these tests

mercilessly revealed the deformation potential of the vehicle front end, the pulse was unrepresentative of many collisions and all vehicle front-end components were equally deformed.

At the beginning of the 1990s, Dr. Klanner from ADAC developed a barrier which was deep enough to provide effectively unlimited deformation (Figure 19). In a collision with the ADAC barrier, the reaction forces exerted on the car structures are controlled by the stiffness of the barrier, and the high forces of a rigid object collision are never reached. Furthermore, the deformation potential of the barrier is very large, meaning that rather than forcing deformation of the vehicle structure, as is the case in a collision with a rigid object, the barrier itself absorbs a large part of the kinetic energy. EEVC considered this barrier and rejected it, choosing to adopt the limited deformation barrier described above.

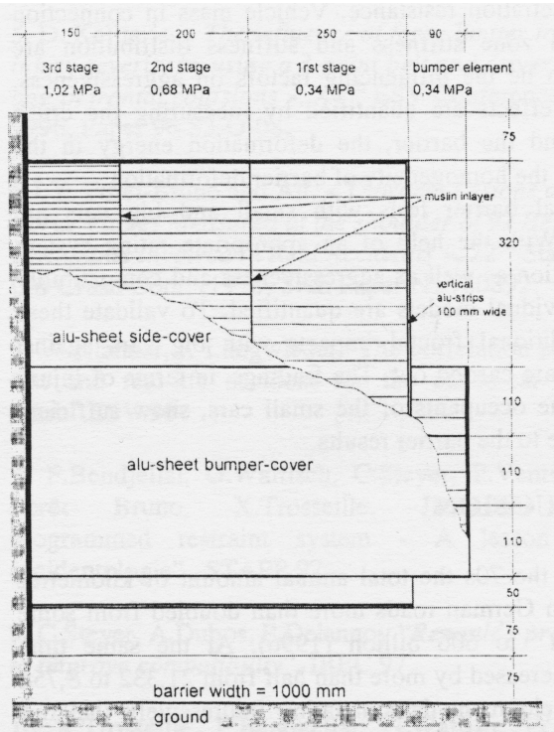

Figure 19. ADAC-barrier.

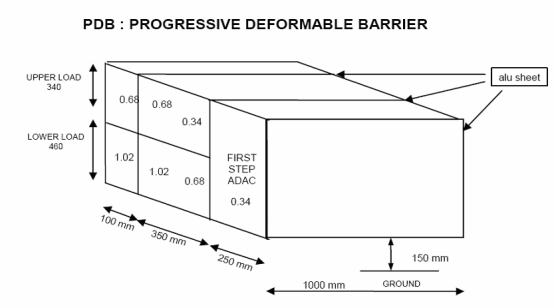

Figure 20. Progressive Deformable Barrier (PDB).

French Industry saw merit in Klanner's idea, and further developed it into an alternative barrier with effectively unlimited deformation, the PDB (Figure 20). Like the ADAC barrier, the forces exerted on the vehicle structure are limited by the barrier stiffness, and the barrier itself is able to absorb a large amount of energy.

The fact remains that discussion of further developments in frontal crash testing is currently very difficult. For Europe, two main alternatives are under consideration: a combination of the PDB with a rigid full width test, and a continuation of the existing R94 with an additional full width test with a deformable element and load cell wall.

In considering such barriers for the assessment of vehicle safety and compatibility, it is essential that the specific test procedures and analyses are assessed according to strict scientific criteria which, together with relevant accident analysis, answer the following questions:

What are the advantages of the proposed compatibility test procedures and assessments for real world safety?

What are the disadvantages or foreseeable drawbacks of the proposed test procedures and assessments?

What is the potential of the proposed test procedures and assessments regarding world-wide harmonisation?

The following attempts to discuss some of the possibilities which accident research and FEM simulation offer us to predict developments through modified test conditions.

FRONTAL COLLISIONS: OPPORTUNITIES AND RISKS OF A BARRIER WHICH PREVENTS BOTTOMING OUT

Klanner's idea, when he defined the ADAC barrier, was to prevent bottoming out of the barrier. A longitudinal member should not impact with a rigid and ideally smooth wall but, as in real life, should interact with an obstacle with a defined stiffness. This is closer to the reality of a car-to-car accident. The aluminium honeycomb structure punishes penetrating skewers, such as longitudinal members which are not supported by a stable cross member. It offers only limited resistance to these elements. The aluminium honeycomb creates pressure and the level of force is determined by the surface pressure. A small surface means the longitudinal member receives only a small amount of support force in the barrier, and is thus not deformed.

Sometimes effects such as these are seen in car-to-car collisions. The goal of structural interaction is to provide sufficient support between two colliding vehicles so that deformation of the front ends of the vehicles will dissipate as much energy as possible; thereby ensuring that the survival space in both cars remains intact.

However, other vehicles are not the only opponents in car crashes. For example, the opponent could also be a tree. Let us assume that a manufacturer has built a vehicle with a longitudinal member that is too rigid and is now testing the vehicle with a PDB. The longitudinal member will penetrate deep into the barrier, but with only moderate force. The manufacturer would therefore only find a moderate deceleration in the vehicle during the test and would consider the vehicle to be safe. But if this vehicle crashes into a tree, the tree will exert resistance against the longitudinal member. The longitudinal member will be deformed, not the tree, but now at a high level of force and with high decelerations. The seemingly safe vehicle with the moderate compartment deceleration suddenly shows itself to be highly dangerous. Possible results are increased intrusions into the compartment and/or occupant decelerations for which the restraint system is not designed.

This situation was simulated in FEM. In Figure 21 to Figure 23, the effect of a "normally" designed longitudinal member is compared with that of a very rigid longitudinal member.

Figure 21 shows that the ECE-R94 test at 56 km/h identifies the differences; increased deformations can be seen in the compartment of the rigid vehicle. This effect becomes even more apparent when the vehicle impacts the ECE-R94 barrier at 64 km/h (Figure 22). The behaviour of the vehicle in both tests is very similar to the expected result. Since the rigid longitudinal member creates a bridge of force from the front of the vehicle to the compartment and thus prevents most parts of the front of the car from being deformed, less deformation work is done in the front of the car. But since kinetic energy must be absorbed, the deformation takes place in the passenger compartment. This is similar to what would occur in a collision with a tree. In a vehicle-vehicle accident, the vehicle would still have the chance to receive the lacking deformation energy from the other vehicle. This is not desirable, however. At a sufficient speed it would only shift the intrusion to the compartment of the opposing vehicle.

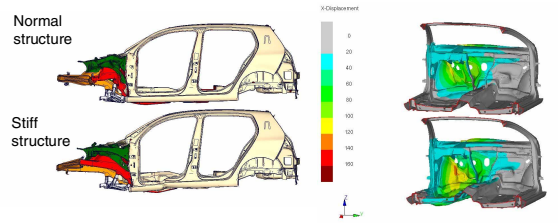

Figure 21. ECE-R94-test of a normal car and a car with a very stiff longitudinal. The increased stiffness can be detected by the higher level of intrusion into the compartment.

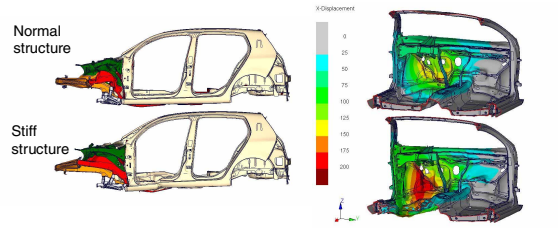

Figure 22. ECE-R94-barrier-test with impact velocity of 64km/h (EuroNCAP) of a normal car and a car with a very stiff longitudinal (same as Figure 21). The increased stiffness can be even better detected by the higher level of intrusion into the compartment.

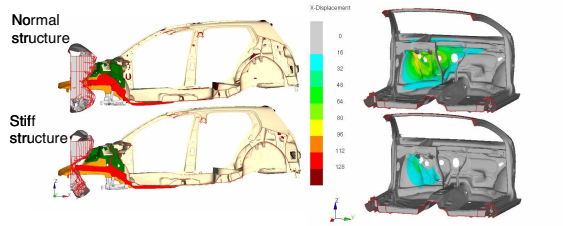

Figure 23. PDB-test of a normal car and a car with a very stiff longitudinal (same as Figure 21). The increased stiffness is compensated by greater deformation of the barrier and identified as a positive measure providing more safety, because intrusion into the compartment is significantly reduced.

The PDB conceals this effect (Figure 23). If the compartment deformation of the vehicle with the rigid longitudinal member is examined, it can be seen that the intrusions are reduced in comparison to the vehicle with the normal longitudinal member. This is very problematic. In this example, the designer would be tempted to adopt a measure which would actually decrease the safety level of the vehicle. He or she would be faced with the moral conflict of whether to objectively improve the vehicle or to develop it in such a way that it would perform well in the test. Such a situation should not arise.

A further aspect is the large amount of deformation energy which the PDB provides. This is illustrated for the individual elements of the barrier in Figure 24. The total available deformation energy is 302 kJ, and with 700 mm of impact area 212 kJ are still available. The volume of deformation energy in the barrier is critical because it conceals how much energy a vehicle itself has to dissipate during the impact. 212 kJ is the amount of kinetic energy a 1524 kg vehicle possesses when travelling 60 km/h. Therefore, such a vehicle does not need to contribute any of its own deformation energy in a test against the PDB. As such, there are broadly different structural designs, with broadly different degrees of available deformation energy, which could be used in a small vehicle to pass a test against the PDB. Details about this were published at the ESV conference (Zobel, 2005 [6]). However, since the volume of deformation energy which is built into the deformable structures in the front of the car is responsible for a vehicle's self-protection level, this means that the PDB test can be passed even if the level of self-protection is low.

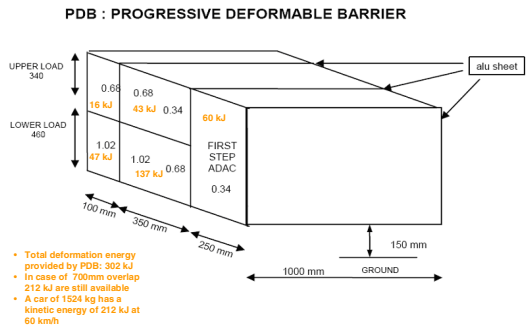

Figure 24. Deformation energy, provided by the different segments of PDB.

The German Federal Highway Research Institute (BASt) tried in one publication (Pastor, 2005 [7]) to determine the influence of the available deformation energy on the accident. This can only be done very roughly, but is representative with regard to the scale. If 28% more deformation energy were available, according to the calculations of the BASt, we would have 8% fewer fatalities. Even if the absolute accuracy of these numbers is disputed, the tendency they show is correct. This implies, conversely, that reducing the deformation by 28% would increase the number of fatalities accordingly. The introduction of a barrier such as the PDB would therefore have the potential to increase the number of fatalities, since it is possible to reduce the available deformation energy in the vehicle and thereby lower the level of self-protection.

FRONTAL COLLISIONS: OUTLINE OF A CONTRIBUTION TOWARD THE IMPROVEMENT OF STRUCTURAL INTERACTION

Influenced by these ideas, the German manufacturers represented in the VDA have jointly investigated ways in which compatibility in Europe could be improved. It is clear from the accident research that the dynamic which forms the basis of the positive European trend should be treated with caution. Therefore, radical changes have been deemed undesirable. The ECE-R94, which had obviously proven effective, was not questioned. Instead, methods were found by which to improve the structural interaction of vehicles, in order to make better use of the deformation energy available in car-to-car collisions. It is undisputed that the central goal of vehicle safety is that vehicles need deformation energy (for self-protection) and that their structures must be designed in such a way that the kinetic energy present in car-to-car crashes is dissipated in the crumple zone. It is for this reason that structural interaction is important. At the beginning of the compatibility debate it was observed that two vehicles which both have sufficient deformation energy for a collision with the wall at speed x, also have sufficient deformation energy in a car-to-car accident for a collision at the closing speed $2x$. This applies regardless of the weight ratio (Zobel, 1997 [8]) and (Zobel, 1998 [9]). The significance of structural interaction is very well described by IIHS with reference to the problems posed by Sport Utility Vehicles (SUV) in America. (Farmer, Lund, 2006 [10]). The German manufacturers are following this accident-oriented path. They see a geometrical alignment of the structures as their first priority.

The VDA-position on compatibility promotes steps for a regulation, oriented towards compatibility, based on accident statistics. The position is open for new scientific enhancements, as long as these will have additional positive effect in real world accidents. We see this as a basis which can be used to bring diverging interests together. Measures which offer the most help to the affected persons should be taken into consideration. They should take into account injury mitigation as well as accident prevention measures, which have proven to be even more effective than injury mitigation today.

SUMMARY AND OUTLOOK

The following provides a generally positive outlook:

Europe has made significant progress in the area of vehicle safety. Germany has taken a leading role in this transformation.

Europe is unlikely to achieve its ambitious goal of reducing the number of persons killed in traffic accidents by half in the first decade of the new millennium. Nevertheless, with a reduction of approximately 25%, considerable progress will have been made.

Infrastructure measures could raise the EU-wide improvement up to 35%. This would happen if, in all EU-member-states, 50% of rural traffic was on motorways.

Germany is expected to be one of the few countries to achieve the EU goal. This shows that the traffic safety concepts developed in Germany are very effective. The German automotive industry demonstrably has an important stake in this.

Frontal collisions make up a greater percentage of severe accidents than they did in the past. This indicates that the safety level in the area of side collisions has improved disproportionately.

Self-protection is a primary factor in vehicle safety and should therefore be given top priority in the future.

Vehicle compartments have become more stable. This has led to an increase in the protection of vehicle occupants.

Nevertheless, partner protection has also improved in the European fleet.

When developing a barrier, care must be taken not to stop or reverse the extremely positive trends described above.

A further improvement in vehicle safety is possible with careful steps within the limitations of the existing regulations. German manufacturers are prepared to support such an approach and have outlined it in a position statement (see first section).

The foreseeable future developments for accidents should also to be taken into consideration in the further development of the side impact barrier.

Fundamentally, a greater integration of accident research into the development of vehicle safety regulations is absolutely necessary. It is not enough to identify the target population of a measure, but before a proposed measure is put forward for regulation, research should be conducted to establish the benefit of this specific proposal in a future fleet.

No positive trend is so stable that it cannot be significantly damaged or even reversed.

REFERENCES:

[1]: **Klanner, W., Felsch, B. und van West, F. (1998) "Evaluation of Occupant Protection and Compatibility out of Frontal Crash Tests against the Deformable Barrier" 16th ESV Conference, Windsor.**

[2]: **Dellanoy, P. (2000) "EUCAR Summary" EEVC Document Number 111, 15th Meeting of EEVC Working Group 15, Crawthorne, UK.**

[3]: **Martin, T. und Dellanoy, P. (2006) "Validation of PDB approach" VC-Compat Final Workshop, Eindhoven, NL.**

[4]: **UTAC (2004) "Self and partner protection test and assessment protocol based on current regulation R94 and PDB Barrier" Version 2.2.**

[5]: **Schwarz, T., Strube, C., Zobel, R. und O'Brien, S. (2005) "Aspekte zur Entwicklung eine weltweit harmonisierten Kompatibilitäts-Berwertungsverfahrens" VDI Tagung Innovativer Kfz-Insassen- und Partnerschutz, Berlin.**

[6]: **Zobel, R., Thomas, G., Schwarz, T. (2005) "Towards beneficial, scientifically meaningful and applicable compatibility testing" 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington.**

[7]: **Pastor, Claus. (2005) "Potential benefit of improved vehicle compatibility" Conference proceedings: Kompatibilität im Straßenverkehr, Dresden**

[8]: **Zobel, Robert. (1997) "Barrier Impact Tests and Demands for Compatibility of Passenger Vehicles" Conference proceedings: Innovativer Insassenschutz, Berlin**

[9]: **Zobel, Robert. (1998) "DEMANDS FOR COMPATIBILITY OF PASSENGER VEHICLES" 16th International Technical Conference on the Enhanced Safety of Vehicles, Windsor, Canada**

[10]: **Farmer, C.M. and Lund, A.K. (2006) "Trends over time in the risk of driver death: What if vehicle designs had not improved?" *Traffic Injury Prevention* 7:335-42.**

[11]: **Rieger, G., Scheef, J., Becker, H., Stanzel, M., Zobel, R. (2005) "ACTIVE SAFETY SYSTEMS CHANGE ACCIDENT ENVIRONMENT OF VEHICLES SIGNIFICANTLY - A CHALLENGE FOR VEHICLE DESIGN" 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington.**