Pedestrian Protection In Europe
The Potential of Car Design and Impact Testing

Executive Summary

The European Community has had impressive success in achieving the highest pedestrian protection level on the globe. In the years 1980 to 2000, the fatality rate per million inhabitants in Europe decreased by 65 % from 40 to 14.

The target set by the EU Commission in 1999 was to reduce pedestrian fatalities by 30% and severe injuries by 17% by 2010. According to actual traffic data and statistical expectations, this target will be reached without any European directive and test procedure. This trend results from design measures, the influence of active systems on the behavior of a car during the pre-crash phase and is also due to road safety instruction programs.

A negotiated agreement was contracted between the European Commission and the automotive industry. This agreement includes two phases of introduction for the four pedestrian impactor tests.
Phase 1 starts in 2005 and the introduction of phase 2 is planned for 2010. The tests in phase 1 will be the 3.5kg head impactor against the bonnet and the lower leg impactor against the bumper.
Phase 2 will be defined by further research in 2004. EEVC currently proposes separate head impactor tests of 2.5kg for children and 4.8kg for adults and the known lower leg test. The fourth test is an upper leg impactor against the front panel, the headlamps or the car bonnet's leading edge.
In general, impactor testing is not suited to monitor the kinematics and the overall injury risk of an impacted pedestrian. Thus, the results from isolated impactor tests may be misleading and conflicting potentials for the different height groups cannot be properly evaluated. On the other hand, full-scale tests with dummies which show more realistic kinematics cannot easily be reproduced. The need for an advanced numerical simulation procedure is obvious.

An evaluation of the GIDAS and IHRA data shows the proportion of injuries in the different contact zones. Only injuries with AIS 2+ are focused on.
For all parts of the body the rates are 44-49% for vehicle front relevant parts and 13-27% for the ground. Nearly 20% of the contacts occur on the windscreen but from a research study done by DEKRA it was concluded that at speeds up to 40km/h the impact leads neither to life-threatening head decelerations nor to such forces and bending moments to the neck.
Only 6 to 17% of all head injuries are in vehicle front relevant zones. In most cases the bonnet was the contact area (6-16%). The bumper, the bonnet leading edge, the front panel and the headlamps cause only a maximum of 1.2% of serious injuries to the head. But ground contacts cause 22-49% of all severe to fatal head injuries. Regarding bonnet and ground only the relative amount of ground contacts increases dramatically: 58% (22%/(16%+22%)) for the IHRA data and 90% (49%/(6%+49%)) for the GIDAS data.

To calculate the realistic potential of the impactor tests, i.e. percentage of AIS2+ injuries on the relevant vehicle front zones, all relevant accidents in the databases were analyzed using various criteria, since not all databases share the same parameters. The study made use of all car-to-pedestrian accidents involving frontal impacts with passenger cars from which pedestrians sustained injuries as a result. Because of information missing from the accident configuration in the IHRA data, the second criterion used was the impact speed below 60km/h.

Results from GIDAS:
For all parts of the body there is a potential reduction of 18% of AIS2+ injuries related to the proposed EEVC-tests. The rate of ACEA-phase 1 with 14.5% is considerably higher than the rate of 3.2% for the upper legform tests proposed by EEVC. For serious head injuries the difference is much more significant. Only 2.4% for phase 1 and <u>no</u> potential for the additional tests suggested by EEVC WG17. The results are based on a conservative approach because all collision speeds are taken into account.

Results from IHRA:
The potential for ACEA-phase 1 to reduce serious injuries to all parts of the body is 19.7%. For the additional EEVC WG17 tests a share of 7.1% at the bonnet leading edge, the front panel and the headlamps is calculated. The bonnet with approx. 9% has a reasonable potential for head injury reduction. These results are obtained for collision speeds up to 60km/h.

These facts lead one to expect the number of pedestrian fatalities to be reduced by 30 and of those seriously injured by about 6,500.
The consequences for testing can be summarized as followed. ACEA-phase 1 has a potential to reduce AIS2+ injuries to the lower extremities and the head. This goal can be reached with the lower leg impactor test and with the 3.5 kg head impactor test.
The increase of the potential by the EEVC WG17 tests is less than that expected by the Commission. On the other hand, efforts to meet the upper leg requirements are enormous, so that measures for accident avoidance or injury mitigation are more promising to reach higher potentials.
These findings should be considered during the review of the EEVC WG17 tests. It is conceivable that there are also alternatives which as a result of

active safety measures may realize higher potentials than those expected by the suggested impactor tests. Given the findings of this study and the plans in Japan to introduce legislation on pedestrian protection, there should also be discussion on whether there is any sense in implementing EEVC proposed tests as they currently stand. The key word is harmonization.

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1 Background

Very soon the European Commission will publish an Industry Commitment which aims at improvements for the protection of pedestrians in vehicle accidents. The target set in 2000 was to reduce pedestrian fatalities by 30% and seriously injured pedestrians by 17% by 2010. The German automotive industry appreciates the opportunity to contribute to a reasonable solution.
In the mid seventies an agreement was reached between European authorities, research institutes and the automotive industry to investigate the potential to reduce the number of casualties in car-to-pedestrian accidents.
Out of these joint research and investigation programmes the following main conclusions have been drawn:

- Concerted action is promising to effectively reduce the number of casualties, taking into account infra-structural, educational, medical and vehicular measures,
- only limited possibilities on the car front end are available to reduce serious injuries, since the secondary impact with the ground has been identified as a major source of life-threatening head injuries,
- the existing physical dummies are not suited to predict the benefit of safety measures on the car, and while subsystem tests seem to be more promising for testing, they have inherent disadvantages because they cannot simulate the behaviour of a complete human being,
- to develop safety systems to avoid pedestrian accidents,
- the further need for in-depth accident investigations and statistical results.

In the 1970s, as a result of these findings, the responsible disciplines initiated ambitious programmes in the different fields of traffic safety.

The automotive industry also contributed by sponsoring research activities and developing safety vehicles within the framework of the "International Conference for Experimental Safety Vehicles", ESV.
Since then, and frequently for reasons not entirely connected with pedestrian safety, a group of characteristics appeared in production vehicles:
- Smooth front end shape with a recessed bonnet leading edge,
- plastic fascias with foam layers replaced steel bumpers,
- recessed bumper leading edge,
- integrated headlamps,
- laminated windscreens, and
- anti-lock braking systems.

It may be argued that these design measures were not introduced to benefit pedestrians at all. Nevertheless they certainly did benefit pedestrians and it is often the case that the best design improvements give benefit in several different ways.

1.1 Highest Level of Pedestrian Safety in Europe

As a result of this joint effort, pedestrian safety on European roadways has been impressively improved. According to the International Road Traffic Accident Data (IRTAD), the fatality rate for pedestrians decreased from about 40 to 14 pedestrians per million inhabitants in the years 1980 to 2000, a reduction of 65%.
In the same 20 years, the fatality rate for car occupants dropped by 30% from 85 to 60 fatalities per million inhabitants (**table 1**).

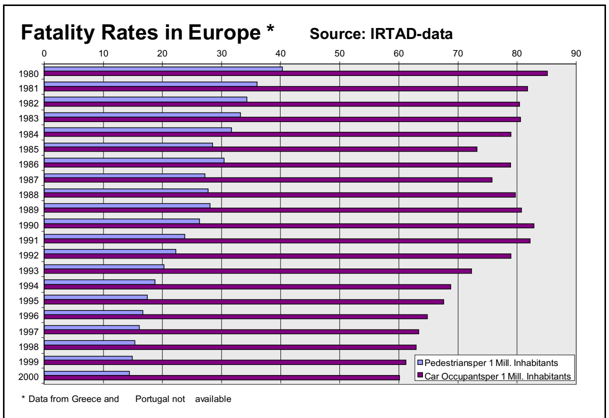

Table 1: Fatality rates in the EU

To point out the importance of this increase of pedestrian safety in Europe, a comparison with the developments in the USA and Japan is helpful.
On the basis of the international accident data, **table 2** gives an overview of the last 20 years. This reveals that Europe ranks first in pedestrian fatality reduction. Since 1993, the European member states have set the highest pedestrian safety level.

In the year 2000, the fatality rate in Europe is 14 pedestrians per million inhabitants, in contrast to the USA with 17 and Japan with 23 fatalities.

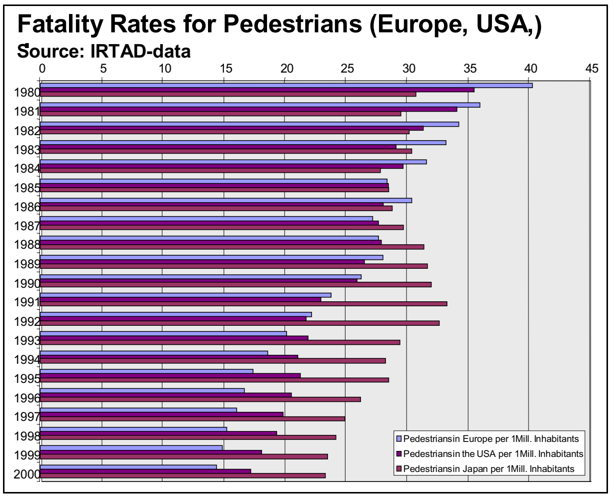

Table 2: Fatality rates for pedestrians (EU,J,US)

So far, the authorities in USA are not planning any vehicle regulations for pedestrian safety.
The improvement of pedestrian safety is the leading success in European traffic safety development. These results verify the strategy implemented in 1980 to require reasonable and joint action by all involved authorities. The automotive industry is concerned, however that despite these statistical facts some safety lobbyists are styling this impressive success as a "poor" result (see ETSC - Campaign), thus misleading European consumers and discrediting the achievements of other consumer groups during the last 20 years.

1.2 Pedestrian Casualties in Different Age Groups

The German national accident data enable a detailed analysis of different age groups for both fatally and severely injured pedestrians (IRTAD includes no separate data on severely injured).

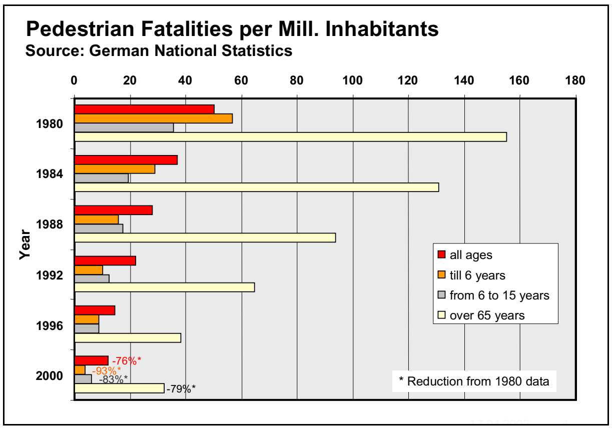

Table 3: Reduction of fatalities in Germany

Table 3 points out, that for child and senior pedestrians the fatalities per million inhabitants have been reduced even more, from 36 to 6 and 155 to 32 respectively. The numbers of severely injured pedestrians dropped by about 60% (**table 4**).

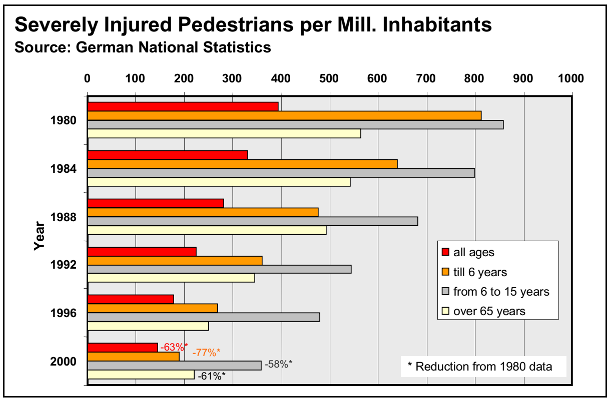

Table 4: Reduction of severely injured, Germany

2 Pedestrian Safety in Europe in the Year 2010

In absolute numbers, the pedestrian fatalities in 13 EU member states dropped from 14,631 to 6,000. This means a reduction of about 60%. The same reduction can be assumed for the seriously injured pedestrians, based on the German national data.

Taking into account this constant decrease of pedestrian casualties over the last 20 years, it can be expected that a further decrease of about 30% of pedestrian fatalities in Europe will occur over the next 10 years (**table 5**). These 30% correspond to the target set by the European Commission and will be reached without any ECE directive or regulation. This trend results mainly from car design measures, the influence of active systems on the behaviour of a car during the pre-crash-phase and due to road safety instruction programs in the past. In the following years the actual provisions on the car and the infrastructure changes, for example traffic calming measures, will affect the future trend in a positive way.

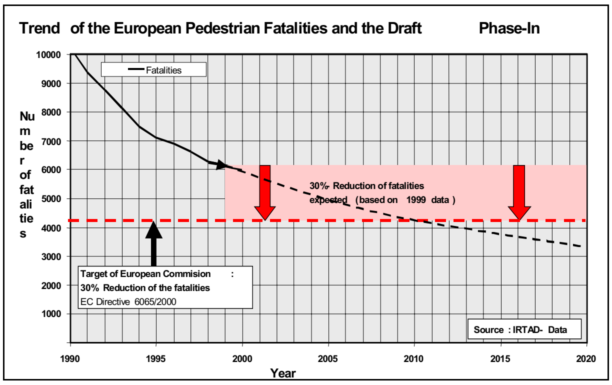

Table 5: Trend of reduction and EC-directive (fatalities)

The same trend can be expected for the reduction of seriously injured pedestrians. The target set from the EU commission is a value of 17%.

3 Results from In-Depth Studies on Car-to-Pedestrian Accidents

To estimate the effectiveness of any future European regulation focusing on vehicular safety measures to further increase the protection of pedestrians, a detailed evaluation of actual in-depth-accident data is appropriate.

3.1 German In-Depth Accident Study (GIDAS)

One of the most representative in-depth-accident data base, regarding to pedestrian accidents, is found in the GIDAS (German In-Depth-Accident Study). GIDAS is done under a joint contract with the BASt and the Forschungsvereinigung Automobiltechnik, FAT.
The GIDAS includes data from the years 1999 to 2001. The accidents were investigated by teams of the Medical University of Hanover and the University of Dresden.

At the end of 2001 about 3,200 accidents have been investigated and analysed. The data includes a total of 427 accidents with pedestrians (13% of the entire data set). The GIDAS-data for these pedestrian accidents correlate well with the German National Data, thus giving a random sample of the German traffic situation and the actual car population. **Table 6 and 7** demonstrate that this data is representative, with the comparison of the age groups and the injury severities.

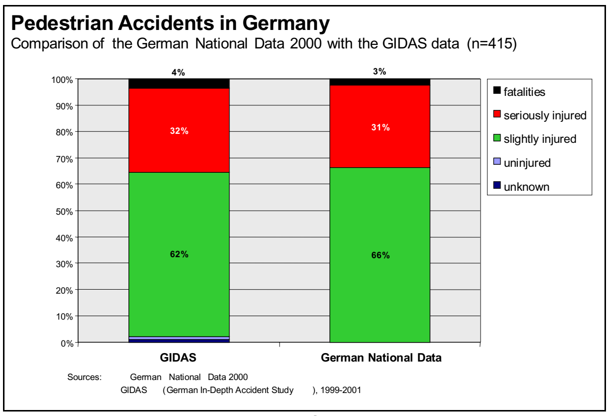

Table 6: Distribution of injury severity

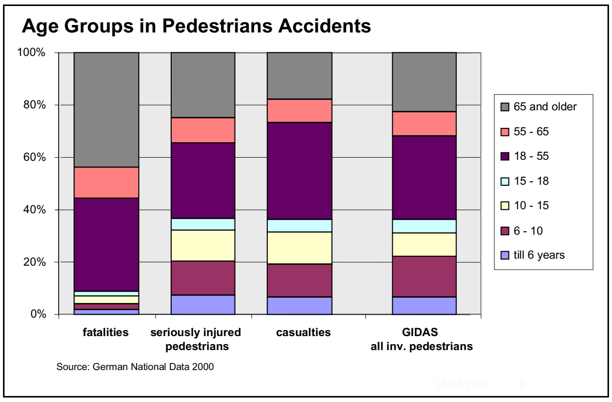

Table 7: Age groups of involved pedestrians

3.2 Injuries and Contact Zones in the GIDAS- and IHRA-data

Table 8 gives an overview of the relationship between contact areas and the associated body regions for all 116 reported severe to fatal (AIS 2+) injuries from 53 pedestrians in the GIDAS-data. Most frequent are contacts with the bumper, followed by head–to-ground impacts, the windscreen and the bonnet

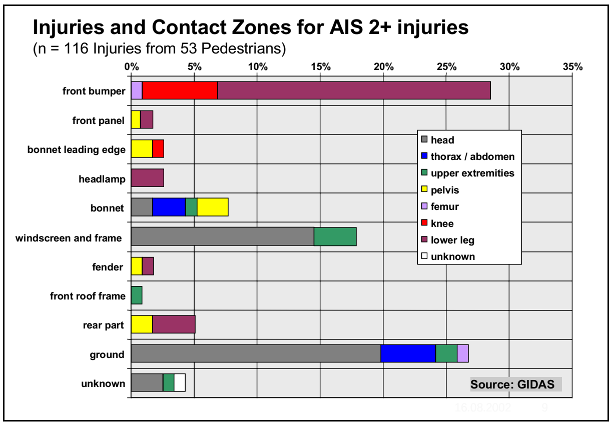

Table 8: Contact areas for AIS 2+ - injuries

Table 9 summarises the frequency of contacts, leading to severe or fatal injuries (AIS 2+) for all body regions.

Contact zones	GIDAS (1999-2001) 100% = 116 injuries	IHRA (Europe) (1985-1995) 100% = 1460 injuries
Parts of vehicle	**share**	**share**
front bumper	28%	21%
front panel and headlamps	5%	3%
bonnet leading edge	3%	10%
bonnet	8%	15%
Subtotal of vehicle front	**44%**	**49%**
windscreen and frame	18%	24%
ground surface	27%	13%
others	11%	14%

Table 9: Frequency of contacts for AIS 2+ - injuries, all body regions (front-to-pedestrian impacts, only passenger cars, all impact speeds)

The GIDAS-results may be compared with the European data of the Global IHRA (International Harmonized Research Activities) accident data base, which includes data from USA, Japan and Europe.
This analysis clearly shows that only half of the contact areas are on the vehicle front.
Nearly 20% of the contacts occur on the windscreen but from a research study done by DEKRA it was concluded that up to 40 km/h the impact does not lead to life-threatening head decelerations nor to such forces and bending moments to the neck.

3.3 Head & Face injuries and Contact Zones

In car-to-pedestrian impacts, specific attention is given to head injuries as the leading cause of fatalities.
For the GIDAS- and IHRA-data the number of severe to fatal (AIS 2+) head & face injuries with the associated contact zones is listed in **Table 10.**

Contact zones	GIDAS (1999-2001) 100% = 45 injuries	IHRA (Europe) (1985-1995) 100% = 512 injuries
Parts of vehicle	**share**	**share**
front bumper	0%	0%
front panel and headlamps	0%	1%
bonnet leading edge	0%	0,2%
bonnet	6%	16%
Subtotal for vehicle front	**6%**	**17,2%**
windscreen and frame	35%	51%
ground surface	49%	22%
others	10%	9,8%

Table 10: Frequency of contacts for AIS 2+ - injuries to head and face (front-to-pedestrian impacts, only passenger cars, all impact speeds)

The results from both of the data bases give clear evidence, that 73-84% of the life–threatening head injuries are due to contacts with the windscreen/frame area and contacts with the ground. However, in the GIDAS-data 49% of all the reported head injuries are caused by the secondary impact with the ground, whereas in the IHRA-data only 22% of the head injuries are attributed to contacts with the ground. These differences in the distribution of the various contact zones can be mainly explained by the different car populations (1985-1995 versus 1999-2001) with different front shapes and the resulting kinematics of the impacted pedestrians. In a paper, published by the Accident Research Unit of the University of Hanover (Otte, 1999), there were 41% of all head injuries with AIS 2+ attributed to a contact with the ground surface. 87% of the cars included in the investigation were built before 1990 and 13% later.

The changes of contact frequencies dependent upon the front shapes is explained in chapter 3.5 on page 6. The same reason may explain the great difference for bonnet contacts with 6% versus 16% respectively. The bonnet leading edge, the front panel and the headlamps play no role in producing head injuries. The detailed analysis of the GIDAS-data reveals that there is no head contact in the front third of the bonnet, independent from the different body heights of the pedestrians (**table 11**). Otte published in 1999, that only head impact speeds over 40 km/h cause significant injuries to the pedestrian's head. Tests with a new test rig which simulates the contact of a dummy torso against the windscreen (Berg, 2000) clearly show, that the loads for head and neck caused by the windscreen are not life-threatening.

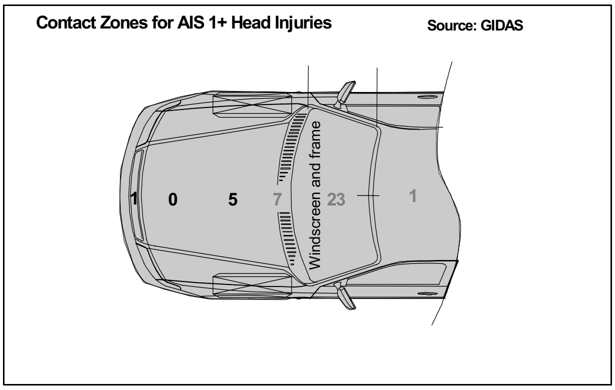

Table 11: Frequency of contacts for AIS 1+ - head injuries

3.4 Lower Extremity Injuries and Contact Zones

Contact zones	GIDAS (1999-2001) 100% = 55 injuries	IHRA (Europe) (1985-1995) 100% = 572 injuries
Parts of vehicle front	**share**	**share**
front bumper all	61%	52%*
lower leg	46%	39%
knee	13%	5%
femur	2%	3%
front panel and headlamps	9%	6%
bonnet leading edge all	6%	19%
pelvis	4%	12%
bonnet	6%	4%
Subtotal for vehicle front	**82%**	**81%**
windscreen and frame	0%	0%
ground surface	2%	5%
others	16%	14%

Table 12: Frequency of contacts for AIS 2+ - injuries, lower extremities (front-to-pedestrian impacts, only passenger cars, all impact speeds)
(*including 5% "others")

In both, the GIDAS- and IHRA-data, about 75% of the bumper contacts are related to the lower leg injuries. Knee injuries account for 5-13%.

4 Prediction of the Injury Mitigation Potential Due to a Frontal Car-to-Pedestrian Test Procedure

4.1 GIDAS-data

To estimate a realistic overall potential of a test procedure relating to the front end of passenger cars, the portion of impacts with passenger cars (75%) and the full frontal car impacts (54%) should only be considered. These shares, taken from the GIDAS-data are presented in detail in **tables 13 and 14**, respectively.

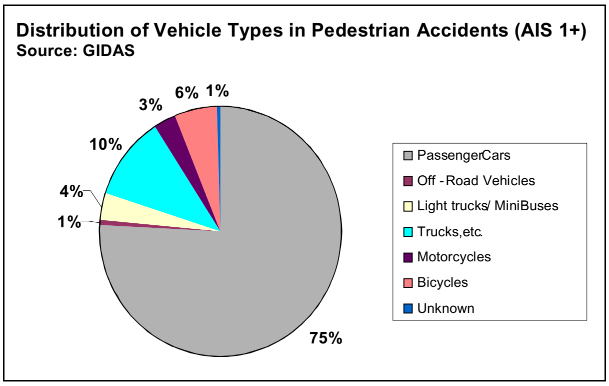

Table 13: Share of passenger cars in pedestrian accidents

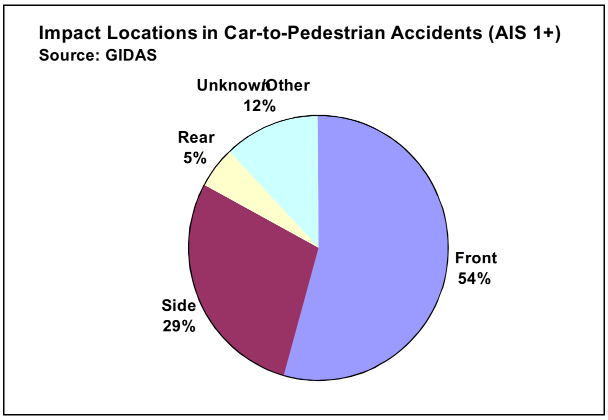

Table 14: Impact location on the cars

Taking into account these findings, to estimate the exposure of the car front in the European pedestrian impacts, the frequencies given in tables 13 to 14 should be multiplied with a factor of 0.4 (0.75 x 0.54).
The resulting realistic injury reduction potentials for both serious and fatal injuries are explained in the two trees below, **Table 15 and 16**. The basis is 100% for all vehicles involved in impacts with pedestrians. The realistic potentials for all the relevant parts/contact zones included in the proposed EEVC test-procedure are calculated on the top of the tree.

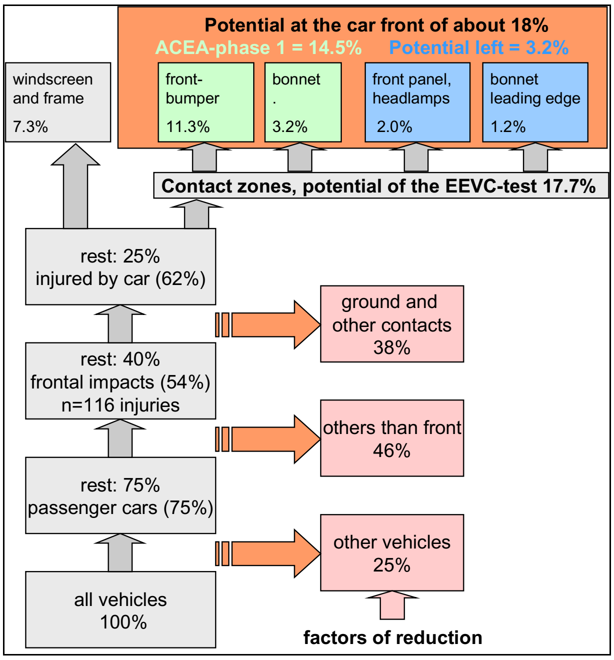

Table 15: Potential of injuries (all body regions, AIS2+) in the GIDAS-data

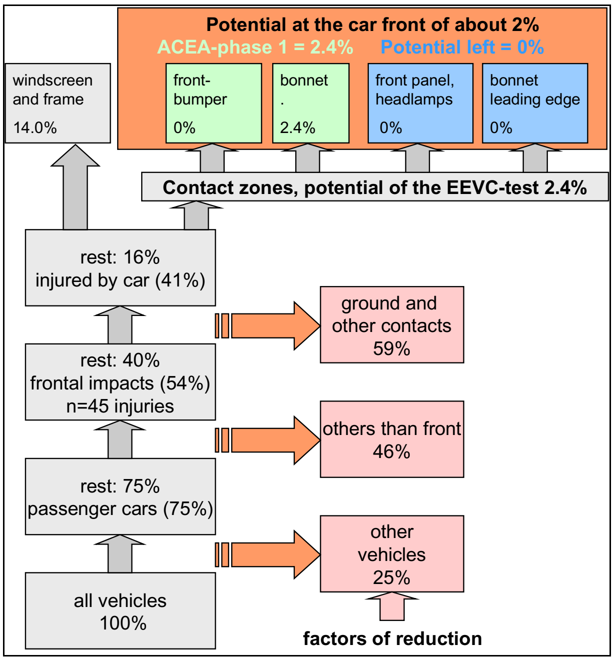

Table 16: Potential of head injuries (AIS2+) in the GIDAS-data

According to the GIDAS-data the theoretical injury reduction potential by the EEVC pedestrian test procedure is limited to 17.7% for serious injuries to all body regions and 2.4% for serious head injuries. No potential is given for the bonnet leading edge. The results from Table 15 and Table 16 are based on a conservative approach because all collision speeds are taken into account. Higher collision speeds (>60km/h) will have nearly no potential to survive (see also next chapter).

4.2 IHRA-data

It should be noted, that the present evaluation of the IHRA-data reflects the traffic situation and the car population as they existed in 1985. Therefore, an updated version of the IHRA-evaluation would be beneficial, since the car population has significantly changed within the last 10 years.

Furthermore, accident investigation analysis gives clear evidence that in a full frontal car-to-pedestrian impact with a speed equal or greater than 60 km/h, there is practically no chance for pedestrian survival. These impacts can be viewed as catastrophic events, without any feasible countermeasures on the car surface to prevent the fatal outcome. This results from the large energy transfer and the resultant pedestrian kinematics.
In the IHRA-data 74% of the severe to fatal (AIS 2-6) injuries are reported with impact speeds less than 60 km/h.
Taking into account these percentages, to estimate the exposure to car fronts in the European pedestrian impacts, the frequency of contacts for

the IHRA-data, given in **tables 17 to 18** should be multiplied with a factor of 0.55 (0.75 x 0.74).
The resulting injury mitigation potentials for both all serious injuries and serious head injuries based on the IHRA-data are explained in the following two trees.
According to the IHRA-data the theoretical injury reduction potential due to the EEVC pedestrian test procedure is limited to 26.8% for serious injuries and 9.5% for serious head injuries.

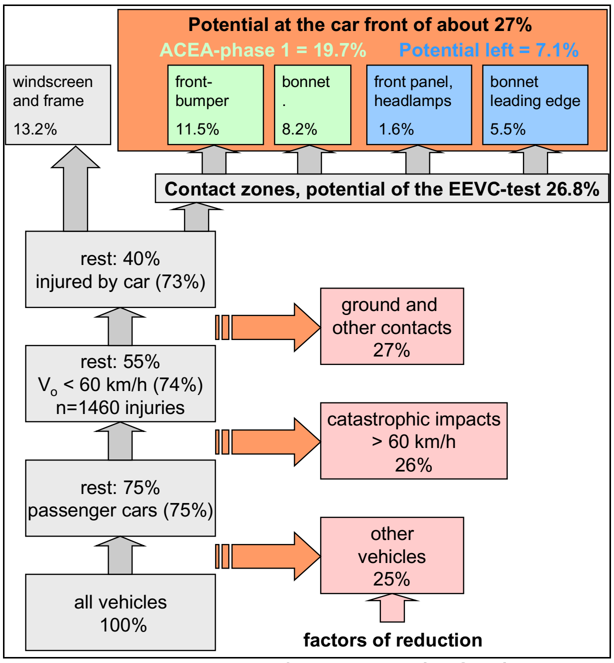

Table 17: Potential of injuries (AIS2+) in the IHRA-data

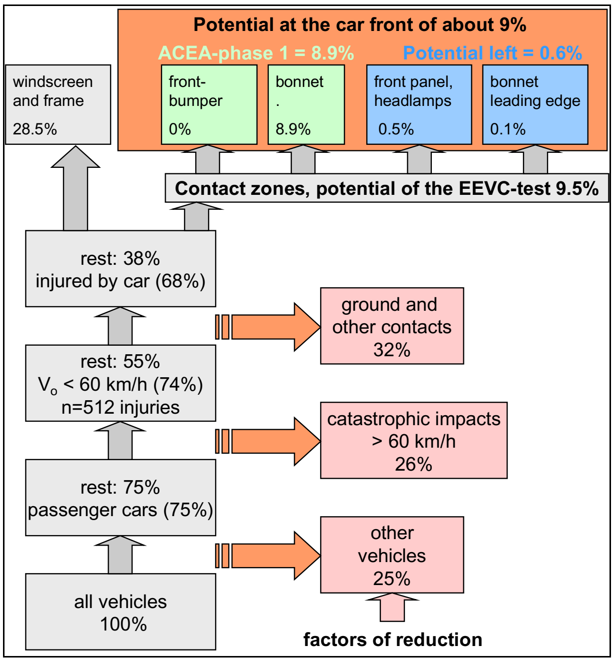

Table 18: Potential of head injuries (AIS2+) in the IHRA-data

4.3 Joint Estimates for Injury Reduction Potential

Table 19 gives an overview on the protection potential for the different contact zones.

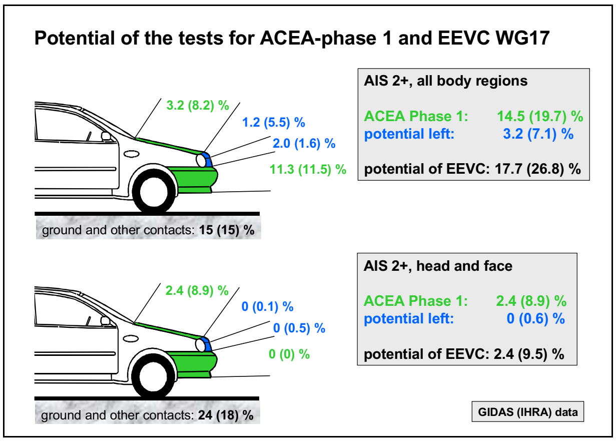

Table 19: Potential for ACEA-phase 1 and EEVC WG17

The result is a very low potential of 7.1% for the bonnet leading edge, the front panel and the headlamps.
With 11.5% the bumper system seems to have a reasonable potential.

4.4 Consequences for Impactor Testing

The frequency of impact contacts in the GIDAS-data point out, that measures on the car front have a potential of 27% for all serious injuries suffered in pedestrian impacts in Europe. About half of these injuries are due to contact with the bumper. Injuries due to contact against the bonnet leading edge account only for 1.2 %. This result stands in contrast to the IHRA-data and other previous investigation results. This difference could be explained by design changes resulting in the recessed front shape of cars in the European vehicle fleet. In light of this remarkable change of significance, any specific test on this part of the car is no longer suited to effectively reduce the number of pedestrian injuries in the future and should be deleted from any planned test procedure.

In light of the low number of bonnet contacts (3.2% for all and 2.4% for head injuries) the two impactor tests proposed from the EEVC WG17 overrepresent the importance of this area of the car. Since most bonnet contacts are related to pedestrians with body heights under 1.60 m, the test simulating a child-to-car impact is the only possibly meaningful one.

5 Potential of the EEVC-test

Of most interest is the expected casualty reduction from pedestrian accidents in Europe.
The GIDAS- and the IHRA-data provide a basis to estimate the potentials of saved lives and injuries of pedestrians.
On a statistical basis, a seriously injured pedestrian is polytraumatised and receives about 2 injuries during an impact. From the pedestrians suffering a serious (AIS 2+) head injury every fifth pedestrian is likely to be killed.
Based on these findings the potential to reduce casualties by the proposed ACEA-phase 1 and EEVC WG17 procedure is represented in **table 20**:

	seriously injured	fatalities
European casualties 2000	**74,494**	**6,143**
GIDAS	**8.8%** see table 15 (17.7%/2)	**0.5%** see table 16 (2.4%/5)
Potential from ACEA-Phase 1	**5,363** (7.2%)	**30** (0.5%)
Potential left	**1,191** (1.6%)	**0** (0%)
Total potential based on GIDAS-data for EEVC WG17	**6,554**	**30**
IHRA (Europe)	**13.4%** see table 17 (26.8%/2)	**1.9%** see table 18 (9.5%/5)
Potential from ACEA-Phase 1	**7,375** (9.9%)	**110** (1.78%)
Potential left for EEVC WG17	**2,607** (3.5%)	**7** (0.12%)
Total potential based on IHRA-data	**9,982**	**117**

Table 20: Estimated potentials of pedestrian protection testing for complete European vehicle fleet exchange

The total amount of savings due to the theoretically estimated potential for the EEVC WG17 approach is questionable. The VDA/TNO I study indicated that there could be negative effects for children when the car would be designed according the upper legform requirements.

6 Injury Reduction Potential in 2010

Based on the European pedestrian casualties in the year 2000, a test procedure simulating a pedestrian impact situation with a speed up to 40 km/h, as proposed by the EEVC – and recently agreed in the GRSP ad hoc WG "Pedestrian Protection", will have a theoretical potential to save 30 to 117 pedestrian fatalities and 6,500 to 10,000 seriously injured people in Europe. Assuming a renewal of the car population within 10 years, the potential savings are 3 to 12 fatalities and 650 to 1,000 seriously injured in the first year after implementation.

The potentials estimated by ETSC for EEVC WG17 tests claiming that up to 2,000 lives and 17,000 serious injured could be prevented annually, are far too optimistic.
The difference of the potentials coming from ACEA-phase 1 and EEVC WG17 can be estimated as well. In the EEVC WG17 procedure an additional impactor test against the bonnet leading edge is proposed. For all serious injuries the contact frequencies with the bonnet leading edge, the front panel and the headlamps account for 18% (3.2% out of 17.7% in the GIDAS-data in table 15). That means that EEVC WG17 will have a theoretical potential to save 18% of seriously injured pedestrians. In contrast, TRL is estimating 75% additional savings from the EEVC WG17 tests. An estimate for additional injury mitigation due to a second impactor test on the bonnet with the adult headform seems to be rather hypothetical and needs explanation.

In **table 21**, a comparison of the potentials from the ACEA-phase 1 and the EEVC WG17 tests is given. Up to the year 2010, a reduction of 1,843 fatalities is expected from the 30%-trend. In a ten year period after implementation, the ACEA-phase 1 tests will have an additional potential of about 600 (IHRA-data) and 160 (GIDAS-data) fewer pedestrian fatalities. The potentials are calculated in the following way. For the GIDAS-data a potential of 3 is expected in the first year after implementation, in the second year 3+3=6, in the third year 6+3=9 and so on. The result of all these values in each year (3+6+9+...=160) is the potential over the ten year period. The additional tests by EEVC WG17 do not improve the fatality reduction rate obviously (see table 21, right diagram).

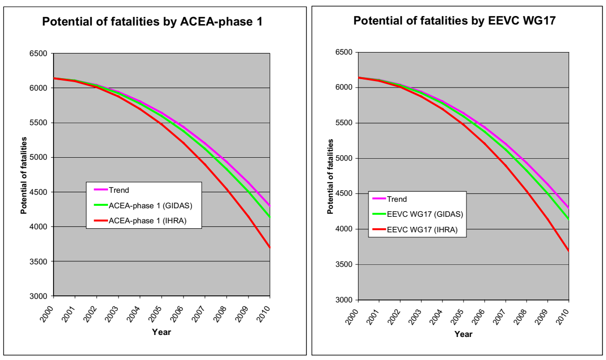

Table 21: Estimated potential ACEA-phase 1 (left) compared to estimated potential for the EEVC WG17 tests (right)

7 Cyclist Casualties

Taking into account the complex nature of car-to-pedestrian impacts, due to varying body heights, impact situations, car geometries and pedestrian kinematics, it seems very questionable that any significant reduction of cyclist casualties can be achieved. This is a product of assumed complex influences. At present, it cannot be denied that possible conflicting requirements and implications for the cyclists may result from specific pedestrian protection measures because suitable research data is lacking.
In a study done by SWOV (Kampen, 1994) it was assumed that pedestrian measures on the car front would positively influence cyclist impacts.
The European Commission uses a number of 3.5% reduction in deaths and 8% decrease in serious injuries. However, the basis of this study are missing and additional information is necessary for validation.

8 Projected Potential Due to Active Systems for Accident Avoidance

In light of the observed low and even conflicting potential of pedestrian safety measures on the car front end to protect the most vulnerable groups in traffic accidents, the strategy to avoid pedestrian accidents is much more promising. In addition, this strategy is proactively supported by automotive industry activities to further increase the protection of car occupants.
As an example, the brake assistance systems - introduced in 1997 and used in new car series of different manufacturers - is one of these advanced active systems to avoid or mitigate accident casualties. This system, in combination with the ABS (anti-lock brake system) provides optimum brake system pressure when a driver makes an abrupt braking operation to avoid a hazard. Using this technology the car achieves maximum deceleration, thus reducing the braking distance.
Table 22 gives an example of the capability of the brake assistant: assuming a travelling speed of 50 km/h and the braking behaviour of an average driver, a reduction of the stopping distance of about 6m can be expected. As a result, the accident may be avoided, the impact severity may be mitigated or the endangered pedestrian may be allowed sufficient time to escape from the impact.

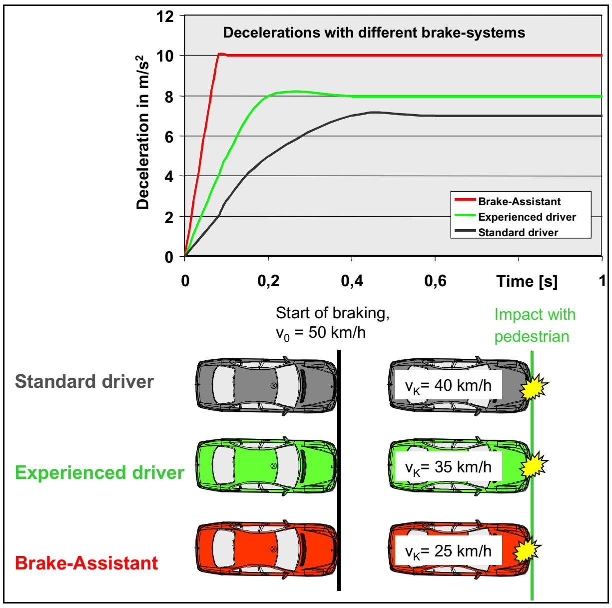

Table 22: Reduced collision speed by using a brake-assistant

Investment into research for advanced systems, aimed at accident avoidance rather than injury reduction is the most promising strategy to reduce traffic casualties for pedestrians and occupants. Given the actual and rapid development of advanced sensor technologies, this is a realistic objective in the near future.

Possible new active systems in vehicles which have additional potential to reduce pedestrian accidents in the future include:

- Brake-Assistant
- Anti-Lock Brakes Systems (Enhanced)
- Headlamp Lighting Systems (swivelling headlamps or bend-lighting)
- Radar Sensors (24 GHz-technology)
- Increasing Visibility
- Intelligent Mirror Systems
- Wheel & Tire Systems
- By-Wire Systems
- Yaw Control Systems

9 Conclusion

The European community has impressively succeeded in achieving the highest pedestrian protection level on the globe. In the years 1980 to 2000, the fatality rate per million inhabitants in Europe decreased by 65 % from 40 to 14.
This achievement is the result of a reasonable and joint strategy taken by the responsible European authorities in 1980, in the fields of traffic management, medicine and road safety campaigns. For example, establishment of zones with limited speeds, crosswalks, enhanced emergency services, education programs in schools.

The target set by the EU–Commission in 1999 is to reduce pedestrian fatalities by 30% and severe injuries by 17% in 2010. According to actual traffic data and statistical expectations, this target will be reached without having any European Directive and test procedure. This trend results from design measures, the influence of active systems on the behaviour of a car during the pre-crash-phase and due to road safety instruction programs.

Independent from any specific protection system and testing procedure, the statistical potential to further reduce pedestrian casualties by means of protective systems on the car front is very limited. Potential reductions of 30 pedestrian fatalities and about 6,500 seriously injured pedestrians are expected. This is far less than the saving of 2,000 lives and 17,000 serious injuries, estimated by the EU-Commission.

The proposed EEVC WG17 impactor tests are based on statistical data going far back to 1985. That data represents an outdated car population. Considering the current car population the kinematics and loading on impacted pedestrians are quite different. Therefore, an adaptation of the proposed impactor tests to the actual accident data and the actual car population is recommended. Also, the automotive industry needs practical and reliable tools for impactor testing.

In general, impactor testing is not suited to monitor the kinematics and the overall injury risk of an impacted pedestrian. Thus, the results from isolated impactor tests may be misleading and conflicting potentials for the different height groups cannot be properly evaluated. On the other hand full-scale-tests with dummies which show a more realistic kinematics aren't well reproducible. The need for an advanced numerical simulation procedure is obvious.

The additional potential for the EEVC WG17 tests to further reduce seriously injured pedestrians is only 18% (compared to ACEA-phase 1). It appears correct that 18% is not negligible, but changes at the car front are really complex to design and can lead to negative effects for children. The enormous costs of these complex design solutions can be used more effective for the development of much more promising active systems. These systems have more potential to mitigate or avoid pedestrian to car accidents and also for other impact configurations.

Due to the even more complex and quite different kinematics of the impacts with cyclists, the benefits for cyclists must be questioned. The publishing of the basic assumptions in the SWOV study is appreciated.

In light of these facts and shortcomings, the impact tests negotiated in the self commitment of the car industry in ACEA-phase 1 are to be judged as the maximum compromise by the German automotive industry.

The automotive industry is open to additionally sponsor advanced active systems or numerical simulation systems, instead of supporting ineffective and possibly conflicting testing procedures due to the EEVC WG17 tests.

The consequences for testing can be summarised as followed. The potential injury reduction of ACEA Phase 1 is addressed to the lower extremities and the head. This can be reached with the lower leg impactor test and with the 3.5 kg head impactor test.
The increase of the potential by EEVC WG17 tests is less than expected by the commission. On the other side the efforts to meet the upper leg requirements are enormous and could have negative effects for children. Measures for accident avoidance or accident severity reduction and thus injury mitigation are more promising to reach a higher potential.

Abbreviations:

ABS - Anti-Lock Brakes System

AIS - Abbreviated Injury Scale

BASt - German Federal Highway Research Institute (Bundesamt für Straßenwesen)

ECE - Economic Commission for Europe

EEVC - European Enhanced Vehicle-safety Committee

ESV - International Conference for Experimental Safety Vehicles

ETSC - European Transport Safety Council

EU - European Union

FAT - Forschungsvereinigung Automobiltechnik

GIDAS - German In-Depth Accident Study

IHRA - International Harmonized Research Activities

IRTAD - International Road Traffic Accident Data

Phase 1 – Reduced EEVC WG17 requirements, ACEA suggestion

EEVC WG17 Proposed impactor test for adult head, child head, upper leg and lower leg

SWOV - Dutch Institute for Road Safety Research (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid)

TU-Berlin – Technical University Berlin

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