Compact accident research

Intelligent Vehicle Assessment Regarding Pedestrian Safety

Unfallforschung der Versicherer
GDV

Imprint

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Preliminary remark

In 2009 in Germany 591 pedestrians were killed and 8137 were severely injured in road traffic. 332 of these pedestrians were killed in car accidents. That is why pedestrian safety at the vehicle front is a major concern in European regulation as well as in consumer rating Euro NCAP.

Vehicle manufacturers make an effort to realise measures in order to cure the vehicle front in series vehicles. Today, the main focus is on passive safety systems, e.g. active bonnet or structural measures.

However, in the near future systems will be available which can recognise an impending accident and can take action in order to mitigate the consequences or even to avoid the accident. Therefore, there is a need for a comparable, integral assessment of different measures in order to identify the most effective system (or a combination of different ones).

This was the aim of a two years research project which was jointly conducted by German Insurers Accident Research (UDV) and Forschungsgesellschaft Kraftfahrwesen Aachen (fka).

Content

1 Method

To assess and compare the safety potential of active and passive pedestrian safety measures on one scale, an assessment procedure has been developed and applied to different measures and vehicle front designs. Previous methods are complex and their realisation would need additional test effort. In this respect, the described method is an advancement of the VERPS-Index [1] with the focus on reduced complexity.

An important characteristic of the assessment procedure is its modular design, combining structural characteristics of a vehicle front with accident kinematics and accident research data (see figure 3). Each module can be enhanced or replaced individually. The assessment procedure uses the vehicle model specific Euro NCAP results and adapts the HIC-values to the real accident kinematics derived from numerical simulations. Since the kinematics strongly depend on the front design of a car, a corresponding categorisation has been developed (see figure 1).

class	h_{BLE} [mm]	α_F [°]	α_{F_wss} [°]	WAD [mm]
one box	> 650	≥ 30	> 165	< 1700
compact	650 - 850	< 20	< 185	1300 - 1600
sedan	650 - 850	< 20	< 185	> 1600
van	650 - 850	≥ 20	< 185	1300 - 1699
suv	> 850 (<1100)	< 20	< 165	> 1700
sports car	< 650	< 20	165 - 185	1500 - 1899

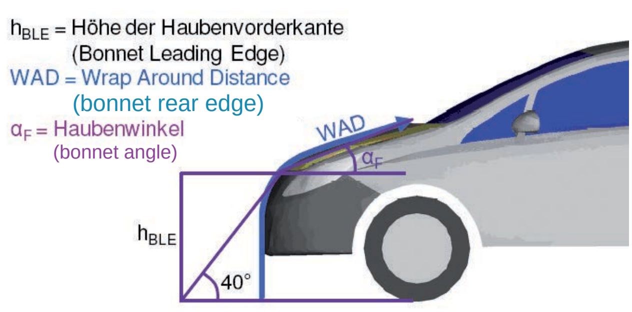

Figure 1:
Geometric parameters of the defined vehicle categorisations

This categorisation allows a vehicle-class-specific consideration of the accident kinematics. For each vehicle class, appropriate simulation data are available. Kinematic parameters are the head impact velocity, the impact angle and the impact probability, which were all determined for the individual areas of the vehicle front categorisation. The assessment procedure primarily provides an index value which indicates the risk of an AIS3+ head injury due to the primary impact at a collision speed of 40 kph (see figure 2). It is calculated for children and for adults by means of an injury risk function. The calculated index ranges between 0 and 1. Thereby, value 1 means a 100% risk of severe head injuries (AIS3+). The value 0 means that there is no risk of severe head injuries (AIS3+) (see figure 4).

$$\sum_{i=1}^{10} R_{i,WAD} * \left(\sum_{j=1}^{12} 1 - e^{-\left(\frac{HIC_{ij} * V_{ij} * W_{i,WAD} + 500}{1990}\right)^{4,5}} * R_{j,lateral} \right)$$

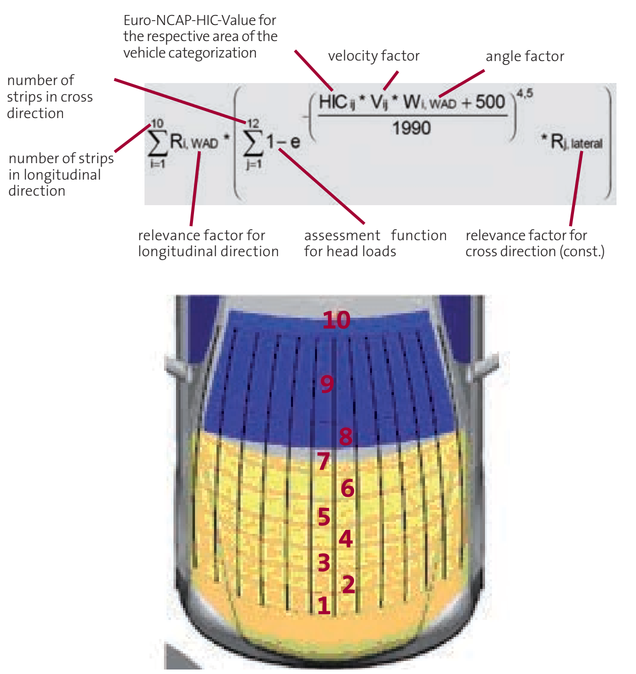

Figure 2:
Index calculation method and classification of the vehicle front in longitudinal and cross direction

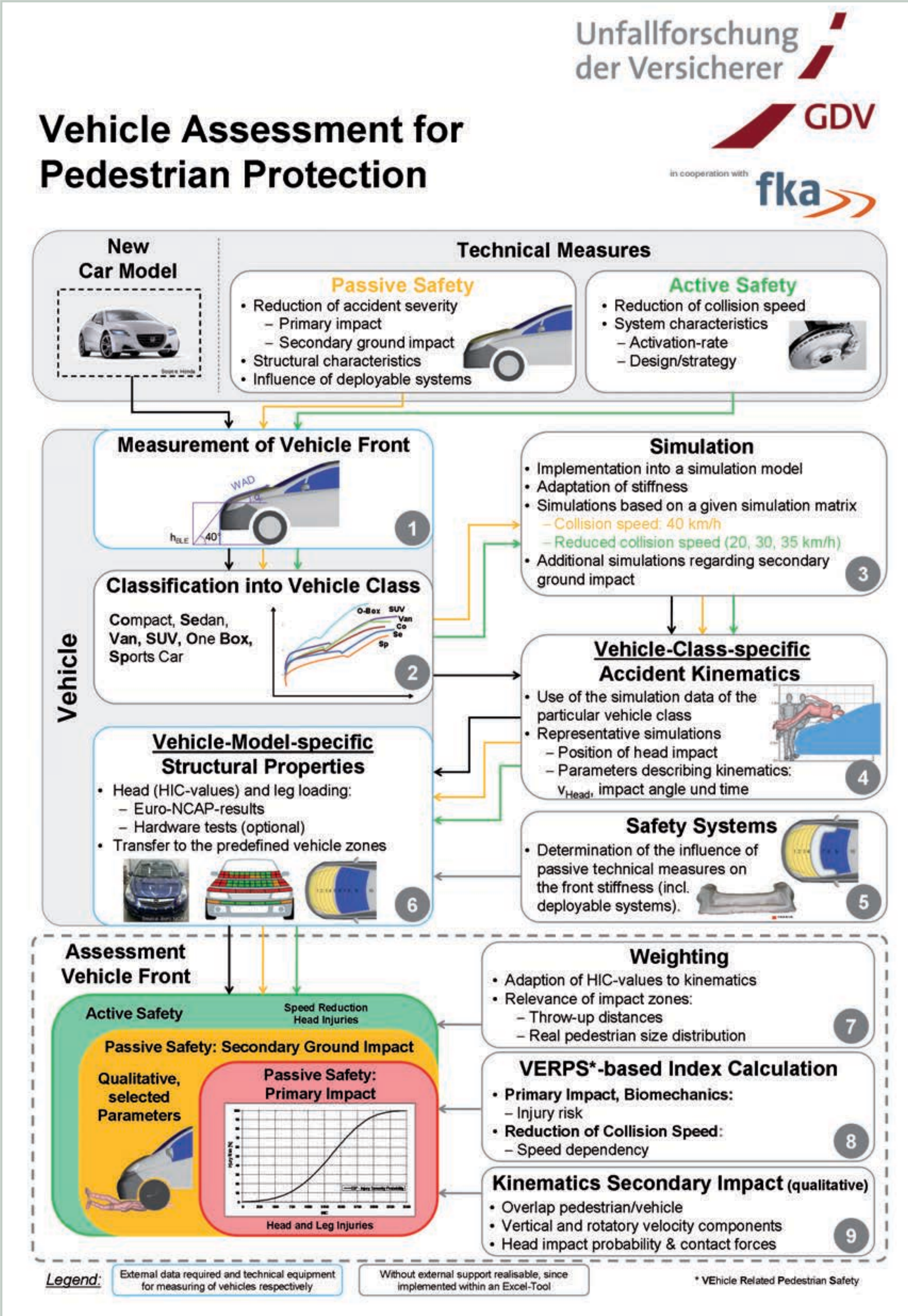

Figure 3:
Overview of the assessment procedure

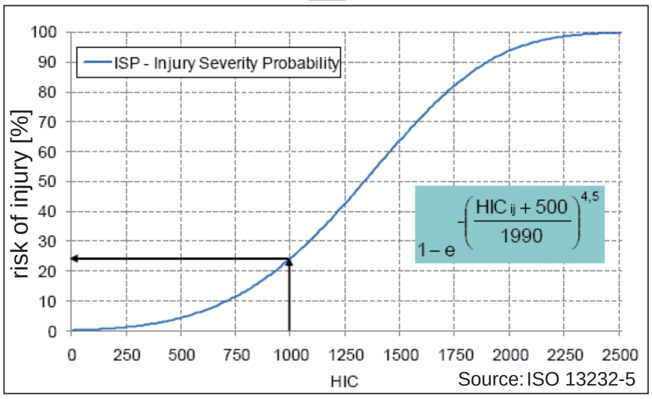

Figure 4:
Injury risk function according to ISO 13232-5 for AIS 3+ head injuries [2]

Based on corresponding simulation data it is moreover possible to describe the index value as a function of collision speed. Thus, active safety systems can be considered with the help of a developed assessment approach. The assessment procedure brings the evaluation of active and passive safety together. Besides the head load the leg load is also assessed. This is carried out by a simplified index calculation, which is again based on Euro NCAP results. The secondary impact is evaluated qualitatively.

2 Results

Index values have been calculated for vehicles which achieved either a "good" or a "bad" rating score within Euro NCAP. This calculation method has further considered different additional safety systems. In figures 5, 6 and 10, active safety systems mean advanced emergency brake systems with pedestrian detection. The systems are characterised by the following limitations:

- Active system 1: no activation at darkness
- Active system 2: no activation at rain/snow
- Active system 3: no limitations.

It could be shown that the benefit of today's measures applied to the vehicle front is limited. Legal test requirements and consumer ratings moreover insufficiently reflect the vehicle-class-specific relevance of particular front areas. Simulation data reveal the high relevance of the cowl, the A-pillars and the lower windscreen area, which all need to be addressed by technical measures (but are not considered in the legal test requirements). Furthermore there is no "one fits all" measure which performs on the same positive level at all vehicle fronts and for all pedestrian sizes. Therefore measures have to be selected and adjusted for each car front.

Depending on the vehicle class, a windscreen airbag for example is able to improve adult pedestrian safety significantly (see figure 6). Children however profit more by advanced emergency brake systems with pedestrian detection due to the limited safety potential of an active bonnet (see figure 5). An effective application of active safety systems demands an adequate passive pedestrian protection, as illustrated by the determined velocity related index curves. An optimal pedestrian protection can only be achieved by a combination of passive safety measures and predictive active safety systems. Consequently, future cars should follow an integrated safety approach, which above all also has a positive effect on the leg loading as well as the secondary impact.

3 Crash Tests

The benefit of relevant and within the assessment procedure regarded passive safety systems has finally been demonstrated by Polar-II dummy tests with an experimental vehicle. The experimental vehicle has been equipped with an adaptive bumper, an active bonnet and a windscreen airbag. In figure 7 and 8, a test with no measures applied to the experimental vehicle (basic test) and a test with sa-

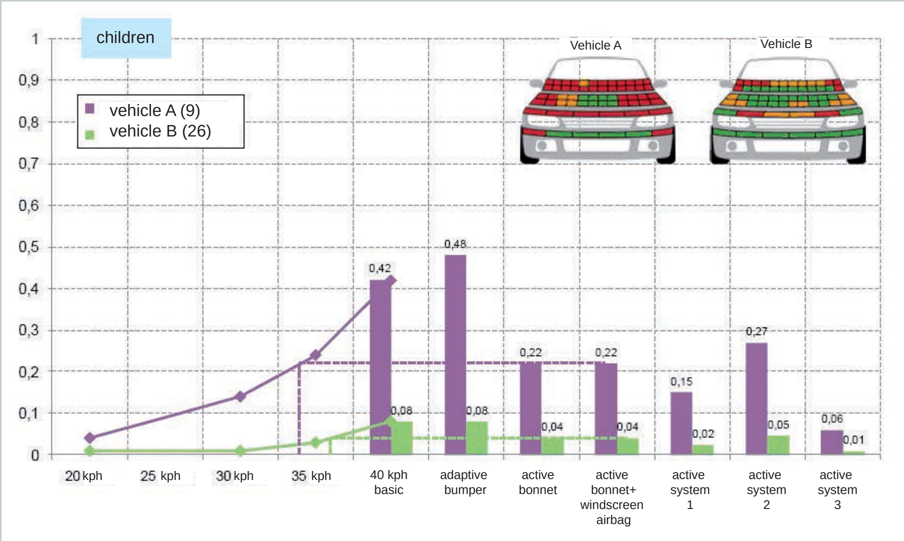

Figure 5:
Head-index-values calculated for a child (category sedan)

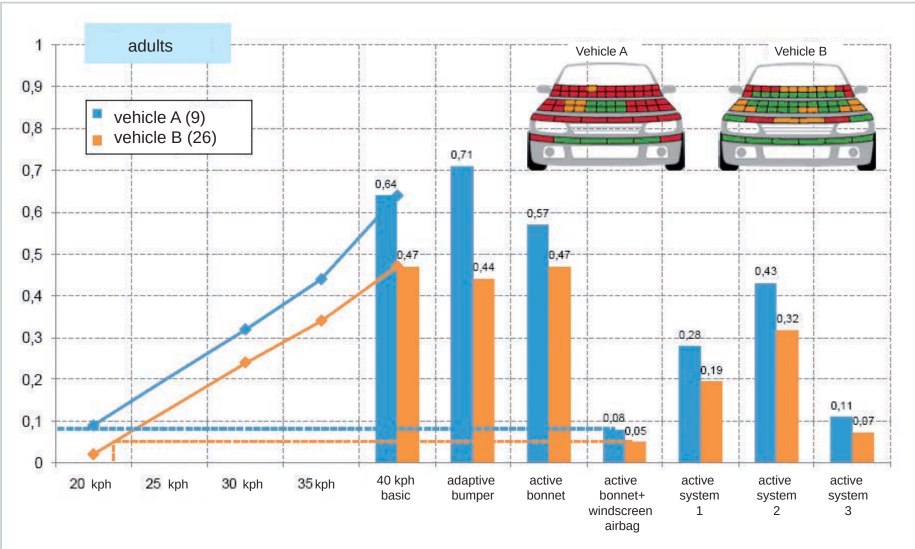

Figure 6:
Head-index-values calculated for an adult (category sedan)

fety systems applied (system test) are shown. Compared to the series vehicle, the leg and head loads could be significantly reduced by these measures (see figure 9). The reduced loads are reflected by the calculated index for children as well as for adults (see figure 10). Moreover, the theoretically calculated values for children of an advanced emergency brake system without limitations (system 3) show a considerably reduced risk for head injuries compared to passive measures. For adults, the index value is already under 10% but is still above the value for a combination of all passive safety measures.

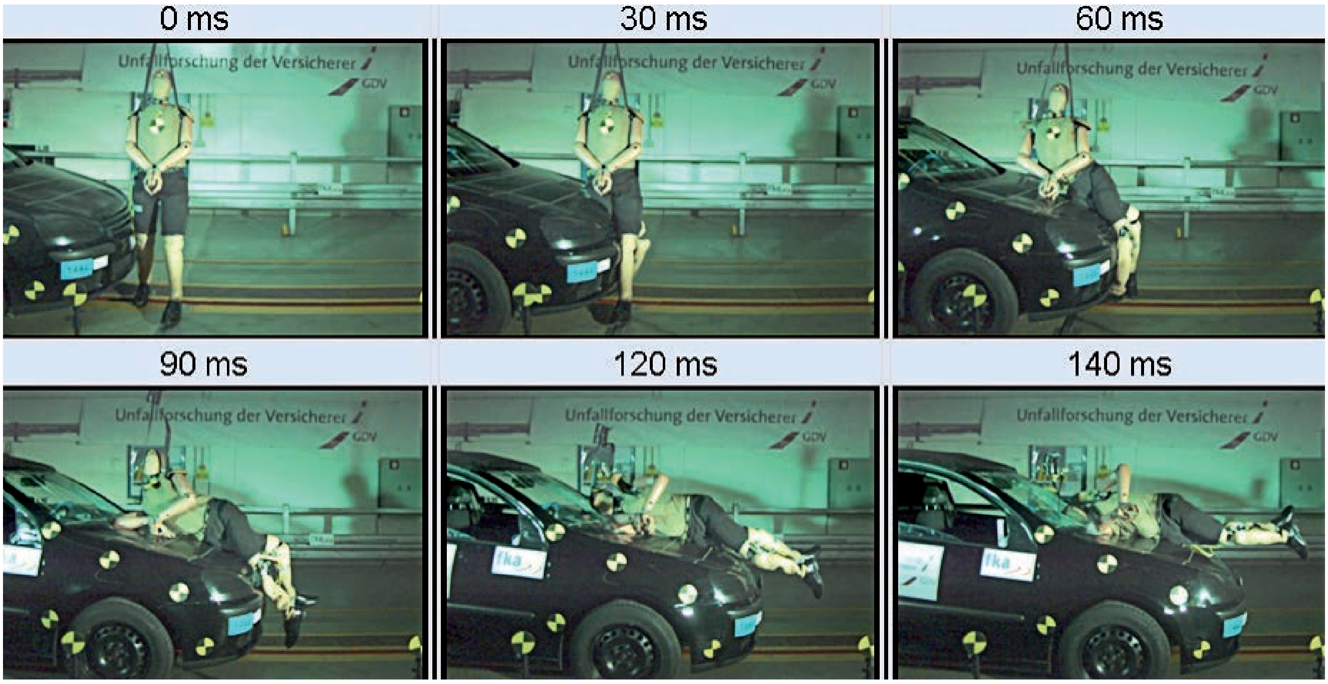

Figure 7:
Basic test (with no measures applied) at a vehicle speed of 41 kph

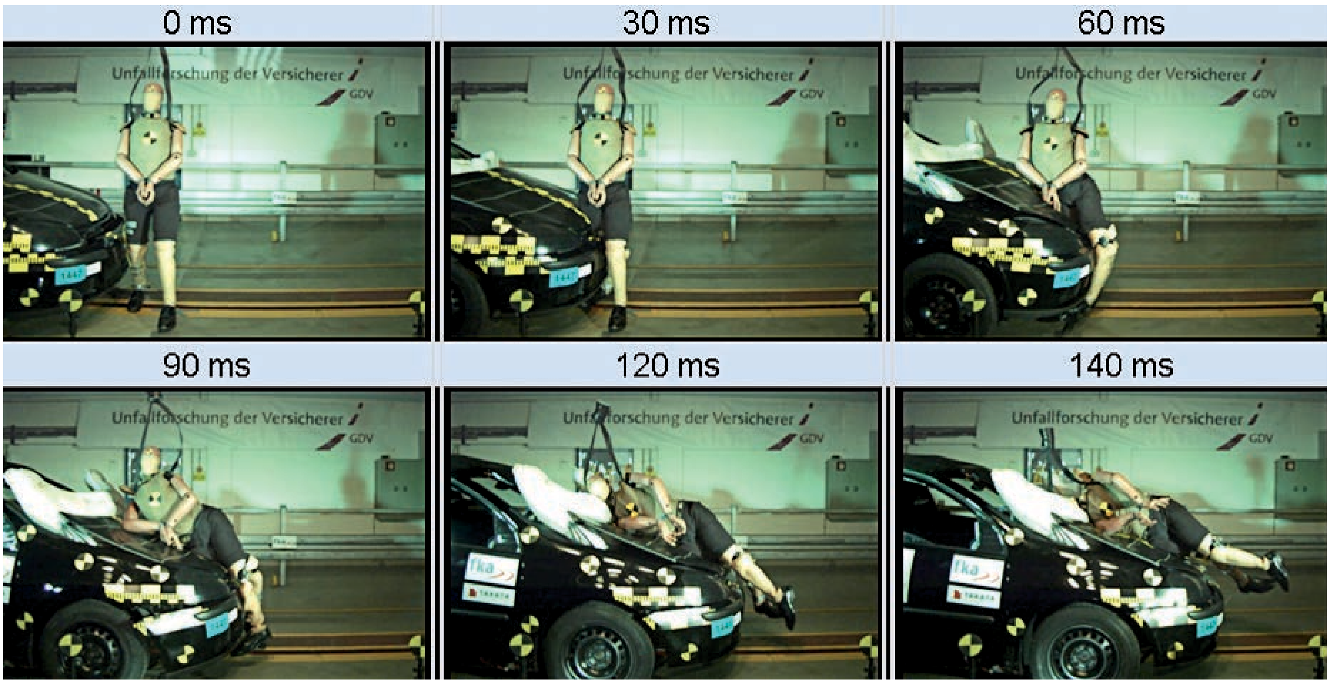

Figure 8:
System test (with systems applied) at a vehicle speed of 40 kph

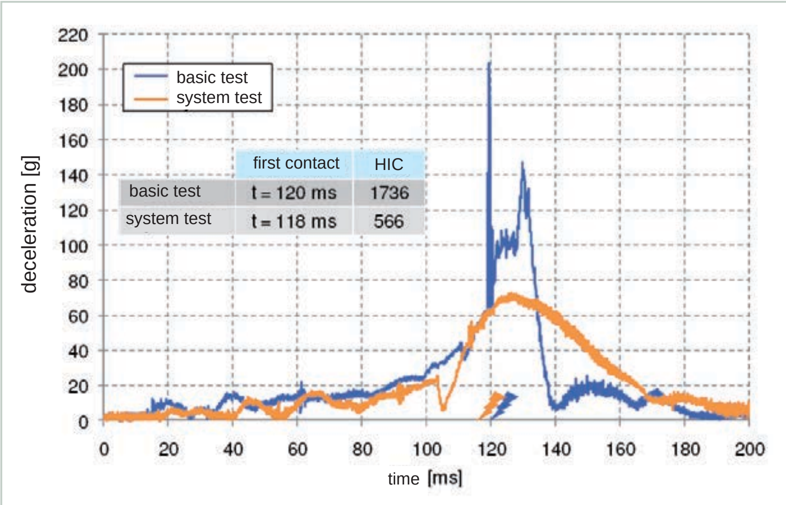

Figure 9:
Acceleration curve for the head

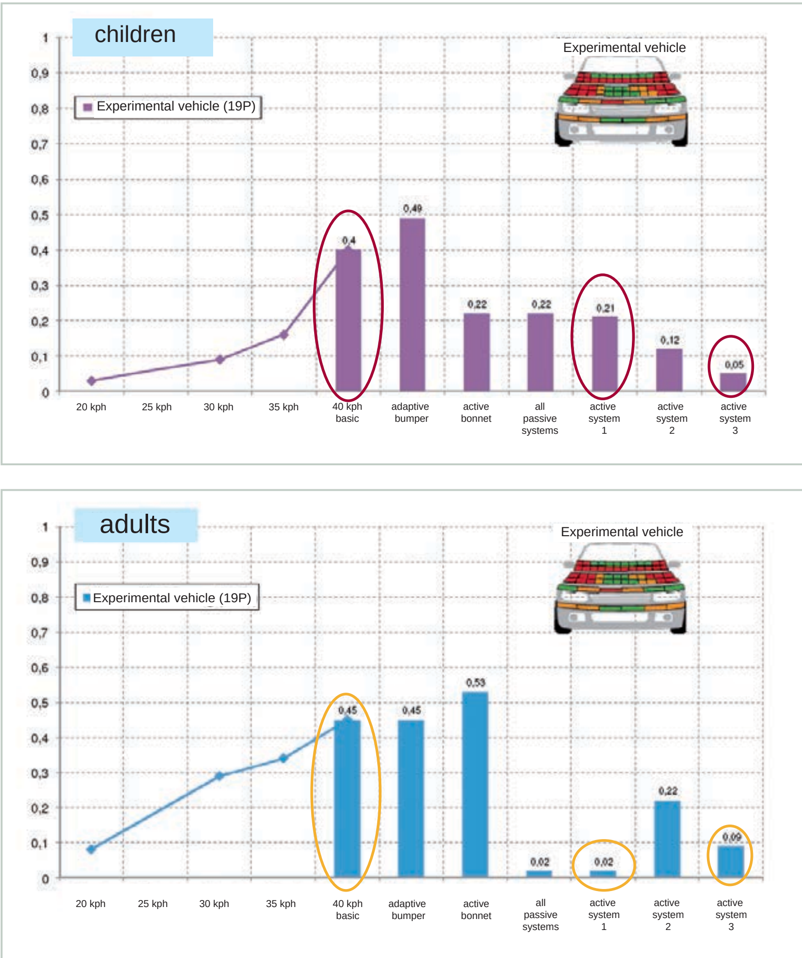

Figure 10:
Head-index-values for children and for adults

4 Call for action

Based on the presented results UDV calls for:

The key parameter of a vehicle-to-pedestrian-collision is the impact speed. That is why speed limits of 30 kph or less should be introduced next to schools, nursery schools and well known black spots. Regarding vehicle engineering the advanced emergency brake system with pedestrian detection has the most promising future. The development of these systems has to be accelerated and these systems have to be made available in all vehicle classes. However, the achieved improvements in the field of passive safety must not be mitigated. The analysis shows that today's test procedures are insufficient. Therefore, an approach is needed where active and passive safety measures are integrally considered and the safety benefit of different combinations of measures can be assessed objectively.

Literature

[1] Kühn, M., Fröming, R., Schindler, V. (2007): Fußgängerschutz: Unfallgeschehen, Fahrzeuggestaltung, Testverfahren. Technical book, ISBN-10 3-540-34302-4, publishing house Springer-Verlag Berlin Heidelberg 2007.

[2] ISO13232-5: Motorcycles – Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles.

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