ASSESSMENT OF THE SAFETY OF AUTOMOBILES

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ABSTRACT:

A means of assessing the passive safety of automobiles is a desirable instrument for legislative bodies, the automobile industry , and the consumer. As opposed to the dominating motor vehicle assessment criteria, such as engine power, spaciousness, aerodynamics and consumption, there are no clear and generally accepted criteria for assessing the passive safety of cars.

The proposed method of assessment combines the results of experimental safety tests, carried out according to existing legally prescribed or currently discussed testing conditions, and a biomechanical validation of the loading values determined in the test.

This evaluation is carried out with the aid of risk functions which are specified for individual parts of the body by correlating the results of accident analyseds with those obtained by computer simulation.

The degree of conformance to the respective protection criterion thus deduced is then weighted with factors which take into account the frequency of occurrence and the severity of the accident on the basis of resulting costs.

Each of the test series includes at least one frontal and one lateral crash test against a rigid barrier, or against a deformable barrier, as well as one lateral crash test between two vehicles of the type being tested, thus taking into account both self-protection and protection of the other involved party.

The computer-aided analysis and evaluation of the simulation results enables a vehicle-specific overall safety index as well as partial and individual safety values to be determined and plotted graphically.

The passive safety provided by the respective vehicle under test can be defined for specific seating positions, special types of accident, or for individual endangered parts of the body.

INTRODUCTION AND DESCRIPTIONS OF THE PROBLEMS INVOLVED

In the complex spectrum of requirements made on an automobile, the following functions dominate: its function as a means of conveyance, a fulfilment of this purpose in the sense of economic utilization possibilities for the user, the observance of those aspects related to the national economy (in production and operation) and minimization of ecological, environmental effects (due to pollutants and noise).
When these requirements are used as a basis of comparison for different vehicles, unambiguous, generally accepted and quantifiable physical assessment criteria are used. From a sociological aspect, it will be necessary, in the future, to also assess the total costs resulting from the use of automobiles. When the damage due to accidents is taken into account, it becomes apparent that stringent safety requirements must be applied to the vehicles.
However there are as yet no known evaluation criteria and standards in this field, which is subdivided into active and passive safety features.
On the whole, a method of assessment for the passive safety provided by motor vehicles seems necessary and desirable both from the viewpoint of legislative bodies, automobile manufacturers and last, but not least, from a consumer aspect.

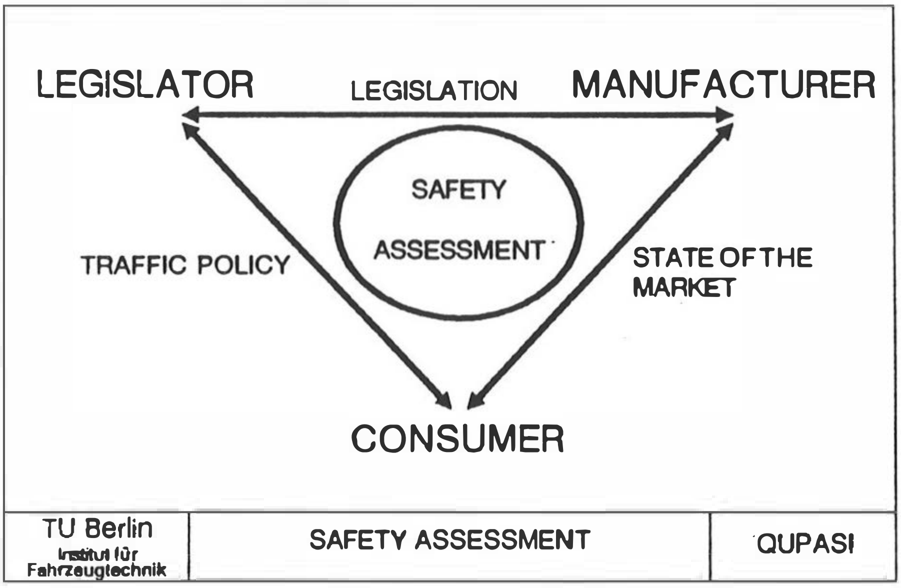

Figure 1. Safety assessment

A safety assessment method of this kind can serve the legislative body as a means for undertaking effective and well-aimed traffic safety measures as well as for checking already existing measures. It could also be taken into consideration when new regulations and guidelines are being formulated and discussed.
As for the automobile manufacturers - they are provided with an incentive to further improve the safety standards of their products and so gain competitive advantages in the eyes of the increasing number of consumers who have become ever more aware of this subject.

For the consumers, an easily-understood safety assessment provides an additional objective selection criterion when buying an automobile, and may arouse or increase public safety-consciousness if its introduction is accompanied by extensive publicity.

Up to date, statistical evaluations providing assessment possibilites of a retrospective validity by comparing characteristic quanties ensuing from accidents, such as damage to property and costs due to injuries [1, 2, 3], are the primary data available for assessing the passive safety of motor vehicles.

Other methods proposed are orientated towards experimental assessments [4, 5, 6, 7] and utilize the results of individual safety tests as evaluation quantities.

Due to the lack of a consistent and practicable method of validating the safety level of individual types or categories of vehicle, the options and problems of safety assessment have been analysed in the course of a research project commissioned by the German Federal Institute for Roads and Highways (Bundesanstalt für Straßenwesen) under the title "Quantification of the passive safety of passenger vehicles".

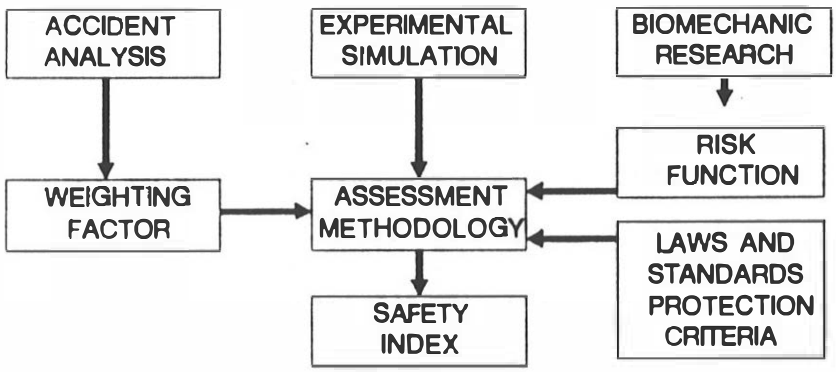

Figure 2. Assessment methods

The proposed assessment method attempts to combine the various differing procedures and envisages an inclusion of occupant biomechanics and the national-economic effects of accidents in an experimental-analytical process (Figure 2).

ACCIDENT ANALYSIS

Accident analysis is of immense significance for the development of an assessment method:

- in working out the boundary conditions for experimental simulation,
- to provide input data for computer simulation, and
- for determining the distribution function of the severity of

injuries for various parts of the body in order to deduce risk functions [9, 10].

Using the accident data [11] compiled by the accident research groups of the TUB / MHH and commissioned by the Bundesanstalt für Straßenwesen, a statistical analysis was carried out with the aim of gaining a detailed understanding of all the quantities which describe real accidents.
These include the various types and causes of collision, the position of the occupants in the involved vehicle, the parts of the body which were injured and the severity of the injuries, the parts of the vehicle which caused injuries, as well as vehicle-specific quantities such as the crash load, the type of retention system used, how the retention system was used and the damage done to the vehicle.
On the basis of a correlation between the points of measurement on a dummy and the corresponding part of the occupant's body, further systematic evaluation of the set of data produced so-called relevance factors which are used to weight the loading values measured on the dummy in experimental simulation.

EXPERIMENTAL SIMULATION

In the definition of the test conditions for the experimental part of the safety assessment, the prescribed acceptance test - a frontal collision with a rigid barrier - and the proposed European lateral collision test with a movable, deformable barrier is taken as a basis. These two tests serve to evaluate the degree of self-protection.
An additional lateral collision test between two vehicles of the model under test has the purpose of taking into consideration the protection of the other party involved in the collision (Figure 3).

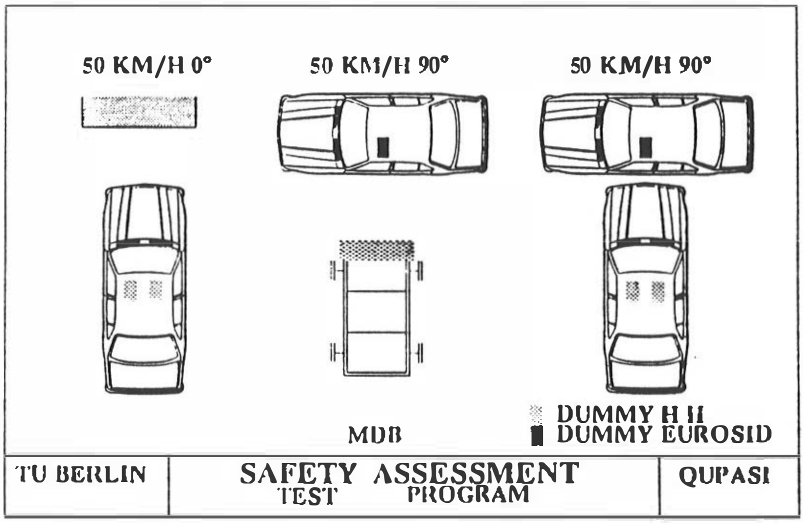

Figure 3. Test series program for safety assessment

The instrumentation and loading of the vehicles correspond to FMVSS 208 and to the European draft proposal for a lateral collision test method. The crash speed for all tests is 50 km/h at an angle of 0° and 90°, respectively.

The occupant loading is measured using Hybrid II and Eurosid dummies, whereby it may be possible to use new types of dummy and to extend the range of measurements.

PRESCRIBED METHOD

A finite number of safety tests is required in order to take statistically proven test results into consideration. For the field of vehicle acceptance tests or model characteristics tests, however, only a single test is required, i.e. the measured values will, with a certain degree of probability, deviate from the true characteristic value.

In order to reduce the experimental effort, an allowance for this scatter of measurements is made by specifying a calculation method.

The rule which is applied includes the definition of a minimum requirement:

MA = limiting value - measurement scatter

and a maximum tolerance limit

TG = limiting value + measurement scatter

The relationship of the respective loading value to these quantities determines whether the values are accepted for the assessment, whether one further repeat test with assessment of the mean values is required, or whether the results are excluded from the assessment procedure.

The measurements obtained from the minimum of three, or at the most - six integral safety tests using the method proposed here can then be subjected to the actual assessment procedure.

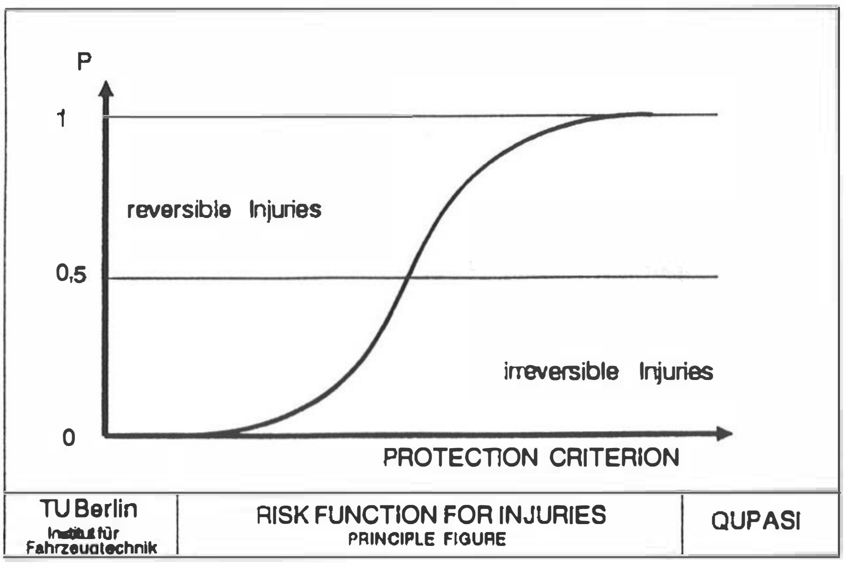

Figure 4. Passenger loading risk function

The physical loading quantities which were measured are first related to the protection criterion level and the tolerance limit defined for the loading of the part of the body corresponding to the respective measurement position. The standardized values thus obtained are the input values for the risk functions for each specific part of the body [9, 10].

By combining accident analysis results with those of computer simulation, these functions represent a relationship between the real accident damage and the experimentally deduced loading values.

In the statistical evaluation, the severities of the injuries, coded according to the AIS, are plotted for frontal and for lateral collisions as functions of the equivalent accident characteristics [9, 11], analogous to the values measure by the transducers in the head, thorax, ribs, pelvis and thighs of the dummy.

As a result, a distribution function is obtained for the probability of reversible or irreversible injuries to each part of the body and for the corresponding direction of application of force (Figure 4).

The results of this statistical evaluation of real accidents are utilized to determine boundary values, as the input data for computer simulation, which are to ensure a uniform frequency distribution and to specify the required number of simulation passes.

The physical occupant loading quantities deduced from the equivalent accident characteristics by using the two-dimensional occupant simulation model ICMF (Insassen-Crashmechanik-Rechenprogramm für Frontalkollisionen - occupants crash mechanics computer program for frontal collisions) [12] and ICMS (Insassen-Crashmechanik-Rechenprogram für Seitenkollisionen - occupants crash mechanics computer program for lateral collisions) [13, 10] can be correlated to the statistical evaluations [9, 10]. By eliminating the equivalent accident characteristics, which are common to both functions, a direct relationship between the loading and the severity of the injuries is established.

ASSESSMENT

The assessment function, the central element of the proposed algorithm, provides the ability

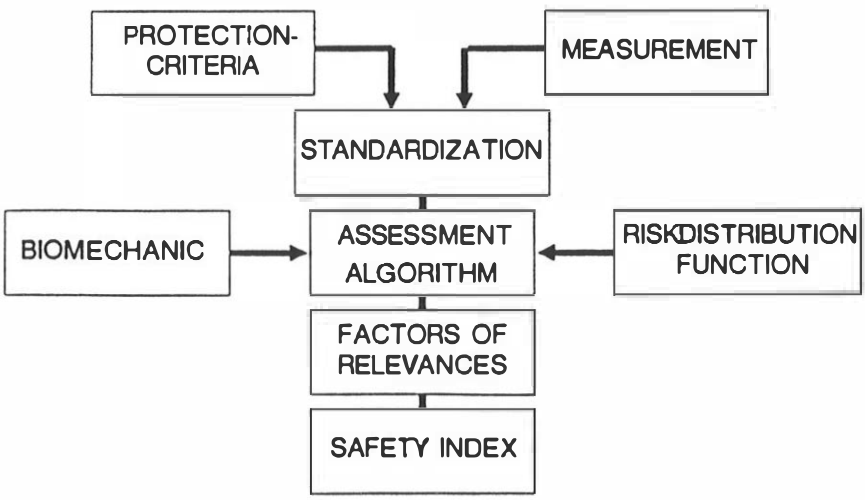

Figure 5. Assessment algorithm

to carry out a continuous validation of the test results, i.e. the standardized individual measured value is assessed below the protection criterion level within the range defined by the risk function. This degree of compliance with the respective criterion is calculated for every measured value and is weighted with the corresponding relevance factors (Figure 5).

The transformation of this method into a computer program [14] enables calculation of both an overall safety index for the whole vehicle and of partial safety indices for the passive safety of the vehicle under test in frontal or lateral collisions. It is also possible to determine safety indices relating to seating positions and to specific parts of the body (Figure 6).

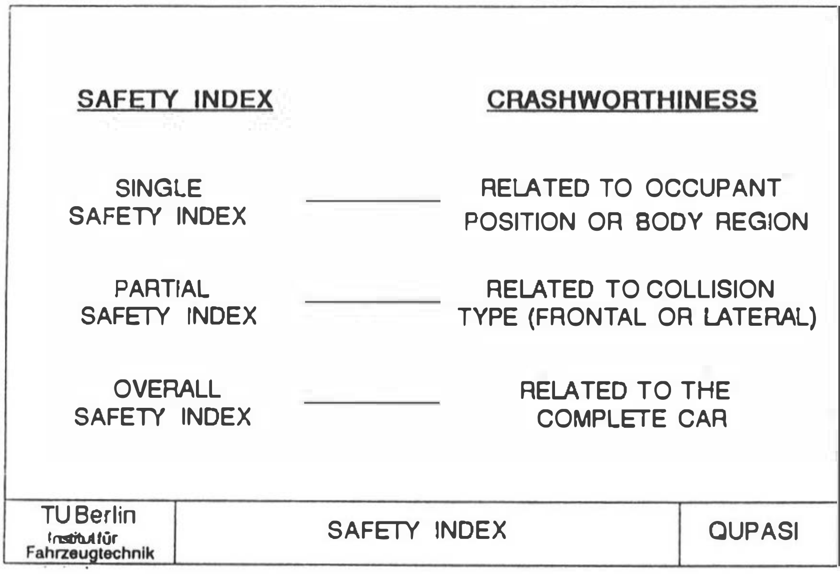

Figure 6. Indices used for assessing the safety of vehicles

APPLICATION

Possible applications of the developed assessment method are comparative safety tests within a specific class of automobiles, a long-term comparison of such automobiles within a sequence of successive models, and the assessment of the increase in safety achieved by modifying a vehicle.

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