QUALITY CRITERIA FOR CRASHWORTHINESS ASSESSMENT FROM REAL ACCIDENTS

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ABSTRACT

The Institute of Vehicle Safety of the German Insurance Association (GDV) conducted a review of the possibilities and the limits to vehicle safety rating systems. The review included four workshops held from 1995 to 1998 that involved a number of international experts who examined existing systems to highlight key issues. Important criteria for the establishment of a high-quality safety rating system have been defined. This paper describes the findings, future developments and activities planned by this committee.

INTRODUCTION

In the past few years, the Institute of Vehicle Safety has studied some 20,000 automobile accidents involving personal injury /9/. The results of these analyses have formed the basis for several studies which have been published and presented at earlier ESV conferences and elsewhere.

Stimulated by the growing public debate as to how to objectively assess automobile safety, the GDV created a group of experts who were to define quality criteria for such assessments. The reason for the creation of this team of experts was that existing safety evaluation procedures have given rise to often inconsistent results. It is possible to classify one and the same vehicle as either "very safe" or "very unsafe", depending on the rating method used.

This discrepancy is due on the one hand to the fact that it is only possible to compare the results from crash tests with the results of retrospective accident analyses when defined conditions are used. On the other hand, since the methodologies of such retrospective accident studies vary considerably, this necessarily causes the results of such studies to deviate as well.

The definition of quality standards appears to be a suitable way of bringing about improvements in the comparability of retrospective methods, although existing methods will first have to be analyzed before new criteria can be defined.

REVIEW OF PUBLISHED SAFETY ASSESSMENTS

In order to be able to integrate into the study the approaches taken by existing methods, the literature was first evaluated /1/. The methods below were included in the study:

- Folksam Car Model Safety Rating /2/
- Traffic Accidents by Car Model, study by the University of Oulu, Finland /3/
- Driver Death rates by Make and Model from IIHS /4/
- Injury, Collision and Theft Losses by Make and Model from HLDI /5/
- Used Car Safety Ratings, Monash University, Australia /6/
- Injury Accident and Casualty Rate, UK Department of Transport /7/
- Two-car Accidents in Germany Involving Personal Injury, University of Cologne /8/

One important differential feature of such methods is the parameters used to assess vehicle safety. Of utmost importance is the need to differentiate between systems involving crashworthiness and crash involvement, as they are fundamentally different and can lead to different evaluations of car safety.

Crash involvement refers to the likelihood of being involved in a crash (either generally or at different crash severities). A crash over-involvement rate reflects not only active and to a certain extent passive safety aspects of a vehicle, but also the behavioural and travel characteristics of its driver and other active safety deficiencies.
Crashworthiness, on the other hand, has to be a pure evaluation of the passive safety characteristics of a vehicle, as it measures the inherent ability of the vehicle to protect its occupants from injury in a crash.

Crashworthiness information is what the general public usually desires when purchasing a new or used car. However, crash involvement information, too, is valuable for setting enforcement strategies, insurance rates, and establishing other road safety countermeasures.

Table 1 provides an overview of the parameters used by the various methods. In addition, it also shows the factors used to categorize the vehicles, the normalization parameters used and the way in which the vehicles reviewed were grouped together.

THE APPROACH USED IN ANALYZING THE METHODS

The published scientific literature served as a basis on which to examine the structure of existing methods. In order to make a comparison of the methods possible, a "Standardized Presentation" was created for each of the selected assessment methods based on the description of the approaches and the mathematical models contained in the studies. Table 2 shows one example of this standardized presentation for the rating procedure used by the UK Department of Transport (DoT). The standardized presentations of all methods reviewed can be found in Annex 1.

Particular importance was placed on the analysis and processing of the mathematical models used in order to make it possible to program and apply them at a later date to uniform accident material. In addition to the detailed description of the models, a formalized description of the different calculation steps was developed quite similar to the "Standardized Presentation". This is named as the "Formalized Process of Calculation", an example of which can be found in Table 3. This approach benefits from the following advantages:

- description of the database
- clearly organized presentation of the systematic sequence of calculations
- description of important risk exposure parameters
- description of the categorization
- description and presentation of the results.

The formalized methods of presentation made it possible to present and compare the approaches used by the different rating methods in a clearly arranged manner. The formalized presentation of the mathematical models considerably facilitated the programming of the individual methods used in the various studies. The possibility of computerizing the mathematical models, however, was a prerequisite for applying the method to uniform accident material.

Table 1. Overview of various rating systems currently available

Publishing organisation	Rating measure used in the publication	Dimensions covered by the measure Crash involvement (CI) Crashworthiness (CW)	Factors used to adjust the ratings before comparison between models	Factors used to categorise the [adjusted] ratings into car groups
Insurance Institute for Highway Safety (USA)	Driver death rate per 10,000 registered vehicle years	CI and CW	None currently (previously included car wheelbase and driver age & sex)	wheelbase body style
Highway Loss Data Institute (USA)	1. Occupant injury rate per insured vehicle year a) by injury b) injury cost >$500 2. Vehicle damage payments per insured vehicle year	CI and CW CI	* driver age * driver age * excess deductable	Wheelbase body style
Folksam Insurance (Sweden)	1. Relative risk of driver injury in two-car crashes 2. Risk of death or permanent disability to front seat occupants 3. Combinations: 1 by 2	CW CW CW	Car weight None Car weight	Car Weight
Department of Transport (UK)	Rate of driver injury (and severe injury) in two-car crashes with at least one injured driver	CW	* speed limit * point of impact * driver sex * driver age	size of car
University of Oulu (Finland)	1. Relative risk of driver injury in two-car crashes in built-up areas 2. Relative number of drivers injured in two-car crashes in built-up areas to that expected 3. Total driver injury rate per 100 million km.	CW CW (includes a measure of aggressivity of the make/model) CI and CW (includes aggressivity)	* driver age * driver sex * car mass * driver age * driver sex * car mass Km drivern by type of area + driver age	car mass car mass crash type
Monash University Accident Research Centre (Australia)	1. Rate of driver injury in tow-away crashes 2. Rate of death or hospitalisation of injured drivers 3. Combination: 1 by 2	CW CW CW	For all comparisons: * driver sex * driver age * speed limit * No. vehicles	Market group (related to mass, size and cost)
University of Cologne (AFO) (Germany)	Degree of injury and average cost of injury	CW	* innocent drivers	car mass

Table 2.
Standardized Presentation of the UK DoT Method

Safety Assessment Method **Estimates**	**Cars: Make and Model: The Risk of Driver Injury and Car Accident Rates In Great Britain: 1992** Department of Transport, UK, 1994
Dataset	• England • Two-car crashes including at least one injured driver • Number of accidents: >100.000 • Number of injured individuals: >100.000
Required Frequency for each Car Model	• > 150 accidents
Considered Parameter	• Number of accidents in which the driver of the assessed car was injured exclusively • Number of accidents in which both drivers were injured • Number of accidents in which the driver of the opposite car was injured exclusively -> determination of the injury risk D_i for each car model i
Safety Rating Values	Relative safety value P_i calculated with the aid of D_i and $D_{all\ cars}$
Data Adjustment and Adaptation	• Speed limit at the scene of the accident to describe the accident severity • Age group and sex of the driver • Type of collision (first point of impact) -> calculating adjustment factors for D_i
Formation of Groups, Catego-rizing	• Dividing the models of car into groups based on length • Relative rating within every weight class depending on the percent-age deviation of P_i compared to P-mean of the class

Table 3.
Formalized Process of Calculation, Example Method used by the University of Oulu, Finland

Comprehensive accident database Finnish Insurance Companies	Finland

↓

Selection of all accidents involving 2 private cars with damage > 3000 FIM within city limits

↓

Determination of factors A-F:

Relative risk of injury $RR_{ic} = \frac{N(I_{ic})}{N(I_{ic}) + N(I_{oc})}$	$N(I_{ic})$ = number of injured drivers in the inspected car model i $N(I_{oc})$ = number of injured drivers in the opposite car ic = inspected car model oc = opposite car
Number of injured drivers in the inspected car model per driven kilometer	$= \frac{N(I_{ic})}{M_{ic}}$
Number of all drivers injured in accidents involving the inspected car model per distance travelled annually	$= \frac{N(I_{ic}) + N(I_{oc})}{M_{ic}}$
Number of injured drivers based on the total number of accidents involving the inspected car model	$= \frac{N(I_{ic})}{N(A_{ic})}$
Number of injured drivers in the opposite cars of the inspected car models based on the total number of accidents involving the opposite car.	$= \frac{N(I_{oc})}{N(A_{ic})}$

↓

Assessment:

$RR_{ic} < 0,5$: above-average passive safety of car model i

Injured drivers per expected number of injured drivers with 95% confidence interval categorized in 3 classes based on the Poisson distribution; statistical test parameter for significance Q_i:

$Q_i < 1,96$:	Above-average safety	(+)
$-1,96 =< Q_i =< 1,96$	Average safety	(0)
$Q_i > -1,96$	Below-average safety	(-)

APPLICATION OF THE METHOD TO UNIFORM ACCIDENT MATERIAL

The GDV Institute of Vehicle Safety collects data at periodic intervals on traffic accidents involving personal injury from large-scale studies as a basis for accident research. The following large-scale analyses have been carried out, among others, since the institute was founded:

- IS ´69 - Internal automobile safety
- FS ´74 - Analysis of two-car collisions involving personal injury in 15,000 cases
- FS ´80 - Analysis of two-car collisions involving personal injury in 5,500 cases
- FS ´90 - Analysis of two-car collisions involving personal injury in 15,000 cases

The FS 90 accident material, which was used as the basis for the model calculations, comprises 15,000 two-car collisions in which a total of 30,000 automobiles were involved. Approximately 80 parameters were collected per case in what was termed the basic assessment. The analysis covered accident files on two-car accidents involving personal injury provided by the German automobile insurers. There is an in-depth description of this material in /9, 10/. The parameters that were entered included:

- location
- sex and age of the driver
- type of vehicle
- severity of injury sustained by passengers
- type of collision
- extent of damage to the vehicles involved
- etc.

This made it possible to use most of the rating methods described and apply them to this accident material /11/. We were unable to calculate either of the two American methods, since the data structure used in the FS 90 study gives no information about how many cars of one model are insured within one year.

For calculating the other methods the GDV has been extended. The annual mileage of the respective vehicles had to be integrated into the database in order to assess the method used by the University of Oulu. The method used by the UK DoT required the entry of vehicle lengths. It was possible to adapt the FS 90 database in this instance as well.

In order to calculate a ranking of the vehicles with respect to their passive safety, the following twelve car types were selected:

Small car class:
VW Polo
Opel Corsa
Fiat Uno
Peugeot 205

Compact car class:
VW Golf
Opel Kadett
Ford Escort
Mazda 323

Luxury class:
Mercedes-Benz 200 - 300
BMW 5 Series
Audi 100
Opel Rekord

These 12 vehicles were calculated on the basis of their passive safety for each of the methods. It was found that there was great differences in the assessment of automobile safety despite the use of uniform accident material. The BMW 5 Series, for example, was evaluated as being both the safest vehicle (ranked 1st in the Folksam car model safety rating) on the one hand and as the least safest car (ranked 12th by Monash University) on the other hand, refer to Figure 1. A similar spread was also found for the Opel Corsa and the Peugeot 205).

EVALUATING THE RESULTS OF THE MODEL CALCULATION

The model calculations based on uniform accident material demonstrated that the results of the current rating systems clearly have a different outcome irrespective of the accident material used. Two systems (Folksam and DoT) come very close as far as their results are concerned, whereas the Monash method (1992) provided entirely different results. It must also be taken into consideration, however, that all methods reviewed have experienced continuing development during the intervening period.
Furthermore, it was also found that a database containing 30,000 cars (15,000 car-car accidents) as is the case with the FS-90 database, is limited for a safety ranking intended to evaluate less common models of cars. A safety ranking of the 50 most common models, for instance, would require several times the amount of data material contained in the FS 90 database. This means that in Germany for instance, it would only be possible to rely on the data from official statistics.

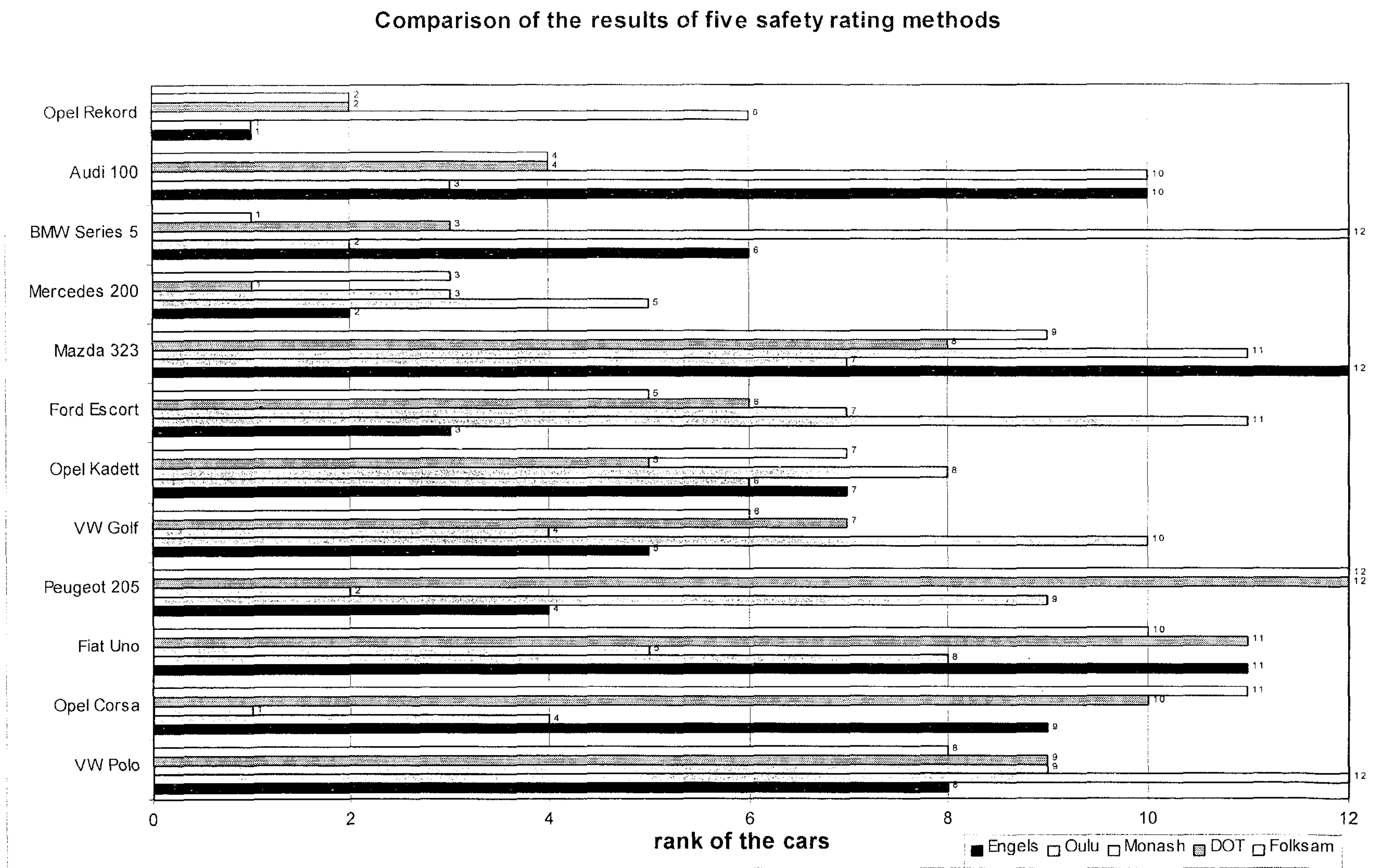

Figure 1. Total ranking of 12 car models using different ranking procedures (uniform accident material FS 90)

These data, however, do not have enough structure available for a ranking.

RESULTS OF THE EXPERT'S DISCUSSION

One important issue in evaluating the results of the calculated rankings is the question of the extent to which the mathematical models used are actually representative of passive safety.
This issue was discussed among a team of experts in four different workshops. Annex 2 contains a list of the names of participants. There are plans to transform this group of experts into a ongoing project to allow the work already begun on the comparison of the various methods to be continued and updated. It would also make it possible to institutionalize the work on quality criteria for safety assessments.

The previous workshops have been devoted to a discussion of the topics below which, among other things, have been incorporated into resolutions, recommendations and guidelines.

Database Requirements for Safety Rating Assessments - A high quality database was seen as an essential basic requirement for a reliable and accurate rating system. The data need to be comprehensive and have sufficient detail to enable adequate control of possible extraneous factors.

The most reliable and comprehensive data format for these evaluations is that adopted by crash investigators, but these data are limited in number because of extraordinary costs.

Police and insurance databases are usually of sufficient size but some of their parameters are limited in quality and key parameters like impact severity and type of collision are often not available.

The number of cases necessary to make reliable assessments per model is another important issue and one that requires further research. Equally important, the distribution of cases should be by random selection and representative of the types and severity of crashes that occur in the real world.

The prospect of sharing data within Europe and even on an international scale is one possibility of obtaining sufficient data for a high quality rating. This would also allow vehicle types with a small population to be rated. For such data it would be necessary to internationally standardize the parameters used by the different investigators.

Controlling for Risk Exposure and Substitutes for Impact Severity - One essential element in car safety assessment is to collect and input the parameters required for an assessment of impact severity. These parameters are, among others:

- type of accident (car to car, car to truck, etc)
- type of collision
- Energy Equivalent Speed - EES
- Change of speed Δv
- impact angle
- overlap

Both the age and the sex of the passengers involved play another important role in the assessment of the passive safety of a vehicle on the basis of a retrospective accident analysis, since these parameters have a very decisive effect on the extent of injury a person sustains.

Since the cited parameters are not contained in every data record, as explained above, methods must be developed to replace these and to validate the substitution using a "reference data record", for instance. High-, medium- and low-priority parameters which have a very decisive effect on the quality of a safety rating would be defined in a first step. These parameters are contained in Table 4 below.

Table 4. Safety Rating Parameters of high, medium and low priority

High Priority	*Medium Priority*	*Low Priority*
Vehicle mass or size	Vehicle model year	Mileage (total + annual)
Crash Severity	Vehicle Identification Number	No. registered cars
Injury severity (AIS scale)	Use of safety systems*	Years of insurance
Type of crash	Two or four doors	Marital status of the driver
Age of the driver	Trim and transmission	No. of occupants
Sex of the driver	Crash location	
Guilt of the driver	Driver size and weight	

It is obvious that a safety rating that uses only low- and medium-priority parameters will be less valid and less relevant than a method that is based on high-priority parameters.

As already discussed above, it is feasible, however, to substitute parameters such as impact severity by a combination of other less relevant parameters, provided that there is proof that these parameters have a "similar impact". Continued research work, however, is necessary in this respect.

Outcome Measures - Current systems include assessments of safety based only on property damage, minor and major injury. While most crashes have relatively minor outcomes, it is the severe cases that are more likely to reflect on a vehicle's inherent crashworthiness characteristics, provided that control mechanisms are in place to avoid negative selection.

A high quality rating system needs to include sufficient injury detail to permit meaningful analysis. It is desirable for these data to be coded in terms of injury description and severity using the Abbreviated Injury Scale (AIS). The addition of long term outcome details such as rehabilitation and impairment would also be useful in determining safety outcomes.
The cost of injury or harm associated with the crash is a promising means of incorporating all these aspects but should only be used on databases of sufficient size and representativeness to ensure that extreme outcomes do not unduly influence the ratings.

Publishing Results from Rating Systems - In the existing safety rating methods, different strategies can be envisioned when presenting the results of the investigations to the public. Some authors publish the ratings as "*safety assessments*", others as differences in performance and let the reader interpret these in terms of which is more safe.

An allied issue is the degree of sophistication that can be attributed to minor differences in outcome and hence what is an appropriate rating scale. Current systems vary from simple 3 or 5 point classifications scales up to continuous rating scales, although the latter often include a 95th percentile band along with the single point score.
Experience seem to suggest that, irrespective of how these ratings are published, the media will always interpret these results in terms of simple ratings of which car is the safest. This needs to be taken into account when deciding on how to publish results.

Future Steps & Research Needs - From the discussions within the expert's group, a number of limitations, data shortcomings and items requiring further research were identified. Some of the systems reviewed have been recently updated and analysis techniques modified. The expert's group will review these latest versions to gain additional insights into high quality criteria for safety rating systems. Based on the present status, the major research needs are listed below:

- There was considerable discussion about the quality of travel speed information for determining and controlling crash severity. It was proposed that a small sample of representative crashes where data is available from police, insurance and crash investigations should be evaluated in an attempt to answer this question.

- This might also include the feasibility and accuracy of collecting closing speed data combined with speed limit information to get a feeling of how these parameters are interconnected.

- There is clearly a need for a comprehensive European database of sufficient size and detail to enable scientifically robust comparative ratings of passenger cars. The European Commission is currently examining the feasibility of establishing a European Community Road Accident database (CARE) which would seem to offer considerable potential for assessing crash involvement and even crashworthiness of cars, if there are necessary safety data in sufficient quality availible.

- Nineteen exposure items including 7 high priority items were identified in Table 4 that need to be checked for in any future safety assessment. It would be useful to refine this list even further to identify those that are essential from those that are desirable, thus minimizing analysis effort and maximizing the chances of locating a suitable database.

- There is growing interest in addressing not only self-protection of passenger car occupants but also partner protection. Several Europen projects are analysing which description systems are available.
It would be useful to examine the possibilities of assessment systems to highlight vehicle aggressivity and the desirability of including this aspect in any future safety rating system.

- Sample size will be a key issue for providing a robust and reliable ranking, yet this was not able to be resolved totally during the expert's discussions. There was consensus on the need for further work in this area, but only in the light of a clearer understanding of what is achievable in establishing suitable databases and criteria.

- Consumers need clear, unambiguous information of the relative safety of the various makes and models of cars available. Crash tests and real world accident data will inevitably provide differing ratings of passive safety due to their limitations. It is absolutely essential that further consideration be given to how these different procedures can be better compared in future and that information of both systems could be combined into a general report on car safety.

ACKNOWLEDGEMENTS

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ANNEX 1: STANDARDIZED PRESENTATIONS OF THE REVIEWED SAFETY RATING METHODS

Standardized Presentation: Folksam Car Model Safety Rating, Folksam Insurance Company

safety assessment method **study**	**car model safety rating** FOLKSAM insurance company, 1989/90 FOLKSAM insurance company, 1991/92
database	• Sweden • car-versus-car collisions including at least one injured driver (starting in 1991) • number of accidents: 26527, 1985-1990 (for the 1991/92 study including at least one injured driver) • number of injured individuals 28153, 1986-1990 (only adult drivers/front-seat passengers)
required frequency of each vehicle type	• no information given
considered parameter	• number of accidents where both drivers (in the assessed and in the opposite vehicle) were injured • number of accidents where only the driver in the assessed vehicle was injured • number of accidents where only the driver in the opposite vehicle was injured -> determining the relative injury risk R_i for each vehicle type i • risk of fatal injuries for the driver of the assessed vehicle (as a function of the ISS value) • risk of permanent injury after-effects for the driver of the assessed vehicle (as a function of the AIS value) -> determining the mean risk of serious consequences MRSC for each vehicle type
safety values of reference	• safety value **Z** calculated with the help of - MRSC (mean risk of serious consequences) - R (relative injury risk)

data correction and data adaptation	• different weight proportions of the accident vehicles; increasing or reducing the R_i value by a "**weight effect**". This effect is calculated on the basis of all the vehicles available in the data base (e.g. for the 1990/91 study: 0,035) • considering passenger influence with the help of the "**passenger factor**"
formation of the classes **categorizing**	• creating an average Z with the help of the vehicle types and subordinating Z into four weight classes • developing a relative rating within every weight class depending on the percentage deviation of Z_i in contrast with Z

Standardized Presentation: Cars: Make and Model, Department of Transport, UK

Safety Assessment Method **Estimates**	**Cars: Make and Model: The Risk of Driver Injury and Car Accident Rates In Great Britain: 1992** Department of Transport, UK, 1994
Dataset	• England • Two-car-crashes including at least one injured driver • Number of accidents: >100.000 • Number of injured individuals: >100.000
Required Frequency for each Car Model	• > 150 accidents
Considered Parameter	• Number of the accidents in which the driver of the assessed car was injured exclusively • Number of the accidents in which both drivers were injured • Number of the accidents in which the driver of the opposite car was injured exclusively -> determining the injury risk D_i for each car model i
Safety Rating Values	Relative safety value P_i calculated with the help of D_i and $D_{\text{all cars}}$
Data Adjustment and Adaptation	• Speed limit at the scene of the accident to describe the accident severity • Age group and sex of the driver • Collision type (first point of impact) -> calculating adjustment factors for D_i
Formation of Groups, Categorizing	• Dividing the models of car into groups based on length • Relative rating within every weight class depending on the percentage deviation of P_i compared to P-mean of the class

Standardized Presentation: Injury Risk Rates, University of Oulu

safety assessment method **examination**	**Injury Risk Rates by Car Models in Two-Car-Crashes** University of Oulu, T. Ernvall, 1994
database	• Finland • two-car-crashes in build-up areas plus damage value of > 3000 FIM • number of accidents: 119899, 1987-1992 • number of injured individuals: 10 267 injured drivers
required frequency of each car model	• no information given
considered parameter	• number of **injured drivers** in the **assessed vehicle** • number of **injured drivers** in the **opposite vehicle** -> determining the relative injury risk RR_i for each car model i • number of injured drivers in relation to the **driven mileage** of the car model i -> injure risk rate for each car model i • number of all injured drivers involved in **accidents** with car model i -> injure risk rate for each car model i • number of injured drivers for each number of accidents of the inspected car model i -> injure risk rate for each car model i • number of all injured drivers in opposite vehicles for each car model i accidentsi -> injure risk rate for the opposite individual in car model i
safety values	RR_{ic}: relative injury risk Q_i : statistical test result to signify the expected number of injured individuals and the actual number of injured individuals in a car model (95% reliability)
data correction and data adaptation	none
formation of classes, categorizing	RR_{ic} < 0,5 within all of the car models identifies a vehicle as safe above average Q_i functions as a standard to assess whether the safety of the vehicle is above average, average, or below average

Standardized Presentation: Vehicle Crashworthiness Ratings, Monash University

safety assessment method **examination**	**Vehicle Crashworthiness Ratings from Victoria and New South Wales Crash Data** Monash University, M. Cameron et al, 1992
database	• Australian States of Victoria and New South Wales • car accidents including medical expenses for one injured individual of > Aus$ 317 (Victoria) and cars which were sufficiently damaged to require towing (New South Wales), respectively • number of accidents: unknown, 1983-1990 (Victoria); 1989-90 (New South Wales) • number of injured individuals: 12 867 injured drivers (Victoria), 10097 (New South Wales)
required frequency for each vehicle type	• no information given
considered parameter	• number of injured drivers in the assessed car model • number of all (including drivers) accidents including car model i -> determining the injury risk IR_i for each car model i • number of all fatally injured drivers of the assessed car • number of all hospitalized drivers of the assessed cars • number of all (truly) injured drivers of the assessed cars ->determining the injury severity IS_i for each car model
safety reference values	• CR_i = combined value from $IR_i * IS_i$ (in analogy to FOLKSAM)
data correction and adaptation	• standardization of the injury risk IR and the injury severity IS by considering the influence of the driver's sex and speed limit at the scene of the accident
formation of the classes, categorizing	• categorizing the car models into seven vehicle classes (remark: this was not done with the help of criteria like wheel-base or car weight but according to the understanding common to the Australian market - large, medium and small cars, luxury cars, sports cars, four-wheel drive vehicles and passenger vans. • relative rating within every vehicle class due to CR • additionally, a summing-up and an assessment according to the manufacturers was implemented.

Standardized Presentation: Status Report, Insurance Institute for Highway Safety

Safety Assessment Method **Estimates**	**Status Report** Insurance Institute for Highway Safety, USA, 1992
Dataset	• USA • All the accidents including fatal injures (concerning passengers in cars registered 1984-1988) • Number of accidents: no information, 1986-88 • Number of injured passengers: no information
Required Frequency of Car Models	• no information given
Considered Parameter	• Number of fatally injured passengers in the assessed car model i • Number of registered vehicles of the car model i ->Determining the [killing rate] for each 10,000 registered vehicles of the car model i • Wheel-base of car model i • Proportion of fatally injured passengers in car model i (passengers > 30 years) • Proportion of fatally injured female passengers in car model i -> Forecasting the [killing rate] for car model i
Safety Rating Values	• [killing rate] R_i • Forecasted [killing rate] R'_i • Proportion of R_i to R'_i
Data Adjustment and Adaptation	none
Formation of the Groups, Categorizing	• Dividing the car models into 5 groups of car (four-door, two-door, sports car, luxury cars, station wagons) and differentiating 3 wheel-base groups for each group of car • Determining the number of R_i in the ranking/rating list compared to all the car models and grading of R_i according to this rank within every group of car • Determining the number of the proportion of R_i to R'_i in the rankings

ANNEX 2: MEMBERS OF THE EXPERT'S GROUP

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Mr. Max Cameron, Monash University Accident Research Centre, Australia.
Prof. Dr. Timo Ernvall, University of Oulu, Finland;
Prof. Brian Fildes, Monash University Accident Research Centre, Australia.
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Mr. Josef Haberl, BMW, München, Germany;
Mr. Lasse Hantula, Finnish Motor Insurers' Centre, Helsinki, Finland;
Mr. Kim Hazelbaker, Highway Loss Data Institute, Arlington, Virginia, USA;
Mr. Werner Huber, Technical University of München, Germany;
Prof. Dr. Hartmut Keller, Technical University of München, Germany;
Mr. Anders Kullgren, Folksam Insurance, Stockholm, Sweden;
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Dr. Robert Zobel, Volkswagen, Wolfsburg, Germany;