CONSUMER INFORMATION ON THE CRASH PERFORMANCE OF CARS:

The role of the EU

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The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European transport casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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Introduction

Car crash protection or secondary safety measures have enormous potential to reduce injury in the event of a crash. Nevertheless, there is a large difference in the level of crash protection which is offered by various car makes and models. In fact, it has been estimated that if all cars were designed to be equal to the best current car in each class, 50 per cent of all fatal and disabling injuries could be avoided. The scope for further improvement is clear.

Legislation, product liability and market forces form the three main routes to improved car design for safety. Generally, the response of manufacturers to market forces is much quicker than has ever been achieved by the legislative route. Both consumers and manufacturers are becoming increasingly aware of the importance of safe car design in buying decisions. According to a UK survey among British car drivers, safety features are now the second most important aspect that they would like to see improved in their next car, closely following security features. At the same time, car manufacturers refer to safety features in almost all advertisements. It is often difficult, however, for the consumer to judge the safety claims being made without objective information. Therefore, there is a need for relevant and impartial information so that consumers can make well-informed decisions when buying a car.

This ETSC report presents an overview of current practice in consumer information on the crash performance of cars, both in EU countries and elsewhere. It aims to identify best practice in car safety rating systems and the way in which information can be communicated successfully to consumers. A discussion of the role of the EU in encouraging and promoting best practice in this area concludes the review.

Current practice in car safety rating

In recent years, a variety of methods for rating car crash safety have been developed in order to provide information which can guide car buyers. These methods fall into one of two broad categories: retrospective systems and predictive systems.

Retrospective systems

In retrospective systems, safety ratings are based on the actual performance of cars in real accidents. The frequency and severity of injury to car occupants in individual model cars are determined by examination of police accident statistics and/or insurance injury claim data.

Examples of retrospective systems, which are discussed in more detail in the review are *The Folksam Rating System (Sweden); The VALT Safety Rating System (Finland); The Department of Transport Rating System (UK); The Highway Loss Data Institute Rating System (USA).*

Although the general principle of this approach is the same for all systems, there are many differences in the exact methodology, such as the types of accidents which are included in the analyses, whether seat belt usage is accounted for, and how the effects of driver behaviour and exposure are controlled. There are also major differences in how the results are communicated to the public.

Ultimately, the best measure of the safety performance of a vehicle will be how it actually protects driver and passengers in real accidents. Retrospective safety ratings can be of particular help in assisting buyers of used cars, which have the lion share of the car sales market. Since data are collected anyway, subsequent analyses to calculate relative safety performance of car are relatively cheap. However, this real world approach also has its limitations.

Firstly, retrospective methods can only provide consumer information late in a car model's production run when, inevitably, many cars of that model have already been purchased, making it less useful for new car buyers. For less common car models it might be completely impossible to get sufficient accident data. Several national accident databases are needed to cover a large part of the European fleet.

Another problem is the difficulty in isolating the influence of car design from all other factors that contribute to the outcome of an accident. For example, people with different driving styles or of different age groups will choose different types of cars, use their car in different situations and in a different way. These factors may well bias the relative safety of a particular car model and are particularly hard to eliminate.

A further drawback of this approach is that the data only provide limited explanation of *why* certain makes or models perform better in accidents than others. Retrospective methods generally provide data on the difference in frequency of injury accidents and injury seriousness. Additional in-depth data are needed to understand these underlying reasons. Finally, because the retrospective approach is largely statistical, the results may not always be easy for the consumer to interpret.

Predictive systems

Predictive systems assess a car's safety performance before it is used on the road. Predictions are based on controlled whole car crash tests of individual models; tests of components of the car which have been proven to be important in accidents; and/or visual inspections and rating of the interior of cars.

New Car Assessment Programme (NCAP)
Whole vehicle crash tests generally take place in the framework of the New Car Assessment Programme (NCAP). An NCAP has run in the USA since 1978 using a full frontal rigid barrier test, and in Australia since 1992 using an offset deformable barrier frontal test and a full frontal rigid barrier test. The UK has just started an NCAP with EEVC based procedures for an offset deformable barrier frontal impact test, full-scale side impact test and pedestrian protection tests. In addition to NCAP, motoring organisations, motoring journals, and insurance institutes also carry out whole vehicle crash tests.

Types of whole vehicle tests (frontal impact, side impact, pedestrian friendliness) and test procedures (e.g. velocity, ground clearance height, percentage overlap) vary across the various programmes, and inhibit the comparison of crash test based systems. The methods of presenting results to consumers also vary.

Secondary rating systems
Secondary rating systems rely on a combination of visual inspection and component testing of a number of areas of car design taking into account the current state of knowledge of injury causation. With the support of the European Commission a European secondary rating system has been developed and published in 1994 to be used by consumer groups throughout the European Union. The European system is developed on the basis of the UK Consumers Association secondary safety system which was first introduced in 1983.

Predictive methods also have their advantages and drawbacks. Predictive methods have the greatest potential for influencing people's decisions when buying a new car, since ratings will be available as soon as a new car model is launched. Crash test based systems, however, are fairly expensive, which means that it is impossible to test a car in all possible accident circumstances which occur in real life. Inspection-based techniques are cheaper and, if fed with data from crash tests and in-depth accident data, predict safety performance in many different accident circumstances and for different seating positions.

Ratings are based on *expected* performance in real life crashes deduced from laboratory data. Laboratory data have the advantage that factors such as driving style are excluded. Every model is tested under identical situations. The laboratory approach requires that reference is paid to real world accident data to ensure its validity. To date, available data show that there is good similarity between predicted crash safety and safety in real accidents, but this needs continuous monitoring.

Communicating safety information to consumers

Given the variety of safety rating systems which exist, it is very important that each publication should explain clearly what that particular safety rating means, and drawing attention to any limitations. It should always be emphasised that such ratings measure crash performance in the event of an accident rather than affect in any way the chance of an accident occurring in the first place.

When relevant data have been collected, there is a huge amount of information on each car model. This information is very technical and needs careful interpretation. It is clear that in this raw form, data cannot be presented to the general public. Currently, the ways of presenting the results vary considerably across the various systems and programmes. Some have a very high degree of simplification, other try to communicate much more detail.

No studies have been traced which have systematically investigated the effectiveness of different ways of communicating results to consumers. In general, it can be said that the simpler the message, the more subjective weighting of results has taken place, and vice versa.

What the best solution may be, what level of detail is feasible, which level of subjectivity is appropriate, are recurrent issues of debate in this field. Further international exchange of experience would be valuable to identify the appropriate balance between over-simplistic and overly detailed information.

Conclusions and recommendations

There has been some good experience with both retrospective and predictive approaches to allow rating of the safety performance of different car makes and models. The important role of car rating systems in providing consumers with information on safety performance of cars, as well as the mutual interdependence of the various rating systems justify further development of each of them towards the highest possible level of quality.

The various crash test-based, inspection-based and retrospective systems have evolved largely independently. Each system has been shown to usefully contribute to the provision of safety information to the consumer. Co-ordination of approaches could enhance this information further.

A first prerequisite for optimal use of any rating system is the quality of the information, which will depend on a number of factors such as:

- how realistic is the whole vehicle or component test;
- how much is read from any one test result about safety performance;
- how well safety ratings take account of factors which might bias the results;
- how well results of other rating systems and in-depth injury data are taken into account.

Current practice in safety rating systems indicates that some but not all programmes pay adequate attention to these factors.

Although individual Member States can make progress themselves, substantial added value is to be expected from joint efforts to optimise rating systems and to produce high quality data. In recognising the role of market forces in improving car safety design, progress would further EU Treaty objectives to promote road safety. Therefore, ETSC recommends the following EU initiatives:

- ***Establishment of an EU new car crash safety evaluation programme***
  Such a programme could provide valuable information to allow the setting up of an EU NCAP, it could allow the further development of the European Secondary Safety Rating System, and it could avoid unnecessary duplication and cost. An EU programme would require agreement between European crash testers on test procedures and protocols taking into account current knowledge of best practice. In ETSC's view, crash test procedures for consumer information should be based on the current test procedures for frontal impact, side impact and pedestrian protection as developed by the European Experimental Vehicles Committee. In the case of the frontal impact test, the test speed should be 64 km/h to be representative of severe injury producing frontal accidents.

- ***Development of a system for pooling EU accident data for retrospective ratings***
  Pooling of EU accident data for retrospective safety ratings could ensure that ratings on new models are available sooner and that less common models can be rated as well. This requires agreement on common data collection and data analysis methods, taking into account potential confounding factors as much as possible. Make and model information could also be added usefully to the national data. Probably data from three or four countries would be sufficient.

- ***Development of a framework for cross-system input***
  Development of a framework for continuous mutual input from results of whole vehicle crash tests, secondary rating systems and retrospective rating systems could ensure that the latest information is reflected in all systems.

1. Introduction: aim and scope of the review

Safety has become a marketable feature in car sales and car manufacturers highlight increasingly the safety features of their products. From a safety point of view, this is a very positive development, since the response of car manufacturers to market forces is much quicker than can ever be attained by the legislative route.

However, it is necessary to ensure that safety information is based on reliable and relevant data, so that consumers can make well-informed decisions about car purchase and further increase the demand upon car manufacturers to produce the safest cars possible. Furthermore, it is important that the information reaches the car buying public in an easily accessible and understandable way.

In an increasing number of EU countries, and in Australia and the US, there are regular publications which rank cars on safety features. This review presents an overview of typical consumer information on car safety, both in EU countries and elsewhere. It aims to identify best practice in car safety rating systems and how this information is communicated successfully to consumers. Recommendations regarding the possible role of the EU in promoting best practice are presented.

Section 2 examines the role of consumer information in stimulating further developments towards safer design of cars. Section 3 outlines the two main approaches to rating car safety, and describes a number of systems currently in use both in EU Member States and overseas. In Section 4, the advantages and drawbacks of the various methods are discussed. An outline of possible ways to forward the role of the EU in encouraging and promoting best practice in this area concludes this review.

2. The role of consumer information

Car crash protection or secondary safety measures have enormous potential to reduce injury in the event of an accident (see ETSC (1993) for an extensive overview). Nevertheless, there is a large difference in the level of crash protection that is offered by various makes and models and the differences between them are only partly explained by differences in weight. It has been estimated that if all cars were designed to be equal to the best current car in each class, 50 per cent of all fatal and disabling injuries could be avoided (Tingvall, 1994). A recent Finnish study based on police and insurance data suggests that injuries in car-to-car accidents in built-up areas would decrease by 27 per cent, if all car models in each mass class reached the best level in secondary safety in that mass class (Tapio, Pirtala and Ernvall, 1995).

Information on the safety features of various makes and models can make consumers aware of these large differences and so increase their demand for adequate safety features in cars of all classes. These market forces, fed by consumer information, also have a direct effect on car manufacturers who are encouraged to go beyond minimum legislative standards to maintain or increase their market share. At the same time market forces produce a climate for legislative discussions which is more favourable to progress (Farquhar et al., 1994).

According to a recent UK survey among car drivers (Lex Report, 1994), safety features are the second most important aspect that drivers want to see improved in their next car, closely following security features. This year's survey (Lex Report, 1995) showed that safety features are likely to become even more important in future car purchasing decisions. For example, 35 per cent expect their next new car to have an airbag, whereas only 2 per cent have one now; 34 per cent expect to have an anti-lock braking system (ABS) on their next car, which only 10 per cent currently have. Even larger percentages of drivers would like such safety features if money were no object. There is no doubt that there is a high level of consumer demand for improved levels of car safety.

Industry certainly recognises consumers' interest in car safety features, since an increasing number of car advertisements focus on one or more safety aspects (Bell et al., 1994). However, it is difficult for the consumer to judge industry's claims in this respect without objective information. Therefore, there is a need for relevant and independent information so that consumers can make well-informed decisions when buying a car.

3. Current practice in car safety rating

In recent years, a variety of methods for rating the crash performance of car models have been developed in order to provide information which can guide car buyers. There are various methods of collecting information on the comparative safety of different car models, which fall into one of two broad categories:

- ***Retrospective systems*:**
  In retrospective systems safety ratings are based on the actual performance of cars in real accidents. The frequency and severity of injury to car occupants in individual model cars are determined by examination of police accident statistics and/or insurance injury claim data. As a consequence, results are not available until a model has been on the road for some time, so this system is potentially more useful for used rather than new car buyers.

Although the general principle of this approach is the same for all systems, there are many differences in the exact methodology, such as the types of accidents which are included in the analyses, whether seat belt usage is accounted for, and how the effects of driver behaviour and exposure are controlled. There are also major differences in how the results are communicated to the public.

- ***Predictive systems***:
  Predictive systems assess a car's safety performance before it is used on the road. Predictions are based on one or a combination of the following approaches:

  - Controlled whole car crash tests of individual models with ratings based on recorded dummy values and the ability of the passenger compartment to maintain integrity;
  - Tests of components of the car which have been proven to be important in accidents;
  - Visual inspections of the interior of cars with a rating system based on knowledge of how different safety devices and materials affect the risk of injury.

  The variation within each of these categories can be large, in particular with respect to sample size, relevance of the test procedure and the aspects studied.

In the next paragraphs, the methods which are currently applied internationally are described in more detail.

3.1 Retrospective methods

The Folksam Rating System

Folksam is a Swedish insurance company which regularly publishes safety ratings for dozens of popular cars on Swedish roads. The injury risk ratings are based on paired comparisons of car-to-car accidents from police reports where the injury outcome in both vehicles is considered. Single vehicle crashes, collisions with heavy trucks and impact type are not considered.

Injury severity ratings are calculated from a sub-sample of insurance injury claims for front seat occupants. Detailed medical information is available which is used to calculate the risk of death or permanent disability. Cases where the front seat occupants are known to be unbelted are excluded from the analysis.

Paired comparisons are used to correct the injury risk estimates depending on the level of exposure of particular car models to injury accidents. Key factors directly affecting injury risk are judged to be crash severity, and the mass differences between colliding cars apart from the passive safety of cars. Key factors are controlled in the method. Very little difference has been found for the probability of injury between different versions of the same car model, indicating that the influence of exposure is small.

Cars are allocated to one of four size groupings based on weight. For all cars an average crash safety rating is calculated. Models in each group are awarded a colour code based on the following scheme:

Red:	The model is at least 40% less safe than average
Orange:	The model is 20 to 40% less safe than average
Yellow:	The model is up to 20% safer than average
Blue:	The model is 20 to 40% safer than average
Green:	The model is at least 40% safer than average

The VALT Safety Rating System

The Traffic Safety Committee of Insurance Companies (VALT) in Finland regularly publishes leaflets which compare cars on Finnish roads on several factors related to crash performance. The latest edition, based on studies at Oulu University, was published in January 1995. It covers the period 1987 to 1992 and compares 64 passenger car models of 22 makes.

The injury risk ratings are based on car-to-car crashes where compensation has been paid. Only driver injuries are considered. Single vehicle crashes, collisions with heavy trucks and impact type are not considered.

Injury ratings are calculated on the basis of whether or not the driver is injured. The use of seat belts is assumed. For the injury information, only accidents in built-up areas have been analysed in order to minimise the influence of crash speed differences.

Regression analysis is used to calculate the expected accident rate of each car model. Factors judged to affect injury risk are driver age and gender, distance travelled, usage environment, impact type and vehicle mass and they are taken into account. Some control is introduced for crash severity by grouping crashes into urban and rural environments.

Results are presented in the following format by model:

Factors considered for primary safety rating are:
- <u>Accident risk:</u> number of accidents per million km
- <u>Car model accident classification:</u> where the accident number is the same as expected, within the statistical confidence limits, the model is given a yellow classification, where it is below, a green classification, and where it is above, a red classification.

Factors considered for secondary safety rating are:

- Driver injury risks: the rate of personal injury of a car driver (to blame for the accident or otherwise) for the car model in question, i.e. number of victims per 100 million km and per 100 accidents
- Injured driver ratio: compares the rate of driver injuries in the case car to the rate of driver injuries in both cars involved
- Driver injury classification: where the number of injured drivers is the same as expected, within the statistical confidence limits, the model is given a yellow classification, where it is below, a green classification, and where it is above, a red classification.

The UK Department of Transport Rating System

The UK Department of Transport publishes a guide providing information on safety ratings for car models on national roads. The injury risk ratings are based on the risk of driver-only injury in car-to-car injury accidents reported to the police. Single vehicle accidents and collisions with heavy trucks are not considered. Injury ratings are calculated on the basis of whether the driver is injured or not. Belt use is not considered.

Logit functions are used to correct injury risk estimates depending on the level of exposure of particular car models to injury accidents. Key factors directly affecting injury risk are judged to be the speed limit, impact type, age and gender of driver, and mass of car.

Cars are split into four groups based on length: small, small/medium, medium and large. For each model, the risk of injury is pinpointed and can be compared to the average risk for that model's group and to the overall average for all groups. Ninety five per cent confidence levels are shown for each model in the form of coloured bars. The longer the bar, the less reliable is the estimate of injury risk due to small numbers. The bars are colour-coded according to the following scheme:

Red: the model is below the group average
Yellow: the model is within the group average
Green: the model is above the group average

Highway Loss Data Institute (HLDI)

The Highway Loss Data Institute in the United States publishes statistics regarding the frequency of claims for personal injury, vehicle damage and theft. Results are grouped according to six classes of vehicles, based on wheelbase, each class subdivided into large, midsize and small models:

- station wagons/passenger vans
- utility vehicles

- four-door cars
- two-door cars
- luxury cars
- sports cars

Results are standardised for exposure in terms of vehicle years on the road, and for the difference in claim frequencies by age of operator. For any given model, account is taken of any changes in basic bodyshell design and/or restraint systems. Losses are stated in relative terms, with 100 representing the average result for all vehicles in each of the three loss categories.

3.2 Predictive methods

Predictive ratings are based on the evaluation of one or more whole vehicle crash tests, e.g. NCAP (Section 3.2.1) and/or on testing and visual inspection of components which particularly influence injury severity (secondary rating systems (Section 3.2.2)).

3.2.1 New Car Assessment Programmes (NCAP)

New Car Assessment Programmes (NCAP) consist of one or more whole vehicle crash tests on new car models. NCAP is currently applied in the USA and Australia. The UK has just commenced an NCAP and Japan is in the process of starting up an NCAP programme in 1996. The exact methodologies of these NCAP differ and are described below.

USA

The NCAP programme in the United States, developed and carried out by the National Highway Traffic Safety Administration, was the first one in the world. It began in 1978 and since then it has remained essentially unchanged. It comprises a full-width front-into-barrier test at 35 mph (56 km/h). So far the US programme has led to over 300 published crash results.

Injuries are measured using Hybrid II or Hybrid III dummies (manufacturers' choice), restrained by belts.

Results are communicated in the form of a star system ranging from 0 to 5 stars. These are based on combined head and chest injury scores. Femur injury scores have been excluded from this rating. Detailed information, specifying scores for head, chest and femur separately, is available to the public on request.

Currently, an expansion of the NCAP is under discussion. Consumers, insurers and safety experts would like to see other crash modes included, in particular side impacts and offset frontal tests which are more representative of real world conditions. They have queried the effectiveness of the star system to communicate results, believing it to be over-simplistic. The need for studies of the usefulness of additional injury measures, notably neck injuries, chest compression and lower leg loads, by using Hybrid III dummies has also been identified (NCAP Public Meeting, 1995).

Australia

The establishment of NCAP in Australia is relatively new (1992). In the crash laboratory of the Roads and Traffic Authority in New South Wales, each test model is subjected to:

1. a full frontal crash test into a rigid barrier at a speed of 56 km/h;
2. a 40 per cent offset test into a deformable barrier (an aluminium honeycomb barrier) at a speed of 60 km/h. A test speed of 64 km/h, to harmonise with the IIHS test and the UK NCAP test, will be introduced shortly.

Data collected in each crash test provide injury scores for head, chest, upper leg injury, and lower leg injury, based on instrumented dummies (Hybrid III dummies) on the driver and the front passenger seat. In the full frontal test all three body regions are assessed for both the driver and the front seat passenger. In the offset test, leg injuries are excluded for the front seat passenger, because this position is remote from the crush zone. Head injuries are calculated using the 'Head Injury Criterion' (HIC); the risk of chest injury by recording the depth of compression of the sternum; upper leg injury risk is measured by assessing the amount of force on the femur; and lower leg injury by measuring loads between the knee and ankle.

Data are published in magazines or brochures by the New Car Assessment Program itself. A colour code is presented for each of the four regions, depicted in a drawing of a human being (red = high risk; amber = medium risk; green = low risk), separate for the driver and the passenger dummy and for the full frontal and offset test. The exact scores of both dummies are provided as well. Recently, a single index rating of injury risk for drivers and front seat passengers has been provided covering the risk of sustaining life threatening head and chest injuries. Leg injuries have been excluded in calculating the injury risk rating, since these are generally not life-threatening. The injury risk results are presented in bar charts from 0 to 100: the lower the number the better.

To date, tests have been conducted on approximately 40 different models from the categories of small cars, medium/large cars, passenger vans, four-wheeled drives. The programme is about to start testing utility vehicles (pickups). All the high volume selling vehicles in Australia have been tested and new models which are predicted to be high volume selling vehicles will be tested as they enter the market.

Surveys conducted in Australia over the past three years (AAA, 1995) have shown an increasing awareness of vehicle safety. In 1992, safety was ranked 15th behind other criteria. The 1994 survey showed that firstly, the consideration of personal occupant safety has been moved to fourth position behind cost, reliability and size of car. Secondly, 60 per cent of car buyers knew about NCAP, mainly from television coverage, and the majority considered NCAP useful.

United Kingdom

An NCAP testing programme has just commenced in the UK, consisting of a frontal, side and pedestrian test based on the EEVC test procedures:

1. Frontal offset deformable-barrier test at 64 km/h;
2. Lateral mobile deformable-barrier test at 50 km/h and 300 mm ground clearance;
3. Pedestrian-component tests of the bumper, bonnet leading edge and bonnet top.

In the first year at least six models will be tested. No decision has yet been made as regards methods of publishing test results.

Japan

There are plans to introduce a 56 km/h full frontal barrier test in 1996. Measurement of braking distance and a summary of general vehicle safety features will also be provided.

Other whole vehicle crash test initiatives

In a number of countries, crash tests are being carried out with the aim of informing consumers on "the best buy" from a safety point of view. These tests are carried out and published by, for example, national motoring organisations, car magazines, and insurance institutes. Generally, different organisations use different protocols which makes comparisons difficult. Industry, however, responds very quickly to this type of initiatives as well. Some examples are:

US Insurance Institute for Highway Safety
Recently, the US Insurance Institute for Highway Safety (IIHS) has evaluated the crashworthiness of 14 midsize four-door cars (1995 models) by carrying out a 40 per cent frontal offset test into a deformable barrier (crushable honeycomb aluminium) at a speed of 64 km/h. This test is based on the EEVC offset deformable barrier test and differs from the full width frontal test carried out in

the framework of the federal NCAP. According to IIHS, the offset test better highlights important differences in crash safety between car models, partly because the outcomes of an offset test are less dependent on seat belts and air bags and more on vehicle structure.

Three aspects of crashworthiness are evaluated separately:

- Structure
- Restraint systems/dummy movement
- Injury measures (Hybrid III dummies in driver seat), consisting of
  - head measures (3)
  - neck measures (3)
  - chest measures (4)
  - leg and foot measures (2 x 9)

In addition, two other aspects are assessed: the geometric design of the front-seat head restraints and the bumper performance (by four crash tests at 8 km/h: front- and rear-into-full-width-barrier, front-into-angle-barrier and, rear-into-pole).

For each of the five aspects a score is computed that is presented to the public in four different colours:

Red:	Poor
Orange:	Marginal
Ochre:	Acceptable
Yellow:	Good

Each model also gets an overall score, using the same categories. Crash test results contribute most to these overall scores. Of the 14 tested models, three received a "Good" overall score and "a best pick" qualification.

German Motoring Organisation ADAC

The ADAC currently carries out four crash tests, the results of which are published in their own magazine.

1. A 40 per cent frontal offset rigid barrier test at a speed of 50 km/h (in the future a deformable barrier will be used and speed will go up to 60 km/h);
2. A lateral mobile deformable barrier test at 50 km/h and a ground clearance height of 300 mm;
3. A roll-over test on a ramp screwing movement with a speed of 70 km/h;
4. A rear end test on a rigid barrier of 1100 kg with a speed of 50 km/h and a 100 per cent overlap.

German magazine Auto Motor Sport

The tests, which are carried out by the TÜV Bayern / Sachsen and published in the German magazine Auto Motor Sport, cover a wide variety of situations:

1. Frontal offset test (50 per cent barrier with 15 degree angle and anti-slide device, ASD, at 55 km / h);
2. Lateral mobile deformable barrier test at 50 km / h and 300 mm ground clearance;
3. Pedestrian (Hybrid II) dummy test at 30 km / h with real cars, measures of head, thorax and pelvis;
4. Child restraint system test with real car compartment, original child restraint system and seat belt system, impulse of 50 km / h, 32 g, frontal with 3 and 6 years dummies;
5. Car-to-car test, frontal / frontal, 50 km / h / 50 km / h, small car with 50 per cent offset;
6. Car-to- car test, frontal / lateral, 50 km / h, rectangular;
7. Roll-over test with 70 km / h on a ramp screwing movement.

3.2.2 Secondary safety rating systems

The European Secondary Safety Rating System for Cars

The European Secondary Safety Rating System for Cars was developed on the basis of the system created by the UK Consumers' Association and Vehicle Safety Consultants. The UK Consumers' Association introduced this secondary safety system in 1983. A slightly adapted version has been used by the Dutch Consumers' Group since 1989 and by the French Consumers' Group since 1992. With the support of the European Commission, a single European version has been developed and published in 1994 to be used by consumer groups throughout the European Union (IT, 1994). To date, it has rated over 300 makes and models, and is the most comprehensive system currently in existence.

The system relies on a combination of visual inspection and component testing of a number of areas of car design taking into account the current state of knowledge.

For normal passenger cars, the rating system looks at 57 safety critical variables of car design. Each variable is assessed against a fixed set of criteria and given a numerical score. Weightings are then applied to over 50 variables. The weightings reflect the relative contribution to total occupant injury as observed in real-life accidents in countries in the European Union. The system tries to predict the performance of the vehicle in all types of accidents. Design characteristics which are more important in accident types that are more common (e.g. head-on collision vs. roll-over accidents) receive a higher weighting. The weighting is based on the prevention of fatal injuries rather than serious injuries.

The relative importance of a particular variable is influenced by seat belt wearing. The system also takes into account the rate of seat belt wearing by allowing for different usage rates for the front and rear seats. Examples of variables and their weights are:

Variable	Variable weight
6. Fuel tank	0.61
12. Front doors, bodyshell strength	29.71
13. Front doors, side impact strength	6.07
23. Steering, head and face protection	89.93
37. Front seat belts, geometry	23.65
49. Rear seat belts, geometry	3.17

The weighted scores are totalled to give a raw score for the car, which is then corrected to account for the effect of the vehicle weight on occupant protection. This means that big cars can achieve higher total scores than small cars. Only the total scores are used, banded into ratings. This allows for comparison of secondary safety features both within and across various weight classes.

Before results are published in a magazine, car manufacturers may be presented with the scores in each area, including a list of very bad and very good aspects. The manufacturer has an opportunity to present additional test information. This is assessed and, if thought to be appropriate, results in adjustment of the ratings. By presenting scores separately on each variable, manufacturers can see exactly which improvements will contribute most to the overall score of a model.

The rating system is under constant review which is one of the strengths of the system. Based on new accident data and new car designs, weights and coding of variables can be easily adapted. Another major advantage is that the system is sensitive to injury of occupants in all different seating positions.

3.2.3 Car rating systems under development

T&E Five Star Classification Scheme

The European Federation of Transport and Environment is developing a framework for a scheme of environmental classification and labelling of new cars (Holman et al., 1993). This framework aims to provide for classification of cars on their environmental and safety performance. It will give consumers information on:

- CO_2 emissions / fuel consumption
- harmful exhaust emissions
- noise

- safety
- recyclability and use of toxic materials

For each characteristic a car could receive 1 to 5 points. Those cars that attract 5 points would receive a star for that particular characteristic. In total a car could receive 5 stars.

With respect to safety, the ranking would differentiate between new models and models that had been on the market for some time. For new cars it would only be possible to receive 3 points:

- one point for having seat belt pretensioner
- one point for having a driver's airbag fitted as standard
- one point for passing various crash tests for driver and front seat passengers which would consist of
    - Full frontal barrier test at 56 km / h
    - An offset barrier test a 55 km / h
    - A barrier test with a deformable barrier at 50 or 55 km / h
    - A side impact test to measure maximum intrusion into driver's compartment and stiffness of the construction (USA or EU proposed test)

When these cars have been on the market for some time, they will be ranked according to their actual accident performance as well as on two car impact injury data.

Berlin Research Project - safety index quantifying passive/secondary safety

In the frame of a research project by the Federal Highway Research Institute (BASt), the Technical University of Berlin has developed a procedure for the assessment of the secondary safety of cars on the basis of accident analysis, biomechanical and crash test data which are combined using a standard algorithm.

The level of crash performance in four different impact tests is assessed by dummy measurements. The performance level is then weighted according to the incidence of injuries in real world accidents on the basis of accident data from the Medical University of Hannover.

Using this method, it is expected that it will be possible to assess the performance of the whole vehicle as well as its performance in different types of impact and for different seating positions. This procedure, which is currently being validated, offers the possibility of predicting the safety performance of cars in real-world accidents.

4. Discussion of current practice

4.1 Retrospective rating systems

All retrospective rating systems described provide information on the safety performance of different cars based on analysis of real world accident data from police records and insurance companies. Ultimately, the best measure of the safety performance of a vehicle will be how it actually protects drivers and passengers in real accidents. Accident data provide information on many factors, such as car characteristics, accident types and circumstances, which affect the outcome of real life accidents and have to be of sufficient quality to be used in rating analyses.

If data are collected for other purposes, the subsequent analyses to rate safety performance of cars are relatively cheap. However, this real world approach also has its limitations.

Firstly, retrospective methods can only provide consumer information late in a car model's production run, when inevitably many cars of that model have already been purchased. For less common car models it might be impossible to find sufficient accident data. However, retrospective accident data do provide information on the progress in safety design that has been made and enable consumers to identify makes and models with a generally good track record in safety. These ratings can also assist buyers of used cars, which have the lion share of the market.

It is also difficult to isolate the influence of car design from all other factors that contribute to the outcome of an accident. For example, people with different driving styles or of different age groups will choose different types of cars, use their car in different situations and in a different way. These factors might bias the relative safety of a particular car model and are particularly hard to eliminate. Nevertheless, there are examples of sophisticated analytical methods that partly overcome this problem.

A further limitation of this approach is that data do not provide much explanation of *why* certain makes or models perform better in accidents than others. Retrospective methods generally provide data on the difference in frequency of injury accidents and injury severity.

In short:

Advantages retrospective methods	**Limitations retrospective methods**

• Potential to evaluate all types of real world accidents. • Provide information on various factors which affect the outcome of an accident. • Identification of *generally* 'safe' makes and models and of particular use for buyers of used cars. • If data are collected anyway, subsequent rating analyses are relatively cheap.	• Information is available late in a car's production run. • For less common models it might be difficult to get sufficient data. • Difficult to remove the influence of driver behaviour and exposure from design. • Limited explanation of *why* certain cars do better than others.

4.2 Predictive rating systems

Predictive methods also have their advantages and limitations. They have the greatest potential for influencing people's decisions when buying a new car, since rating will be available as soon as a new car model is launched. Ratings are based on *expected* performance in real life crashes as deduced from whole vehicle crash tests, component testing or visual inspection. In this way, factors other than design which might affect injury severity (e.g. behaviour, exposure) are excluded.

For predictive rating systems it is essential that crash tests are as realistic as possible, and that the evaluation of test results and of visual inspections is based on good knowledge of what happens in real accidents and how injury is sustained. Since cost precludes the use of a large number of whole vehicle tests, only a limited number of crash tests is feasible so inhibiting guidance on a car's performance in the full mix of accident types to which it will be exposed. By testing specific parts or components of a car it can be difficult to take into account the interdependence of these components so the methodology of various predictive methods also needs careful consideration.

Since actual crash performance is deduced from laboratory performance, it is very important that predictive systems pay continuous reference to real world accident data to ensure their validity. Until now, available data show that there is good similarity between predicted crash safety and safety in real life accidents. For example, Gloyns et al. (1991) compared the UK secondary rating system with the Folksam car safety ratings and concluded that there was a significant and consistent correlation, both at the detailed information level and at the level of information presented to consumers. Kahane (1994) correlated US NCAP performance with fatality risk in actual head-on collisions. It was found that drivers of cars which performed well in NCAP have, on average, a 20 to 25 per cent lower risk of fatal injury than drivers of cars in the same weight class which performed poorly in NCAP. Relevance to real-world conditions needs continuous monitoring.

In short,

Advantages predictive methods	**Limitations predictive methods**
• Information is available before a model is launched. • Factors other than design which may affect injury severity, are experim-entally controlled.	• In NCAPs, real world performance is deduced from laboratory perform-ance, which requires regular validity checks. • The most representative, i.e. whole vehicle, tests are very expensive. • Interdependence of components is often difficult to assess.

4.3 Communicating crash performance information to consumers

Given the variety of safety rating systems which exist, it is very important that each publication explains clearly what the particular safety rating in question means, and draws attention to any limitations. It should always be emphasised that such ratings measure crash performance in the event of an accident rather than affect in any way the chance of an accident occurring in the first place.

When relevant data have been collected, there is a huge amount of information available on each car model. This information is very technical and needs careful interpretation. It is clear that in their raw form, these data cannot be presented to the general public.

As has been shown in Section 3, the ways of presenting the results varies considerably across the various systems and programmes. Some have a very high degree of simplification, e.g. the US five star system. Other try to communicate much more detail, e.g. the VALT retrospective rating system.

As far as is known, there have been no studies in which the effectiveness of different ways of communicating results to consumers has been systematically investigated. In general, it can be said that the simpler the message, the less objective it is, and vice versa. In a simple message all sorts of data have to be combined and weighted according to their relative importance. This weighting procedure unavoidably implies a certain level of subjectivity, whereas presenting data with a minimum of subjectivity will require complicated judgements of the consumers themselves. It is clear that a balance has to be found between the two.

5. Conclusions and recommendations

5.1 Quality of existing safety rating systems

There has been some good experience with both retrospective and predictive approaches allowing rating of the safety performance of different car makes and models. Experience to date shows that both approaches have a role, albeit different, to play in providing consumers with useful information when purchasing a car. Predictive systems are most useful in providing information on new cars, whereas retrospective systems inform about cars already on the road. Of the predictive systems, NCAP tests provide a more objective assessment of vehicle safety, but only for the conditions tested, whereas secondary rating systems offer useful information on performance across the range of crash conditions and for all seating positions.

The various crash test-based, inspection-based and retrospective systems have evolved largely independently. Co-ordination of approaches could enhance the usefulness of the information further. Routine standardised crash test data could improve the accuracy of the inspection based systems as could the subsequent feedback from retrospective methods. Similarly, a co-ordinated method of expressing the results to the consumer could improve public understanding of the results. The Swedish Roads Administration, for example, will shortly draw together in one publication the results of different types of safety ratings.

A prerequisite for the optimal use of any rating system is the quality of information, which will depend upon a number of factors such as:

– how realistic is the whole vehicle or component test;
– how much is read from any one test result about safety performance;
– how well safety ratings take account of factors which might bias the results;
– how well results of other rating systems and in-depth injury data are taken into account.

Current practice in NCAP testing, secondary rating and retrospective safety rating indicates that some, but certainly not all programmes pay adequate attention to these factors.

The important role of car rating systems in providing consumers with information on safety performance of cars, and the mutual interdependence of the rating systems justify further development of each of them towards the highest possible quality level.

5.2 Evaluating the crash performance of new cars in Europe

For new car purchase, new car assessment programmes and secondary safety rating systems clearly have the most to offer.

Currently, there is no EU-wide NCAP programme, although one or two Member States have embarked on or are considering such a course of action at national level. A European Secondary Safety Rating System has been developed and commands wide respect, but does not yet maximise its potential in taking whole vehicle crash test performance and component testing fully into account.

ETSC believes that the establishment of an EU new car crash testing programme could provide valuable information to allow the setting up of an EU NCAP as well as the further development of the European Secondary Safety Rating System. A co-ordinated EU programme of crash testing work and evaluation with harmonised test protocols would have the following advantages in:

- recognising the role of market forces in improving car safety design;
- furthering EU Treaty objectives to promote road safety;
- avoiding unnecessary duplication and cost;
- allowing more models to be tested than could be done by any one Member State;
- providing a framework for sharing of results amongst different crash testers;
- ensuring that the results of crash tests, which are quite expensive (@25,000 ECUs), are utilised most effectively.

5.2.1 Elements of an EU new car crash testing programme

Realistic test procedures

Legislative tests represent a minimum level of crash performance. Many cars already in production exceed these tests and, indeed, manufacturers readily point to features which are additional to the legislative specification. Crash testing for consumer information gives comparative information about the performance of cars in a single crash test. It seeks to give consumers information about the availability of good protection. It does not seek to introduce a pass/fail criterion as do legislative tests. Tests selected for consumer information purposes will often be different, therefore, from legislative tests.

The most relevant safety information from new car assessment programmes will undoubtedly come from those using test procedures which are most representative of real accident scenarios producing serious injury (MAIS 3 or above).

In ETSC's view, for European cars, the current test procedures from frontal impact, side impact and pedestrian protection developed by the European Experimental Vehicles Committee should form the basis of consumer tests. The test speed of the frontal impact test should be higher at 64 km/h, however, since it is more representative of severe injury producing frontal impacts and is used in consumer testing internationally.

Results from accident studies indicate that the speed which will probably be adopted in the legislative proposal (56 km/h) will address only about a half of severely injured casualties (MAIS 3 or above) and a smaller proportion of fatal casualties. The accident research cited in the table below indicates that most of the severely injured casualties wearing seat belts had DeltaVs (change of speed during an impact) of at least 60 km/h as did the majority of the fatal casualties. Taking into account further technical considerations associated with CRASH 3, the commonly used computer program which estimates DeltaV, and the dynamics of the offset deformable barrier then a speed of 64 km/h is considered to be the appropriate speed.

Two (US and UK) of the three countries which currently use the offset deformable barrier test for consumer information use a speed of 64 km/h to cover the vast majority of severely injured casualties as well as taking into account the proven ability of manufacturers to design for good passenger compartment integrity at 64 km/h. For these reasons, Australian NCAP will shortly increase its offset test speed for all its frontal impact tests to 64 km/h.

In coming to this conclusion, ETSC has noted the argument presented against going for a high speed that too little is known about the usefulness of the resultant design in lower speed impacts. ETSC believes that the lower legislative speed to which manufacturers are already designing for legislative purposes ensures that design will accommodate lower impact speeds as well.

Cumulative Distribution of Accidents by Velocity Change

(Source:: Rattenbury and Gloyns, 1993)

Sample	**Delta-V km/h**		
	50	55	60
Fatal accidents			
Belted front seat occupants without rear loading (France)	12%	21%	32%
Restrained front seat occupants (UK)	21%	42%	54%
NASS data (USA)	19%	30%	45%
MAIS 3 + (severe injury) accidents			
Belted front seat occupants (France)	40%	51%	62%
Restrained front seat occupants (UK)	50%	59%	67%
Accidents at about 50% car-car overlap (Mercedes cars, Germany)	20%	40%	50%

Selection of models for crash testing

Numbers of tests per model

The accuracy of testing is such that usually no repeatability test on a model is needed. As a result only one test is required for legislative type approval purposes. Australian NCAP, for example, does not use repeatability tests. However, if serious problems are encountered, a second test could be carried out.

Selection of models

A mature crash testing programme will involve testing on all categories of small cars, medium/large cars, passenger vans, four-wheeled drives. In Australia, all high volume selling vehicles have been tested and new models which are predicted to be high volume selling vehicles will be tested as they enter the market. The United Kingdom programme which is just starting is confining its attention to small car testing in the short term which, in safety terms, seems an appropriate place to start. Top selling models in the UK and Europe have been selected with the exception of those due to be replaced shortly.

Specification level

In general, the best sellers in Europe are 3-door vehicles, so vehicles with this specification seem the natural choice.

Equipment level

This would need to be harmonised.

Purchase of models

To ensure that the vehicles selected for testing are the same as any one picked by the consumer from any high street dealer, then special purchase arrangements would need to be made.

Processing of results

As indicated previously, crash test results can be utilised in a variety of ways. Results could be fed into an EU NCAP programme which rates vehicles according to their performance in different crash tests. Additionally, the European Secondary Safety Rating System, used by consumer organisations, could benefit from further crash test input.

5.3 Evaluating the crash performance of cars in use

For second hand cars, retrospective safety rating systems based on analysis of real accidents can provide useful consumer information, as long as potentially confounding factors are strictly controlled. They also can provide the information to monitor the validity of predictive rating systems. Some suggestions for further development of existing systems to allow greater use on an EU-wide basis are as follows:

Pooling data from different EU countries

All retrospective rating systems rely on having a sufficient number of each car model involved in crashes to produce statistically significant results. Pooling data from different countries might facilitate the situation, and ensure that ratings on new models are available sooner and that less common models can be rated as well. In the short term, linked licence and accident data of a number of countries spread over the EU will be sufficient. In the longer term, the CARE system, the EU Road Accident Database, could include the identification of vehicle types by combining it with vehicle licensing information and as such provide information on all EU countries.

All systems try to account for accident exposure by model and other factors such as age of occupant injured. Not all, however, account for crash severity or impact type. There are also differences in the data sources used, and in the number and position of injured car occupants used to define injury risk. Any international comparisons would need to take account of such differences.

Exposure data

The retrospective secondary safety rating systems are based on the injury rates in either national or other large-scale databases, e.g. insurance data. In general, the systems are based on relative risk assessments as non-injury data are seldom available to enable absolute risks to be calculated. There are exceptions such as the VALT system which do have non-injury accident data available to it. Ideally, non-injury accidents would be systematically counted according to a standard definition.

The comparison of both accident and injury rates of vehicle models will be enhanced with improved exposure data that is measured for individual models. This data should be collected in a manner which will tie in with the national accident data.

Determining levels of seat belt use

The use of seat belts by occupants strongly influences the risk of injury, but determination of use remains a problem. It might be reasonable to assume belt use in countries where the rate is high in the general traffic stream, but that might not be a reasonable assumption to make for countries where wearing rates are low. Additionally, there is evidence to suggest that usage rates for drivers involved in crashes is lower than in the general traffic stream.

Other elements for consideration

Although there are methodological problems, it would be useful to assess a model's safety when in single vehicle collisions as well as in car-to-car impacts. In addition, it would be useful to assess injury risk for rear seat passengers, for child passengers and for pedestrians.

5.4 Summary of recommendations for EU initiatives

In order to optimise the quality and quantity of data for consumer information of safety performance of cars, ETSC believes that the following steps are necessary:

- Establishment of an EU new car crash safety programme to avoid unnecessary duplication and cost and to increase the number of models tested. This requires agreement between crash testers on test procedures and protocols taking into account current knowledge of best practice, as discussed in Section 5.2.

- Development of a system for pooling EU accident data to ensure that ratings on new models are available sooner and that less common models can be rated as well. This requires agreement on common data collection and data analysis methods, taking into account possible confounding factors as much as possible, as discussed in Section 5.3.

- Development of a framework for continuous mutual input from results of crash tests, secondary rating systems and retrospective rating systems to ensure that the latest information is reflected in all systems.

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