EEVC/CEVE

European Experimental Vehicles Committee

The future for car safety in Europe

Presented to the Fifth ESV Conference London June 1974

THE FUTURE FOR CAR SAFETY IN EUROPE

A report of the EEVC prepared for presentation

to the 5th ESV Conference, London, June 1974

CONTENTS

ANNEX

FOREWORD BY THE CHAIRMAN

Cars have existed for only a relatively short time but during this period immense changes have taken place in the world, many of them as a direct result of the availability of powered road transport on a personal basis. With the many benefits have come some disbenefits; these have been largely attributed to cars which have attracted rapidly growing attention and public condemnation in recent years. The disbenefits are specifically the problems of road accidents, noise, exhaust pollution and traffic congestion: and more recently the rate of depletion of energy resources by road vehicles.

Research to improve the safety of vehicles has been carried out internationally for some time. Government administrators in collaboration with industry have started investigations to standardise regulations which differ from each other, and also to make recommendations for the highest possible level of safety, using available techniques, whilst remaining acceptable for production. This facilitates the sale of cars between nations, and at the same time improves their safety. Without underestimating this continuing work, some governments have initiated more advanced research, eventually to be used to strengthen regulations to give safer vehicles. Any gain in safety must be achieved within reasonable limits of cost, weight and dimensions. Furthermore, account must be taken of the special difficulties for small light vehicles and the problems of their compatability on the road with larger, heavier vehicles.

In October 1970 a committee of European government representatives was formed which came to be known as the European Experimental Vehicles Committee (EEVC). The Committee maintains liaison between various European national Research and Development activities to increase safety and abate noise and pollution; it also provides a forum for clarifying views on the various technical options and on the response which should be made to the various international initiatives such as those stemming from the NATO Committee on the Challenges of Modern Society (CCMS). The EEVC has no executive or legislative function.

The report on car safety which follows is the result of initiatives sponsored by the EEVC which had the wholehearted co-operation of governments and in which representatives of the European car industry participated.

This report provides important guidelines for improving car safety in the future; improvements which are not limited to countries participating in EEVC. These EEVC activities are not competitive with those of other organisations, who may benefit from the results, by helping to improve and harmonise, on a world level, technical regulations for the construction and equipment of vehicles. This work does not negate studies related to current technical regulations which have been carried out over a long period by existing organisations.

The report is by no means the last word on car safety, indeed one of its objectives is to highlight the work which still needs to be done; nevertheless the Committee hopes and believes that it will contribute to the improvement of safety standards on a worldwide basis.

H. Taylor, Chairman EEVC, June 1974

THE FUTURE FOR CAR SAFETY IN EUROPE

A report of the EEVC prepared for presentation to the 5th ESV Conference, London, June 1974

1. ROLE OF EEVC FOR CAR SAFETY IN EUROPE

The European Experimental Vehicles Committee has existed throughout the period of the development of experimental safety vehicles consequent on the greatly increased interest in 1970 in providing better safety for car occupants.

In spite of and further to the existing work, it was formed originally to co-ordinate the car safety technical activities of European participants in the international programme; its scope was subsequently widened to include noise and pollution. Its members are mostly drawn from those working on research and development in this field for their respective governments but an observer from the EEC Commission attends meetings of the Committee for liaison purposes. Member countries are at present France, W. Germany, Italy, Sweden and the United Kingdom with the Netherlands and EEC Commission represented as observers; most of the car designing countries of Western Europe are therefore represented.

The work of EEVC has been extended during the past year. Working groups have been set up to define on the basis of European experience, technical knowledge and facilities, a sufficiently common view for it to be able to present a soundly based assessment of the future needs for car safety in Europe. The working groups have benefited from the participation of representatives of several car manufacturing companies or some of their joint organisations. The conclusions represent the agreed position of EEVC and do not necessarily reflect the exact points of view of all participants. The remainder of the main text is a brief summary of the conclusions of EEVC, the working groups more detailed reports being included as annexes.

2. THE STUDY OF ACCIDENTS, THE BASIS FOR SAFETY DEVELOPMENTS

The collection of national road accident data has been continuing for about 65 years in some countries in Europe, with procedures being improved during this period, so that by today many basic analyses can be rapidly carried out, which are vital to the planning of car safety and other road safety measures. The study of accidents in one area in more detail by organisations other than the police has also been in progress for about 20 years, though procedures have now become more systematic, with recently a better realisation of the need for also collecting background information with which to interpret the results more fully.

The present position in Europe is discussed in Annex 2, the report of EEVC Working Group 1. It is clear that sufficient suitable data exist on which to initiate car safety proposals although the report also makes recommendations for improvement in collecting accident data. The situation will improve when accident teams, which have only recently started work, have reached the reporting stage. Much of the existing data are not published but are available to government officials and others concerned. One problem has been the need to provide sufficient effort to analyse and publish studies once the actual investigations have been completed.

Though ideally a high degree of uniformity and co-operation between accident investigations for car safety in Europe is desirable, a greater need may be to allocate sufficient effort to make the best use of the data which are becoming available under existing arrangements. The recommendations of the Working Group 1 are given at the end of Annex 2, the need for uniformity or compatibility of definitions and procedures in accident studies, being a particularly valuable suggestion.

3. REPRESENTING ACCIDENT IMPACTS BY TEST PROCEDURES

Road safety is basically motivated by the public desire to save road users from injury. Damage to vehicles though of high economic importance is currently accorded a relatively low priority. Thus the damage and deceleration levels sustained by vehicles are primarily important in so far as they determine the injuries to their occupants. However, the link between them is by no means clear and it is considered that in the longer term the loadings on dummies and not vehicle characteristics only, must indicate the criteria for passing or failing an impact test representative of frequent accident situations. In the short term there are several technical difficulties in doing this. Furthermore the rival claims of tests using complete dummies and those using simple forms representing single components of the human body must be considered. It was almost unanimously agreed that complete and representative dummies are necessary; simple forms often provide poor representations due to interactions between parts of the human body, some of which are brought to rest before others. For regulatory purposes it appears preferable to use a few impact tests making them as representative as possible of actual accidents.

Test dummies should be strong, give repeatable results and be capable of calibration. They should be simplified rather than exact replicas of the human body with sufficient means of recording loads, deflections or decelerations appropriate to the test. Dummies stiffer and stronger than human beings are not ruled out if they can be used to verify the stiffness and energy absorbing properties of vehicle components struck by them. It may be that at some stage dummy design for regulatory purposes must be frozen so that a single design can be universally adopted for particular tests, though it would be preferable to be able to specify dummy performance requirements, rather than its design. In any case the development of both dummies and test procedures must continue and refinements incorporated in future requirements.

A knowledge of human tolerance levels for each particular type of impact and consequent injury is essential for determining injury potential. The range of each human tolerance and how it varies with human size, sex, age and other differences between people has not always been fully recognised and allowed for. Of greater importance may be the need to calibrate the loadings on dummies to truly represent the tolerance levels of humans, which have themselves been estimated indirectly. The need is to record the level of accident impact resulting in some degree of injury in such a way that an impact test procedure can accurately reproduce the impact. Human tolerances have been estimated in the past from tests on human volunteers, animals, cadavers and by tests designed to match impacts resulting in known injuries in particular accidents. The last two procedures are probably the most useful, but whichever is used, decisions must be made in relation to the proportion of injuries which is to be avoided at a given impact level. This implies that enough data must be collected to discover the tolerances for various percentiles of the population. A review of the situation regarding the estimation of each tolerance level and the present estimates of each are noted in Annex 4, the Working Group 3 report. There is a pressing need for a greatly increased amount of effort on determining human tolerances to the many different injuries occurring in vehicle accidents and the procedures should be chosen so that the results can bridge the gap between dummy test impact procedures and impacts in accidents on the road.

4. TEST PROCEDURES WHICH SHOULD LEAD TO THE DEVELOPMENT OF SAFER CARS

Recent work in Europe and elsewhere has emphasised the need, not just for having test procedures to specify safety requirements for cars, but also for checking that cars complying with such requirements actually have better safety records than their predecessors. Better safety may not be achieved because either the tolerance or pass requirements are wrongly chosen or because the test is not really representative of accident situations. In the latter case, it is possible to be led seriously astray and for cars to be constructed with features that do not provide greater safety in practice, maybe at additional cost. Another need is to base requirements on good accident data, not only with regard to details but also for the frequency with which each situation occurs. Cost benefit considerations then show which tests have priority and for which accident situations only cheap modifications can be justified. Procedures to ensure satisfactory progress are discussed in Annex 2.

Although existing test procedures, such as the full frontal barrier impact, are the only fully developed ones, this report suggests how they might be modified to take account of European accident studies, research into safety measures, and development such as in the ESV programmes. These suggest that a substantial reduction in injuries may be expected if these proposals are implemented. However further assessment of the cost and benefits for a range of test severities for each of the tests suggested is needed before final proposals can be made. With this in mind the EEVC would like to make the following comments on future test procedures and requirements for improving safety.

Accident avoidance (Primary safety). The necessity for studies in the field of primary safety or prevention appears less pressing than that for the other sectors of secondary safety and protection. Indeed most problems of primary safety have already been studied in detail and this has led to the establishment of strict specifications even on the international level. However, a list of topics, with an 'indication' of their degree of priority and practicability, has been established by the Working Group 2 (Annex 3), taking into account the fact that it is desirable and possible to progress in these fields.

Pedestrian protection. Recent work in Europe has highlighted the possibility that the intractable problem of reducing pedestrian casualties may be partially solved by redesign of car fronts in profile and later on by preventing pedestrians struck by cars subsequently falling to the ground or striking the windscreen or its frame. There is a clear need for further research and development in this field. Preliminary indications suggest that the front profile of a car should be low so that an adult pedestrian is struck below the knee by a bumper bar of reduced regidity, which would reduce the probability of tibia and fibula fracture.

Occupant protection (Secondary safety). Most effort of the EEVC Working Group 2 described in Annex 3 was spent on car occupant protection needs. The group stresses the importance of its assumption that the wearing of seat belts by front seat occupants will become almost universal in Europe probably by an increase in compulsory wearing. Little need was seen to provide protection for those choosing not to wear belts, though this may leave some car occupants unprotected. The general use of seat belts emphasises the need to improve their convenience when putting them on and their comfort for those of well above or below average size. It also emphasises the need for eliminating slackness by retractable belts or other means, and the great need for matching belts to car interior layouts so that they achieve their potential benefits, something that belts do not always do at present. Interlocks and passive belt systems were not fully discussed, the feeling being that the effects of compulsion should first be assessed before requiring further equipment in the car.

All accident studies agree that the frontal impact is of greatest importance because of the high frequency of its occurrence. More limited evidence suggests that the large majority of injury producing frontal impacts (without belts in use) are at speeds equivalent to barrier impacts of less than 50 km/h. The test procedure to be selected is either a 60° or an offset frontal impact into a rigid barrier at 50 km/h with the measurements being recorded on two front seat dummies restrained by seat belts. Details are in Annex 3. Design studies are needed to find the cost penalty implicit in providing protection for occupants at different levels of impact.

The EEVC Working Group 2 studied side impacts into cars and propose that side impact tests should be with the striking object a similar car to the one under test. The test, detailed in Annex 3, should also encourage designers to search for means of protecting the sides of the occupants and perhaps to have so little intrusion that in many car front to car side impacts the striking car may slide along the side of the car being struck and not lock into it.

This side impact test is particularly chosen to encourage the matching of the front and side structures of cars so that the fronts of cars are slightly less stiff than the sides and so do not easily intrude into them in these impacts. It is particularly easy to meet such side impact tests if the car front has a low bumper which strikes the side sills rather than the car doors and this design feature could also have some influence for providing protection for pedestrians struck by cars.

In Europe the frequency of rear impact leading to fatal or serious injury to car occupants is low. As a result the test suggested in Annex 3 for rear impact is intended to ensure that fire does not break out. It is also desirable that the strength of front seats should be considered. Fatalities to rear seat occupants can be reduced only by imposing a fairly severe rear impact test on the whole car and requiring structural integrity of the passenger compartment to be retained.

Though it may be hoped that the use of seat belts, the universal use of anti-burst door latches, and the now customary roof support strengths should be adequate to prevent most casualties in overturning incidents, a two rotation dynamic rolling test procedure is suggested in Annex 3. An alternative is to have a dynamic impact test on the roof front corner by pendulum or moving barrier. These suggestions reflect a lack of certainty that existing measures are adequate to prevent injury and some limited evidence supports this view; time will tell what is the actual situation.

5. THE FUTURE OF CAR SAFETY IN EUROPE

The EEVC view is that these few carefully chosen car safety requirements should achieve worthwhile savings in casualties to car occupants in Europe. These mostly do not require sophisticated engineering designs for cars and should not be unacceptably costly or impose much weight penalty. Car design teams need sufficient time to do their work of producing light and efficient designs. This latter feature is important for Europe in a situation of increasingly expensive fuel.

Europe is showing that it has the technical ability to study accidents, to make proposals and to carry them out in terms of new car layouts and equipment. With a more co-ordinated effort it will be possible to put these together to the advantage of the road user population in Europe and elsewhere.

ANNEX 1, THE WORKING GROUPS AND THEIR TASKS

The objective which the EEVC has set out to accomplish is to give recommendations based on research work for the definition of the characteristics that could be required of new production passenger cars which will be designed in the near future. The aim is to provide a more satisfactory level of safety for occupants, pedestrians and riders. This level should be established on the basis of a careful evaluation of the cost-benefit ratio and priority appropriate for each safety feature, derived from the best information available in Europe.

In order to accomplish the foregoing objective, three Working Groups (WG1, WG2 and WG3) were set up on an ad hoc basis within EEVC in the autumn of 1973 with the task of making quick assessments of present knowledge of the accident situation and the prospects for safer cars. The work was divided as follows:-

<u>WG1</u> WG1 was to review the sources of accident data available in Europe and to comment on how these should best be developed to further the aims of car safety. This would permit the definition and classification of accident problems in order of importance. Recommendations for the improvement of accident studies would also be made.

<u>WG3</u> WG3 had the task of reviewing the technical problems involved in assessing occupant safety by impact test procedures. These studies were to include an assessment of currently available human injury tolerance limits, anthropomorphic dummies, and test techniques, together with recommendations for future research.

<u>WG2</u> Based on the information discussed by WG1 and WG3, WG2 was to assess realistic safety requirements and to compare their priorities.

Apart from these groups, work is in progress to compare the various sets of economic assumptions used in European countries, as a basis for their cost benefit studies of safety measures.

ANNEX 2

REPORT OF WG1-A REVIEW OF DATA SOURCES FOR CAR SAFETY IMPROVEMENTS

1. AIM AND SCOPE OF THE REPORT

The European Experimental Vehicle Committee decided at its 5th meeting, held in Crowthorne in June 1973, to define the elements of a common position in the field of desirable safety improvements for new vehicles likely to appear on the European market in the early eighties. These recommendations, meant for national or international administrative authorities in charge of regulation and for automobile manufacturers should be based on the knowledge, as objective as possible, of the accident situation in Western Europe and on a comparison of the advantages and disadvantages of the intended measures.

Among the points to be examined to work out this common view, there is in particular the question of the sources of data on traffic safety. More precisely, the questions which can come up in this field are the following:

1) Do the different existing sources of data allow us to take up objectively and correctly the preparation or the decisions concerning the improvement of vehicle safety?

2) How it is possible to improve the existing information system in order to make it more efficient in respect of the aim of improving vehicle safety?

To answer these questions, it was decided to create a Working group, called Working Group 1(WG1),which got together twice in Paris, in November 1973 and in February 1974. A list of participants in this group will be found in the Appendix no. 1. Besides representatives of national administrations, the presence of some representatives of the car industry appointed as national experts is to be noted. We also draw the attention to the fact that all the manufacturers who are members of the Group called the "C.C.M.C." (Committee of Common Market Automobile Constructors) have given their view-point in an interview with the Chairman of the working group. For material timing reasons, it was not possible to hear the representatives of the association of automobile constructors known under the name of the "B.P.I.C.A.", but there is scarcely any reason to think that they should disagree with the view-points given by their colleagues who have been consulted.

In these meetings, it appeared that there was a very broad consensus on how to deal with the problem of the sources of data on vehicle safety. The aim of this report is to state this common view. The report includes, besides a first introductory part, a chapter 2 dealing with the present situation as regards the sources of data on safety and their present use, then a chapter 3 dealing with progress still to be achieved in these fields. The fourth (and last) chapter summarizes the general recommendations of the group. It is here to be noted that, because of the wide variety of practise in European government organizations, some of the recommendations will mean the starting of some particular work in one country, but only the improving of an existing procedure in another. A series of Appendices describing briefly the present state of the information sources on safety, and a list of the principal study and research centres directly involved in these fields, is to be found at the end of the report.

2. REVIEW OF THE USE MADE OF ACCIDENT DATA IN EUROPE FOR THE IMPROVEMENT OF CAR SAFETY

The accident investigation situation in Europe is that national data from the police are generally available and that several detailed studies are in preparation, in progress or at the analysis stage. However, so far relatively few results have been published, either because the results have been confidential to the organization carrying out the survey or because there has been insufficient staff effort available to complete the analyses and to report them formally. Thus the major purpose of this section is to state what data are available and how they are used. The availability is noted in the Appendices; the use that can be made is discussed in the main text.

1. Magnitude of any safety problem

The first step is to access how large is any safety problem being considered. National accident data supplied by the police may tell how many people are injured each year and to what severity, in a wide group of accidents including the problem under study. A detailed survey of accidents in one area may then show what fraction of these injuries are of the particular type and indeed whether the mechanics of the impact lead to the injuries in the way that was originally thought. Such a survey may supply an insufficient number of the particular type of accident and special arrangements may then have to be made to collect further evidence on which to design a suitable safety measure. An example will illustrate the procedure.

Suppose that a question is being asked about how front seat occupants can be protected from the high risks of being crushed by side impacts into their cars. National data might show that in one country some small percentage of all cars in which occupants were seriously injured were damaged at one side only, though in many other accidents frontal impact damage extended into the sides of the cars. A detailed crash injury survey of relatively few accidents might show that most of those injured had been sitting in the front, but that few of these had actually been injured by crushing, most having been hurt by direct impact with the car door or its surround when this had first been struck in the accident. From these details an estimate could be made of the annual total of those actually crushed in side impacts. But perhaps more significantly, the accident data would have shown that the wrong question may possibly have been asked.

In addition to estimating the magnitude of an accident problem for a recent year, it is sometimes important to estimate it on a similar basis for several earlier years so that the trend of the situation becomes clear. Accident problems may rapidly increase or diminish in importance at a quite different rate from the general traffic situation. For car safety situations, this usually arises from social or fashion reasons, for example increasing wealth has reduced the numbers of motor cycles in most countries so that the car/motor cycle impact problem has been diminishing, though the minimum for this particular trend may now have been passed. Another factor to affect trends is change in car design, for example the increasing proportion of front wheel braking for cars has reduced cars spinning due to rear wheels becoming locked and so side impacts in single car accidents seem to be decreasing as new models gradually replace old ones on the road.

The extent to which magnitudes of safety problems can be assessed in the European countries can be seen from the information in the Appendices. Broad estimates can be made in several countries based on police national accident data, while detailed estimates can be made in two or three countries. These enable particular car accident problems to be studied in some detail, and many such studies have been carried out. Doubts are sometimes expressed about the accuracy of police and other data and though it is true that some might be more accurate than others, it is also true that sufficiently accurate estimates can be made for many situations by specialist staff familiar with any problems or shortcomings of the data which they are using. A particular problem is that of some accidents not being reported at all; these largely fall into particular categories such as single vehicle accidents. Work in Sweden and elsewhere has highlighted the problem, enabling estimates to be corrected for appropriate situations.

2. Identification of high risk situations

Though it may be sufficient to know the magnitude of a safety problem, it is often useful to identify the background situation in which accidents occur. Are the accidents mostly in urban or rural areas, by day or during the hours of darkness, on motorway or other classes of road? National and more detailed studies give information about this, though the detailed studies are usually biassed by being situated in one particular area, though allowances for this can often be made. Then safety problems differ, some occur frequently with a low risk of injury, whilst others occur infrequently but nearly always lead to injury. Studies of accidents without injuries as well as these with injuries are needed to show up the difference. Human attitudes to safety measures may be different in high and low risk of injury situations and the difference is of importance when estimating the effectiveness of safety measures.

Accidents should be studied in relation to their background so that not just numbers of accidents, but data about accident rates will be available. Typical rates are accidents per hundred thousand population, per hundred thousand kilometres driven, with different rates for distances driven on roads of different class or speed limit, by day or by night, or for journeys to or from work, or for social purposes during evenings or weekends. The possibilities are many, the value of them however, much depends on the car safety investigation being undertaken. For example the study of loss of control of cars is as much a study of the drivers compared with the whole population of drivers and for these studies accident rate comparisons with good background data are invaluable.

The situation in Europe is that there are countries in which the attendant circumstances of accidents are recorded in some detail. The feature which is least often noted is the estimate of speed of impact because this is not easily estimated, even by experts. However it would be of great value to analysts of accident data. Sources of background data are noted in the Appendices but they are relatively few and often not matched precisely to corresponding accident data. The situation is best for national human and vehicle populations, road traffic and lengths of road available. Background data relating to the road layout situation, traffic speed distributions, driver and pedestrian behaviour is just starting to be collected for one or two detailed accident surveys and these are particularly needed for primary safety studies.

The need for good background data to enable assessment of accident rates to be made, is shown by the overall comparison of accident rates between the various European countries. Most rates have a range of at least two to one between largest and smallest. No explanation of these differences has been conclusively demonstrated, though it seems likely to be attributable to differences in driving behaviour. More detailed studies of background situations in which accidents arise, seem to be required; the present results show that no obvious differences in road usage account for the differences in accident rates.

3. Prediction and ranking of safety measures

One task is to predict the effectiveness of a safety measure in saving accidents; for this two estimates are needed. Firstly a prediction is needed of the magnitude of the accident situation for which the safety measure might be of use, and secondly an estimate of what fraction of these a particular form or specification of safety measure might save. The fractional contribution multiplied by the number of accidents which the measure could affect then gives the effectiveness, which can be compared or ranked with other safety measures. The estimation of the magnitude or number of accidents has been discussed in sections 1 and 2; the estimation of fractional contribution is now discussed.

Estimates of the fraction of accidents saved by a safety measure are made in several ways,

a) relying on expert assessment of accidents in which the measure was not available,
b) a careful comparison of a few accidents in which the safety measure was present with a much larger number in which it was not,
c) large scale trials of cars with the safety measure in everyday use, or
d) the final comparison of when the safety measure is in general use with the previous situation.

a) Th estimation of the effectiveness of a safety measure is necessarily the work of an expert, familiar with both the results of detailed accident investigations and the effect that a safety device or impact specification might be expected to have. If one or two examples of a safety measure exist, they can be tested to improve the basis of the estimates. Having a firm idea in mind of the effect of the safety device, the investigation will consider each of a whole set of accidents in a study in turn and estimate for each, what probability the proposed safety measure might have had on the outcome of the accident if it had been present. A difficult aspect of this work arises if it is possible that in a minority of cases the measure might make an accident situation worse, because in such circumstances there may be no reported accidents on which to assess this effect. If the measure can be specified with, for example, differ test impact speeds, it is important to repeat the estimates of effectiveness for severa speeds; the final estimate of performance is then shown to vary from zero for a test impact speed such that all existing cars meet the requirement, up to some value for a test speed higher than the speeds at which cars actually have their impacts.

b) If several examples of a safety measure exist they can be tested on the roads to check that they actually work and do not develop defects or prove to be unusable. If the numbers are larger, their use in service can be checked to look out for any involved in accidents which would give the first direct evidence whether safety protection has been provided. This is the "clinical" approach; comparing the evidence for one accident with that of another matched accident in which all conditions were as similar as possible, except that in one the safety measure was not present.

c and d) Occasionally it may happen that many cars are in service with the safety device fitted to them, either by chance design or because a manufacturer has adopted a measure before it is legally required. This situation is similar to that of d) the retrospective review of a safety measure, which is discussed in section 4.

Whichever procedures are used to estimate the effectiveness of a safety measure, it is inevitable that the estimates are based on incomplete knowledge and in fact reasonable proof may be enough, as scientific proof is usually impossible.

The ranking of a set of suggested safety measures is another problem. Each has to be considered with respect to engineering feasibility for production and in use, cost to produce on a large scale, effectiveness in saving accidents or injury and acceptance by the public whether accepted voluntarily, after propaganda, or when required legally. From these considerations a degree of justification for each device may be agreed and also the best specification (such as of impact speed) and the earliest possible date of introduction may become apparent.

From this evidence a ranking policy can be proposed, the ranking being in chronological order of introduction of each safety measure. Some would be rejected and others left to await satisfactory engineering development if thought to be desirable in other respects. The question of interaction is most important for ranking because the introduction of one device before another may much reduce the possible effectiveness of the later one. In general terms secondary safety measures protect the same set of accidents as those prevented by primary safety measures and so there is interaction between them. Different primary measures less often interact with each other and similarly for secondary measures. The effect of interaction, which applies to the whole road safety policy (road, road user and vehicle), is that measures introduced early on assume great importance. Interaction explains why the effects (in terms of casualties) of several measures is not usually the sum of the effects of each measure if it was taken alone. Exceptionally, two measures put together may save more injuries than the two separately (eg wearing belt and some redesign of car interiors or lighting speed), but this does not alter the general situation that interaction usually reduces total benefits. It is to be noted that, besides interaction, some other reasons explain why the effectiveness of the whole set of possible measures is never total: there are some specific accidents and injuries which cannot be saved in the present state of technique as we are not able to design any suitable measure which would apply to them (eg the pedestrian problem), and besides, no economically possible measure is ever a hundred per cent efficient.

The situation in Europe is that several countries have been predicting and ranking safety measures for some years on the basis of barely sufficient accident data, but sufficient progress has been made to justify the effort. With results of further accident studies becoming available as indicated in the Appendices, the accuracy of the estimates is likely to improve. Because this situation has been reached, it has been possible for the EEVC to set up the three Working Groups to review the overall situation in Europe.

4. Evaluation of existing safety measures

The final stage in evaluating a safety measure is to check its efficiency in reducing accidents or injuries when in service. If introduced on a large scale voluntarily before legislation, this may be done then to ensure that legislation for universal adoption is correctly based, otherwise it must lag several years behind legislation until many cars are on the road and have had sufficient accidents. Statistical studies of the number of cars to be fitted with a safety device show that large numbers are needed for most accident situations for definite conclusions to be reached about the effectiveness of a safety measure. Thus these trials can be very expensive and difficult to manage. A careful matching of accidents in trial and control groups of cars can ease the difficulty of analysis.

The situation in Europe is that only a few final evaluations have been satisfactorily carried out. No entirely satisfactory comparison between toughened and the recent laminated glass has been completed because the different glasses are used in different countries. On the other hand it does appear that some forms of energy absorbing steering column have not been providing much protection. There have been small trial comparisons between anti-lock braked, load sensing braked and ordinary braked articulated vehicles; these have shown the expected results in most respects but have not been conclusive.

5. Methods for assessing human performance in accidents, human attitudes to safety measures and human tolerance of injury

One reason why slow progress has been made with primary safety measures, relating to the relationship between the driver and his car (his comfort, control loads and movements, his perception of the driving task from the driving seat, and of warnings by instruments), is that it has proved difficult to measure what the driver does and what sensations influence him at the actual time of an accident involving him. A little progress has been made by careful interviewing of drivers after accidents in detailed accident studies. More has been done to measure what a driver does when driving normally but this may differ from his reactions to accident situations.

It can be misleading to rely on interview methods for assessing driver attitudes to safety measures, such as the wearing of safety belts or their response to warnings of car troubles or hazards ahead. Again it seems best to reply on evidence of behaviour at actual accidents, as collected in some current investigations.

Working Group 3 is concerned with stating the situation regarding the estimation of human tolerance to injury. What is needed for progress in car safety design is injur threshold levels which can be used in test impacts for design purposes. All that need be said in this section is that useful progress can be made by using the actual accidents to find how people are injured and by then comparing these impacts with simila test impacts in the laboratory, using the same model of car in similar impact conditions. The speed of impacts to produce similar damage on the parts of the car structure hit by the occupants can then be found and from this the test speed for the injury threshold. Existing detailed crash injury studies are adequate for this work when the deformations of car components struck by the casualties are measured.

3. THE FUTURE NEEDS FOR DATA SOURCES ON CAR SAFETY IMPROVEMENTS

Introduction

Earlier parts of this report have reviewed the existing state of data sources on road accidents in Europe. The aim of this section is to outline the future needs as seen by the members of WG1.

It was thought that realistic planning of research should consider the problems of today and the next ten years. To consider the future beyond the next decade was thought to be too speculative. On the other hand many aspects of vehicle design require a considerable lapse of time before they can be incorporated into vehicles, and then distributed throughout the vehicle population in significant numbers. Good accident research must allow for this, and also it should predict where possible specific problems will develop in the future, as a result of changes in the system taking place today.

General aims of future research

The collection and analysis of data on actual road accidents should be integral parts of the wider problem of traffic safety and associated measures which aim to reduce death, injury and property damage. Field accident research must therefore be closely linked to government and industry, and thought of as a necessary prerequisite to any design or legislative change.

In essence, accident studies, as far as the vehicle is concerned, should provide answers to two types of question.

Firstly, specific mechanisms of injury and the nature of particular collisions need to be understood. Although this work can be conducted to a degree in the laboratory, with the use of volunteers or analogues of one type or another, (animals, cadavers, mathematical models or dummies), the final test of any design feature is its actual influence on a real person in a real collision. The roads of Europe each day provide a laboratory in which designs are perforce being tested, and this information should be evaluated as scientifically as possible.

Secondly, accident studies should provide knowledge on the frequency of various events. Only with information of this type is it possible to identify the relative importance of specific problems, establish priorities for remedial measures, and predict the likely benefits of certain courses of action. The laboratory cannot provide this type of data.

In recent years as accident research has become more scientific, the great importance of good experimental design has become apparent. This has produced the need for more carefully structured studies to solve the problems of representative sampling, illustrating the great need for compatible control data, for general background data on vehicle ownership and use, and for particular attention to be paid to the study of accidents which produce no injury. In planning accident research in the future it is important to resist short term unstructured projects which attempt to examine too many uncontrolled variables, and fail to produce significant results because of inadequate experimental planning. Although there are many urgent problems requiring immediate answers, it is important for the users of the results of accident studies to realise that future work may contradict the present conventional wisdom, and a continuous refining and monitoring programme is necessary if optimum legislation and vehicle design for crash protection are to evolve satisfactorily.

Specific aims of future research

This section outlines certain aims towards which future research should be directed. These aims are common to all motorised countries, and additional benefits to knowledge could be achieved if, without compromising specific national priorities which undoubtedly vary, compatibility and uniformity of data collection and analysis procedures could be introduced internationally.

1) The Magnitude of the Problem

It is fundamental that each country should have a national system for collecting some information on all injury producing accidents occurring within its borders. This information is necessary to evaluate the place of road traffic injuries in comparison to other causes of death and morbidity which are prevalent. Only then can a reasonable policy for the allocation of national resources between the competing demands on public and private expenditure be developed. Reports obtained through the police are, in most countries, the best basic source of data. However, checks are required to evaluate what proportions of accidents of differing types are under-reported by the police system.

The Working Group recommends the adoption of a basic accident recording system of relatively simple format. More emphasis should be given to vehicle parameters, and all the information collected should be of a simple, factual nature, with no room for value judgements. This latter type of information, for example the descriptions of driving behaviour in such terms as excessive speed or absence of training, as explanations for the occurrence of a collision, have been shown to be of little value, and indeed may be harmful. It should always be remembered that these nationwide data are in most countries supplied by policemen, who are performing this task as a subsidiary one to their main activities.

The advantages of uniformity of definitions between nations are important for these basic data. Whilst most countries for example now use the 30 day standard definition for a traffic death, injuries of lesser degrees are defined very differently from country to country. In the long term it will be essential for the development of common European policies, to have common agreed definitions of the basic characteristics of accidents.

Beyond the collection of basic data on a national scale, the Working Group recommends the development of two further levels of field accident study. The second level would produce more comprehensive data than the total national system, but would be restricted to, for example, 20% of all injury producing accidents. This sample would be carefully structured to ensure that it is representative of the relevant variables. These second level studies would be of limited duration to provide representative data on specific problems. The particular data collection procedures would depend on the problems being studied. In France for example a project is underway in which every fifteenth accident will be photographed by the police, thus providing detailed information on vehicle deformation. Similar sample studies are underway in Australia and Sweden for example, where procedures have been established so that all injured car occupants who were wearing seat belts are evaluated. In Germany the HUK organisation provides detailed descriptions of the collision circumstances and associated injuries based on a data source of some 30,000 accidents obtained from insurance files.

Of particular importance for Europe at the present time is a need to resolve the conflicts which exist between the protection requirements for different classes of road user and different collision types. The working group recommends that the following studies be initiated at an early stage:

1) A study of the conflicting requirements between pedestrian protection, car occupant protection and reduction of vehicle repair costs.

2) A study of the frequency of various collision types and their speeds in relation to proposed impact tests. Information is already available which demonstrates that the conventional 50 kph barrier test is representative of only a minority of collisions. The appropriate test conditions for front, front corner, side and rear impact collisions need to be justified before their adoption as legal requirements.

The third level of field accident study recommended is the specialist in-depth approach, where relatively small samples of accidents (a few hundred per year) are investigated in considerable detail. This type of research is necessary for an understanding of specific mechanisms of injury. Whilst the small sample sizes may preclude these studies from having strict statistical validity, they can nevertheless be related to the larger population of accidents by careful use of scaling procedures related to injury severity and collision severity, such as the equivalent test speed concept.

The Working Group therefore suggests that the development of this three level approach to field accident data should form the basis of future work in each country with as much compatibility of definitions as can practically be achieved. The accident investigation studies initiated by CCMS - NATO provide an excellent start, and such co-operative projects should be developed further.

2) Detection of Specific High Risk Situations

In addition to the basic accident data collection projects discussed above in 1), it is considered vital for parallel sources of data to be developed for the detection of specific high risk situations.

Here the need for control data becomes apparent. For questions concerned with primary safety for example, it is necessary to know the nature of the traffix mix, the relative proportions of different makes and models of vehicles in use, their speeds and their respective annual mileages. Similarly other problems require knowledge on occupancy, age, sex, presence of children, seating positions, use of seat belts, use of headlights and many other factors.

In the past the acquisition of these types of control data have largely been neglected, with the result that the significance of much accident data was lost. The Working Group recommends that careful experimental design techniques be used more widely, so that the value of relatively expensive accident data is enhanced by the collection of appropriate controls.

To this end there is much useful information which can be obtained by integrating information from a variety of sources such as licencing authorities, motor trade associations, insurance companies, vehicle fleet operators and the like.

3) Priorities of Proposed Countermeasures

The aims of improved vehicle design and vehicle safety legislation are to reduce the frequency and severity of accidents and their attendant injuries. These apparently simple aims may in reality not be as easily discernible as at first sight appears. This is because of a great amount of interaction between all the contributing factors which come together to create traffic injuries. Many examples of this interaction exist; for instance head restraints reduce the frequency of injury to the neck, they can also in some cars obstruct rearward vision; the front structures of cars can be optimised for maximum occupant protection in the standard barrier 80 kph collision, but if they are, then in head to side collisions the bullet car causes excessive intrusion into the side of the target car.

Primary safety countermeasures in particular require more analysis. The Volvo studies on the likely benefits of anti-lock braking are examples of how a priori assessments of countermeasures can be made.

The evaluation of any countermeasures, either for primary of secondary safety, is a three stage process. Firstly its effectiveness is assessed at the laboratory level. Secondly, the frequency of the particular events which would be modified by the countermeasure are estimated. Thirdly, if the countermeasure appears to be effective thus far, an experimental trial can be designed, the aim of which would be to measure the success of the device in quantitative terms under controlled circumstances.

Implicit in the assessment of countermeasures is the value to be assigned to an injury. The Working Group is convinced of the importance of cost estimates as a necessary prerequisite to cost-effectiveness studies. Although necessarily approximate and indeed notional for some items, cost benefit assessments are considered essential for establishing priorities of countermeasures. It should be remembered that most cost benefit studies are comparative, in the sense that the consequences of one possible course of action are being compared with those of another. Because of this fact, the results from such studies need only to rank choices, so that absolute values of costs do not have to be precise. More research is required on the costs of accidents and injuries however, because average figures for all types of injuries are inadequate for the assessment of countermeasures which influence certain specific types of injury.

The Working Group recommends that all suggested regulations should where possible be examined from a cost effective point of view, before their implementation. Also, when appropriate, research programmes should be similarly scrutinized, so that priorities for future research can be developed more rationally than at present. For example, recent work on the frequency of overtaking has shown that to concentrate a large effort on that particular aspect of driving behaviour is not likely to produce great benefits, because it is associated with a relatively small number of accidents.

Only by cost effective analysis, based on the known frequency and severity of various events can the conflicts in vehicle design between front, side, rear and pedestrian protection be resolved at optimal levels. Therefore, attempts should be made wherever possible to predict effects on the population of collisions before the introduction of changes.

4) Evaluation of Design Changes and Regulations

Once a change has been introduced, it is essential for follow up studies to be undertaken to quantify the effectiveness of the change. The experience of all previous accident, and indeed all epidemiological, research has shown that the reality is often very different from the conception. Common sense has that curious property of being more correct retrospectively than prospectively.

Wherever possible the introduction of a change should be preceded by an evaluation of the problem, the first half of a before and after study. Only then can a sound evaluation of the success of the measure be made.

As a consequence of this fact, the introduction of several measures at the same time should be resisted, even though there may be administrative attractions for such a course. If this is not possible then experimental trials should be initiated before decisions are made.

One aspect of effectiveness studies which will become more important in the future is the examination of non-injury accidents. This type of collision presents special difficulties if it is to be systematically evaluated, but this research will become more important in the future. For some specific questions it is already essential, the evaluation of the effectiveness of seat belts for example.

5) Human Tolerance to Impact and Performance Criteria

The Working Group agreed that one of the most important and immediate problems at the present time is to develop realistic injury criteria for car design. The establishment of performance standards is to be favoured over design standards, but a necessary prerequisite to such standards is a knowledge of the appropriate values, (in engineering terms), which can be assigned to the various parts of the body, as tolerance levels to impacts.

More work is also required on the severity of injury for which a tolerance level is specified. It is unrealistic for example to attempt to prevent all injuries from the minor to the fatal in all accident circumstances. Certain levels of injury must be accepted in some situations. Presumably the avoidance of death is the primary requirement, but the consequence of such a criterion is the acceptance of moderate levels of injury in less severe collision circumstances.

In-depth field accident studies can provide injury tolerance data. Laboratory studies can also contribute knowledge in this area, particularly work on cadavers.

It is important that these two types of research are coordinated as closely as possible to ensure that the laboratory conditions realistically reflect actual circumstances on the roads. This type of work is particularly important in the light of recent findings, which have demonstrated that dummies at their present state of development are far from being realistic simulations of the human frame. Of vital importance at the present time is the correct definition of head and chest injury criteria.

Field accident studies however are absolutely fundamental to the development of correct injury criteria, and the Working Group recommends that the objectives of the in-depth studies should be co-ordinated, internationally where possible, in an effort to produce better criteria than those proposed at present. These studies, by their nature are expensive, and therefore their value should be maximised by good exchange of knowledge at the technical level.

A particular type of research to be encouraged is the reproduction of specific collisions in the laboratory. With the actual injuries to an individual established from the field, the accuracy of the proposed tolerance levels and their measurement can be evaluated in an experimental collision.

An important part of the human tolerance question about which there is almost total ignorance at the present time is how human tolerance values vary throughout the population at risk because of age, sex and exposure differences. This is an important area of enquiry which needs immediate study. First indications are that for some major body areas, the chest for example, human tolerance values may well vary by a factor of four between the fifth and the ninety fifth percentile levels. The consequences of this fact on the single values currently suggested for injury criteria requires evaluation. The in-depth field accident studies discussed above should be directed at this question.

4. RECOMMENDATIONS

As a conclusion of this report, the members of the working group 1 make the following recommendations:

1. Generally speaking, the study of vehicle safety should be placed in the overall framework of accident studies and use all the available data collected by public authorities, insurance companies, car manufacturers, research organizations, etc. These data should be available without any restriction and made compatible as far as possible. Field accident research must be closely linked to government and industry and thought of as a preliminary for most legislative changes.

2. In order to know the importance of the different safety problems, a data recording system on road accidents with casualties should be available at three levels:

At the national level, information collected by the police should state objective facts, simple to write down, and include the essential data on vehicles.

To this first level, an intermediate level should be added, to provide representative data dealing in a more detailed way with specific problems considered as having priority.

The third level of data collection is an in-depth investigation by multi-disciplinary teams of samples of accidents which are necessarily small and not always representative.

The definitions and procedures used at these three levels should be made as uniform, or at least as compatible as possible. For this purpose, it is suggested that the EEVC should have a minimum list of the data to be collected and of the corresponding definitions made to send to the competent administrative authorities for adoption.

3. In order to detect abnormally dangerous situations, it is necessary to complete the collection of accident data by data measuring risk exposure (eg distances covered by different categories of drivers and vehicles), so making it possible to compare groups of casualties with control groups. For this purpose, the classical techniques of experimental design for data collection should be used systematically.

4. The proposals of measures for vehicle safety amelioration should be examined, as often as possible, from the point of view of their probable cost and efficiency. When a potential measure seems to be expensive, efforts appropriate to the importance of the measure, should be made in order to estimate its efficiency by means of experiments before its definite adoption. The orientation of research programs should also take into account, as often as possible, the probable advantages and disadvantages of the measures which are to be examined from a technical point of view.

5. The decisions taken in the field of vehicle standards should be assessed a posteriori. But because of the practical difficulties which are often raised in this type of assessment, it is recommended that the decisions should be taken step by step, in order to facilitate the experimental study of the efficiency of the different intended measures.

6. The accident data collected should make it possible to study the tolerance of the human body and the vehicle performance criteria.

As far as the tolerance of the human body is concerned, priority should be given to the studies of head and thorax injuries which take into account the variability of data on the population exposed to risk. As for vehicle performance, priority should be given to studies of the definition of crash test conditions representative of the real situation.

Also, a study of the conflicting requirements between pedestrian protection car occupant protection and the reduction of vehicle repair costs should be initiated.

These studies should be based on a combination of the observations collected in real accidents and in accidents reconstituted under controlled conditions.

7. Although there are difficulties in investigating primary safety, this field should not be neglected in future accident research.

8. The co-operation and co-ordination of these particularly difficult studies between the technical research centres should be widely encouraged internationally.

APPENDIX 1

LIST OF PARTICIPANTS IN WORKING GROUP 1

France	M. BLUET	O.N.S.E.R.
	M. HALPERN-HERLA	O.N.S.E.R. - I.R.T. Chairman of the group
	M. LEDRU	S.E.T.R.A.
	Melle MUHLRAD	O.N.S.E.R.
Italy	Mr STRAMPELLI	Ministry of transport
	Mr GASTALDI	FIAT
Federal Republic of Germany	Mr FELLERER	V.D.A./B.M.W.
	Dr FRIEDEL	B.A.S.T.
	Mr LANGWIEDER	H.U.K. - Verb
	Mr KREUZBERG	OPEL
United Kingdom	Dr MACKAY	University of Birmingham
	Mr NEILSON	T.R.R.L.
	Dr WATERS	D.O.E.
Sweden	Mr BOHLIN	VOLVO

APPENDIX 2

ROAD ACCIDENT INVESTIGATIONS IN THE FEDERAL REPUBLIC OF GERMANY AND BERLIN (WEST)

Road accident research in Germany is characterized by a great number of individual activities and investigations. A meaningful coordination and rational plans for the promotion of accident research are the most important tasks of the Department of Accident Research of the Federal Road Research Institute, conceived as central accident research agency.

In the following the sources of the most important road accident investigations are laid down in the form agreed upon at the Second Meeting of EEVC WG 1. The objectives of these investigations are distinguished into the groups mentioned below:

(1) Scope and severity of road safety problems.
(2) Identification of dangerous conditions of situations.
(3) Investigation into the problem: accidents vs. motor vehicles.
(4) Effects of accidents on human beings.
(5) Effectiveness: priority listing of counter measures.

A detailed list of references can be obtained from the Bundesanstalt fuer Strassenwesen (Federal Road Research Institute), Bruehler Strasse 1, 5 Koeln 51, Fed. Rep. of Germany.

A. Accident data

(1) Basic statistics

Organisations: (a) Federal Bureau of Statistics
(b) State Bureaux of Statistics
(c) Local Authorites Statistics (eg city or county police)
(d) Federal Motor Vehicle Department (KBA)

Aims: 1, 2

Numbers, dates and areas: Recorded are:
the number of accidents
the number of persons involved
the number of fatalities and injuries
the number of accident causes.

The Federal Motor Vehicle Department (KBA) publishes annually statistical data on the degree of motorization, private motor vehicle ownership, commercial vehicles, trailers, registration of vehicles and certificates of title, transfer of title, and deregistration of motor vehicles and trailers.

(2) On the spot surveys of accidents

Organisations: (a) leading car manufacturers
(b) Federal Road Research Institute (BAST)

Aims: 3

Numbers, dates and areas: 200-400 in depth studies of cars including detailed technical and medical analyses. A part of these investigations is included in the NATO/CCMS pilot study: "Accident Investigations."

(3) Detailed analysis of causes of accidents

Organisation: Motor Insurers Bureau (Verband der Haftpflicht-, Unfall-und Kraftverkehrsversicherer, HUK-Verband)

Aims: 1, 2, 3

Numbers, dates and areas: In 1970-71, 63084 files on serious injury traffic accidents were evaluated. The objective of this study was the establishment of a general data bank to enable the identification of the most critical accident causes and the involved traffic participants.

Organisation: Federal Road Research Institute (BAST)

Aims: 1, 3

Numbers, dates and areas: Due to the unfavourable development of traffic accidents in 1970, a general study of the relation between traffic accidents and highway traffic was made. The study was mainly based on statistical data and publications from the Federal Bureau of Statistics, the State Bureau of Statistics, the Federal Motor Vehicle Department, the Federal Ministry of Transport as well as on other relevant publications.

Organisation: State and community police

Aims: 2 and improvement of geometric design of roads

Numbers, dates and areas: A special card system on a local basis detects critical accident types and gives information on the frequency of typical collisions, run off the road accidents or roadside obstacle accidents.

(4) Crash injuries studies

Organisation: HUK Association (as mentioned above)

Aims: 3, 4

Numbers, dates and areas: The study covers 30,000 accidents with passenger injuries. A further study is in progress this year, covering 100,000 accidents. These studies will provide conclusions on the risk of suffering a certain injury depending on the car model and the seating position in the car.

B. Sources of background data for accident studies

(5) Vehicle examination studies

Organisation:	Motor Vehicle Inspection Department (TUV)
Aims, numbers, dates and areas:	In the Federal Republic of Germany, all motor vehicles are subject to a roughly biennial inspection, in particular in respect to proper function of essential technical safety elements such as brakes, lighting equipment, etc., at any one of the Official Motor Vehicle Inspection Departments where experts and inspectors are in charge of this task. Statistical records are kept on all defects detected. The statistics have no bearing on traffic accidents.
Organisation:	Motor Vehicle Institute of the Technical Allianz Center
Aims, numbers, dates and areas:	Special vehicle examinations are made in respect to structure, primary safety and driver behaviour.
Organisation:	All car manufacturers
Aims, numbers, dates and areas:	To improve the primary and secondary safety of standard car models and newly developed car models investigations, comprehensive studies and tests are made.
Organisations:	German Motor Vehicle Trust Institution (DAT), and the German Driver Control Association (DEKRA)
Aims, numbers, dates and areas:	Experts reports give conclusions as to technical defects and car damage.

(6) Other data

- In the Federal Republic of Germany, a great number of individual research activities are made, in particular in the fields of:

  - human factors
  - cost benefit analysis
  - road improvement
  - speed regulation
  - research into the technical features of motor vehicles
  - traffic medicine and traffic psychology.

- In the Federal Republic of Germany, no official data on the consequences of accidents in monetary terms are available (eg, costs of a fatality). Measures to improve traffic safety, currently contemplated by the Federal Government, are published in the Traffic Safety Program. The section "Motor Vehicle Design and Equipment" deals in particular with the following points: technical measures to prevent accidents, technical measures to mitigate the consequences resulting from accidents, head rests, laminated safety glass and others, safer occupant compartments and experimental safety vehicle.

APPENDIX 3

ROAD ACCIDENT INVESTIGATIONS IN FRANCE

Accident data

1 - National road accident report procedure

Organisation	Data provided by police for SETRA (Service d'Etudes Techniques des Routes et Autoroutes).
Aims	To provide help for decision making and to be used by administration and research organisations.
Numbers, dates and areas	About 250,000 injury-producing accidents and the corresponding 400,000 casualties, every year. These cover practically all the injury producing accidents occurring in France.
Details	The form which is filled by the police includes only simple information, about the place when the accident occurred, the road design, the vehicle type, the state of the occupants. The basic data are published every year (eg: Accidents corporels de la circulation routière - 1973 - SETRA).

2 - Insurance companies' files

Organisation	Accident files collected by the general association of the Insurance Companies (AGSAA); these companies insure about 80% of all vehicles.
Aims	Each accident reported to an insurance company is recorded in order to establish liabilities and evaluate costs.
Numbers, dates and areas	All accidents being reported to an insurance company belonging to AGSAA, whether these accidents produce injury or not. About 5,000,000 vehicles involved in accidents are recorded each year. A report is published every year.

Details	Though orientated towards the specific purpose of insurance companies, these statistics can be used by research organisations to estimate costs of accidents or relations between injury-producing accidents and purely material accidents, or to compare the estimates of injury-producing accidents and purely material accidents, or to compare the estimates of injury-producing accidents with those which are provided by police. Most accidents with only damage to the liable car are not reported.

3 - National accident investigation

Organisation	Data provided by the police and gathered by ONSER
Aims	To provide an intermediate level of statistics between the road accident report procedure and the detailed accident investigations.
Numbers, dates and areas	The data are collected on a representative sample of of accidents, including a fifteenth of all accidents occurring in France (about 16,000 of them). The collection is only starting now.
Details	The source of data is not the accident form filled by the police, but the regular accident declaration report. The results of data analysis will be more quickly available than those of the national file.

4 - Bidisciplinary accident investigations

Organisation	Investigations carried out by ONSER (Laboratory of LYON-BRON) in an area around Lyon, by the RENAULT-PEUGEOT Association in an area near PARIS, and at the SALON-de-PROVENCE hospital. CITROEN will also participate in collaboration with ONSER in Lyon.
Aims	To provide precise data on vehicle deformations and on crash injuries, to research organisations and to the car manufacturers.

Numbers, dates and areas	The study in the Lyon area is more than four years old and about six hundred cars involved in accidents have been fully investigated; the results are being analysed at ONSER. The data from the Paris Region study (about 1400 vehicles) and the Provence study are now being coded.
Details	The investigations have been carried out by three teams of physicians and car engineers. The results will be used to study specific problems, such as the relation between injuries and car deformations, the effectiveness of some safety devices already in service, or the study of priority of benefits. The sample of accidents being necessarily biassed, some of the data will have to be balanced.

5 - Specific investigations

Organisation	Investigation carried out at ONSER with the help of police or administration.
Aims	To provide the necessary data for some studies or specific aspects of the safety problem.
Numbers, dates and areas	The number of accidents investigated vary according to the problem concerned. These investigations have been carried for the last five years; for example: Vehitest (1971), the alcohol rate of the drivers (1969-1970), the relations between pedestrian behaviour and accident risks (1971), real accidents on safety-guides (1973), various kinds of windscreens (1973).
Details	The specific studies concerned here were undertaken to evaluate a priori the effectiveness of some measures. For example, the aim of Vehitest was to estimate the importance of technical defects of the vehicles as a factor of accidents and to provide necessary data for a cost-benefit analysis of different systems of technical car inspections, 1,600 accidents were investigated; the cars involved were inspected by engineers and the accident declaration reports were provided by the police.

Sources of background data for accident studies

1 - Daily traffic data

Organisation	Data collected and analysed by SETRA
Aims	To provide statistics on the average daily intensity of traffic on national roads and motorways.
Numbers, dates and areas	The traffic is observed daily in 900 permanent spots of the national road network. Night observations are also carried out for periods of three months on sections of the main traffic network. The results are published every year by SETRA. The traffic mixture has been analysed in 1970, with data provided by 25 of the 900 pilot spots, and such an analysis is to be repeated every fifth year.
Details	The observations are based on the notion of homogeneity, the criteria for homogeneity of a section of road being the density of population along the section, the width and the number of traffic lines, the intensity of traffic, the administrative department.

2 - Safety "dashboard" study

Organisation	The investigation is carried out by ONSER
Aims	To provide data on traffic out of towns of more than five thousand inhabitants and also on traffic in towns (traffic intensity and mixtures, average speed, use of safety belts), and on the relations between the driver and the vehicle.
Numbers, dates and areas	The investigation on traffic out of towns has been going on for two years and has taken place in 20 departments. During the first year of investigation more than 25,000 vehicles have been observed. The two other types of investigations are just beginning. They will take place in the same 20 departments as the first one.

Details	The twenty departments have been chosen to constitute a representative sample, on the basis of their geographical situation and of their petrol consumption. The observation spots are distributed on the various categories of roads in proportion of the length of the corresponding networks. Results are published every month by ONSER (eg Tableau de Bord mensuel de Sécurité Routière - Décembre 1973)

3 - Sample survey on the road transport of goods

Organisation	Survey carried out by INSEE (National Institute of Statistics) and the Department of Transports.
Aims	To provide data on the traffic of heavy vehicles, such as number of lorries in service, annual distance driven by an average lorry, etc...
Numbers, dates and areas	This survey is done every year. One survey is carried on for a fortnight, and about 50,000 vehicles are observed in a week.

APPENDIX 4

Road accident investigations in Italy

1. National road accident report procedure

Organisation	Data is provided by Road Police, City Police and Military Police (Italian name: Carabinieri) mainly for justice need. Brief data transferred in standard form sent to "Istituto Centrale di statistica (ISTAT-ROME)". All data stored on computer with tabulating, listing and mapping programs.
Aims	To be published into two books put up on free sale. First book with 41 tables concerning type of load, vehicle, time, day, month , driver's age, type of crash, death, injury (driver, passenger and pedestrian) and so on. Second book reports number of accidents, deaths and injuries for each kilometer of Italian highway and motorway.
Number, dates and area	About 200,000 injury producing accidents and 130,000 accidents with damage only a year, for the past four years or more, covering whole Italy.

2. National driver's behaviour report procedure

Organisation	Summary report is sent by police to local office of Motorizzazione Civile (U.P.M.C.T.C.) and to Prefects granting driving licence for every accident producing death or serious injury (more than 40 days before recovery).
Aims	To provide technical data for driver's licence suspension and user factor contributing stored on computer.
Number, dates and area	About sixteen thousand injury producing accidents a year for the past four years or more, covering whole Italy.

3. Car manufacturers accident studies

Organisation	Data is provided by branch to manufacturers FIAT and ALFA ROMEO.
Aims	To collect vehicle damage and injury data in detail for vehicle design purposes.
Number, dates and area	3,000 accidents in 2 years - Torino (FIAT) 100 accidents in 1 year - Milano (Alfa Romeo) Data ready not stored on computer.

4. Highway statistic, traffic

Organisation	Azienda Nazionale Autonoma delle Strade (A.N.A.S. - Roma) provides pointed check of traffic survey during some hours, day (holiday or not) month.
Aims	To compile each year Censimento Circolazione (Traffic Statistic) 1970 (the latest).
Number, dates and area	Traffic data is measured at about 5,000 point in particular sites all overy Italy. Data listed with ten types of vehicles.

5. Registration and traffic vehicles

Organisation	Associazione Nazionale Fra Industrie Automobilistiche (ANFIA - Torino) compile each year "Automobile in cifre" (Vehicle statistic) 1973 (the latest).
Aims	Book put on free sale, concerning production traffic (from tax payment), registration.
Number, dates and area	Whole Italy, every year.

APPENDIX 5

ROAD ACCIDENT INVESTIGATION IN SWEDEN

Traffic accident investigations on various levels are carried out in Sweden by government authorities and institutions and by private companies - the car manufacturers and insurance companies.

This list of data sources has been produced by Mr B R Nilsson of A B Volvo, Car Division, Göteborg, Sweden.

Accident data

1. National road accident report procedure

Organisation	Swedish Road Safety Office (SRSO). The SRSO has a team for certain analysis of traffic accidents. The study started in conjunction with the change to right hand traffic in Sept 1967. NTSA reports every day on fatal traffic accidents. The main information sources for reports are the 119 police forces and the Swedish Central News Agency.
Aims	The study is mainly a follow up study day by day of the accident frequency situation for policy and traffic regulation decision making.
Criteria	Fatal road traffic accident.
Number, dates and area	About 1,200 fatal accidents a year for the past 6 years covering Sweden.
Details	Data are about time, place, type of road, classes of vehicle and numbers of fatal and injured in each accident.

2. General accident studies

Organisation	National Central Bureau of Statistics (NCBS)
Aims	Official statistical data on traffic accidents. Basic data on site of situation and circumstances in which accidents occur.

Criteria	Road traffic accident involving personal injury.
Numbers, dates and area	About 28,000 injury accidents a year. The accidents studies started about 50 years ago. Accidents involving injuries to a person are reported by the 119 police forces to the NCBS.
Details	For the purpose a special form is used, with about 60 questions about accident circumstances, classes of vehicle, environmental factors and injury data.
Storage	All data are stored on computer.

3. Special studies

Organisation	National Swedish Road and Traffic Research Institute (NSRTRI).
Generally	The NSRT-institute makes various special studies, such as traffic accidents with heavy vehicle combinations, influence of speed on road accidents, effect of stud tires etc. These studies are primarily based on the statistical data available but involve also interview questionnaire for people involved in accidents. Some studies, eg the stud tire inevestigation in 1972-73, are accomplished in co-operation with car manufacturers and insurance companies.

4. Car manufacturer accident investigation

Organisation	AB Volvo. The in-depth/multidisciplinary investigations are carried out by two teams - one team for car accidents and one team for truck accidents, in co-operation with police and emergency alarm center and hospitals. The statistical investigations are made in close co-operation with the Volvo 5-year guarantee organisation, Volvia Insurance Company, Volvo dealers and hospitals.

Aims	To create relevant data for various automotive safety questions as: vehicle design, human tolerance factors, product safety and liability, crash test program and specification.
Numbers, dates and area	GO-teams: About 100 fatal and injury accidents a year of each team. The area covered is roughly within 1-hour drive from Gothenburg.
Criteria	Traffic accident involving Volvo 140 and 164 causing occupant injury or any truck accident.
Numbers, dates and area	Statistical investigation: 5,000 to 6,000 at the most severe accidents with Volvo cars a year. This survey was started in October 1973 and is supposed to run continuously.
Criteria	Traffic accident involving Volvo 140 and 164 causing major property damage.
Details	Statistical investigation. The data collection includes an interview questionnaire mailed to the driver involved.
Generally	In addition to the basic investigation activities above mentioned Volvo has various temporary projects related to traffic accident research, eg skid accident investigations, analysis of all the fatal car accidents in Sweden in 1973, human tolerance data derived from road accidents.
Organisation	Saab-Scania
Generally	Saab-Scania has a team within its development department for certain traffic accident research. The data collection and analysis is retrospective in its nature and is limited to the most severe Saab vehicles in accidents in terms of vehicle damage. The research work has temporarily involved a go-to-the-scene activity.

A statistical accident survey has also been made by Saab.

5. Insurance companies accident studies

Organisation	Insurance Company Folksam and others
Generally	Since 1969 the insurance company Folksam has had various accident studies going on. The activities concerned are partly located at the main office in Stockholm and partly at an experimental body-shop in Växjö. The main purpose of the Folksam studies is to reach conclusions from field accidents reported to the company concerning the injury producing mechanisms of the interior design of the vehicle. The insurance company Skandia has recently carried out an investigation related to the child in road traffic, especially the child of pre-school age. Quite recently all the traffic insurance companies in Sweden have agreed to organise a road traffic safety committee, which is thought to have traffic accident investigations on its program. The nature of the investigations has not been announced yet.

6. Sources of background data for accident studies

Organisation	Swedish Vehicle Inspection Company, owned by the Swedish State, the car insurance companies, Automobile Clubs, and the Automotive Association.
Aims	Annual traffic safety inspection of all motor vehicles - cars, trucks, trailers and motorcycles - with an age of three years and older.
Numbers, dates and areas	About 3 million vehicle inspections a year for the past nine years covering Sweden.

If question or information are needed write to the Swedish Road Safety Office.

Address: Statens Trafiksäkerhetsverk
Box 508
126 05 HÄGERSTEN, Sweden

APPENDIX 6

ROAD ACCIDENT INVESTIGATIONS IN THE UNITED KINGDOM

Road accident data and background information are collected in several different ways in the United Kingdom. The main sources of data are listed below. Information is available from those sources marked with an asterisk. Abstracts of reports describing some of these accident data, or the uses to which they are put, can be selected and sent out by the United Kingdom, IRRD Centre, which is at TRRL, Crowthorne, Berks, UK.

Accident data

1. National road accident report procedure (Stats 19)

Organisation	Data provided by police for Department of Environment (DOE) and its Transport and Road Research Laboratory (TRRL)*.
Aims	To provide basic data for policy decision making and a data bank for use by government, research, local authorities and industry.
Numbers, dates and area	Quarter of million injury accidents a year for the past 15 yrs or more covering England, Scotland and Wales (most accidents except for some single vehicle, pedal cycle, motor cycle and car accidents).
Details	About 50 questions about casualties, vehicles involved and attendant circumstances, most with between 2 and 12 multichoice answers. Accuracy based on booklet of definitions (Stats 20). Compilation by headquarters staff at the 63 police forces, with checking at DOE/TRRL. All data stored on computer with tabulating, listing and mapping retrieval programs. Data are about time, place, type of site, classes of vehicle and numbers of injured in each accident. Basic data published annually eg 'Road Accidents 1971' (HMSO*).

2. On-the-spot survey of accidents

Organisation	TRRL*
Aims	To find how and why accidents occur and to identify road, vehicle and road user factors contributing, using survey for policy making and as data bank for government, research and industry.
Numbers, dates and area	2,000 (mostly injury) accidents by four years up to spring 1974 in east of Berkshire, England.
Details	Many details but not a full in-depth study and no injury data. Vehicle and road scene information with interviews of those involved. Some background data collected. Filing of paper records with about 200 items of information stored on computer for each accident for indexing and tabulation purposes. Used as a basis for primary safety assessments. Special studies of loss of control, car colour, brake and tyre condition and driver behaviour.

3. Crash injury study

Organisation	TRRL*
Aims	To find how car occupants and others are injured, for policy making and as a data bank for government and research into incidence and human tolerance of injury.
Numbers, dates and area	Main study is of 1,000 serious or fatal injury accidents since 1965 in Thames Valley area.
Details	In depth study of car occupant injury causation. Many accident details recorded as well as medical investigations into injuries. Separate studies of how pedestrians, motor cyclists and others injured and of performance of windscreens and steering columns in accidents. Filing of paper records with computer storage for indexing and tabulation of over 50 accident and 150 injury items per casualty. Used

	as a basis for car secondary safety assessment but does not record severe impact accidents without serious injury, low in urban accidents.

4. Crash injury and general accident study

Organisation	Birmingham University, Department of Transportation and Environment Planning* in conjunction with the Birmingham Accident Hospital.
Aims	Data bank for studying accident and injury causation for use by government, research and industry.
Numbers, dates and area	2,000 vehicles and occupants in injury accidents since 1965, many in urban Birmingham and outskirts.
Details	Detailed studies, particularly for injury investigations but also for primary safety with various special objectives at different times. Continuing with injury and crash performance of current model cars and pedestrian injury in relation to car exterior design. Much of work planned to suit particular car safety enquiries.

5. Additional police investigations into accidents

Organisation	Almost all of 63 police forces
Aims	To supply further accident data to assist Local Authorities responsible for roads. Also special studies, some to assist TRRL, other to place the determination of responsibility of accidents on a more scientific basis.
Numbers, dates and area	Most police forces help Local Authorities, also occasional studies when needs arise.

Details	Most record road data, additional to those for Stats 19 and store it all on local computers. Special studies include: 1. All fatal accidents, cars into rears of heavy goods vehicles. 2. Extra Motorway accident data. 3. Metropolitan police study of effect of car colour at intersections. 4. Interpretation of skid marks.

6. Car manufacturers accident studies

Organisation	Ford Motor Company and others
Aims	To improve design of cars for safety
Numbers, dates and area	Usually close to car manufacturers sites, various numbers and dates.
Details	Results are not generally made available, but are usually to study secondary safety performance of recent car models or to study reported defects.

Sources of background data for accident studies

7. Vehicle examination studies

Organisation	Vehicle Engineering and Inspection Divisions, DOE.
Aims	To investigate possible vehicle defects in service and in accident to provide data for need for manufacturers recall campaigns.
Numbers, dates and areas	All areas. About 500 vehicles a year found to have defects, mostly goods and public service vehicles.

8. Highway statistics, traffic and other data

Organisation	Department of Environment (HMSO*)
Aims	To publish data annually (eg 'Highway Statistics 1971') to inform those needing data on vehicle registrations, traffic, road mileage etc.
Numbers, dates and areas	Traffic data is measured at 200 points at all times and 1300 points in 1960, 1966, 1973 at random sites over Great Britain.
Details	Further details of national data in 'National Travel Survey', 'National Income and Expenditure', 'Private Motoring in England and Wales', 'Family Expenditure Survey', 'Characteristics of drivers obtained from large scale enquiries (TRRL, LR 389)'.

9. Special counts of background data

Organisation	TRRL and others
Aims	Various aims to help understanding of accident data.
Numbers, dates and areas	Varied, but usually as small as possible in particular areas and not repeated regularly.
Details	Examples include fitting and wearing of seat belts (repeated regularly) and condition and pressure of tyres.

10. Local authority data

Organisation	Most local authorities
Aims	Data collected for planning purposes in local area.
Numbers, dates areas and details	Most areas have large origin - destination studies for road planning. Also measurements of road surface slipperiness, traffic counts and accident studies for monitoring road aspects of safety.

ANNEX 3

REPORT OF WG2 - THE ORDER OF PRIORITY AND MAJOR REQUIREMENTS FOR SAFER CARS FOR THE NEAR FUTURE

1. PROGRAM MAIN GUIDING PRINCIPLES

After considering the information discussed by Working Groups 1 and 3, this group was to proceed with an analysis of the various problems to lead to the definition of the corresponding safety requirements and their order of priority. Finally proposals for possible future action were to be made to the main committee.

The actual speeds and other detailed suggestions made by Working Group 2 in this report for possible impact tests and other procedures are preliminary indications rather than final statements of an EEVC point of view. Time was not available for WG2 to estimate costs and benefits to be expected from a range of measures, such as speeds of impact for a test procedure, so that optimum conditions could not necessarily be selected.

The WG2 task program has developed along three main guiding principles and with the following priorities:

A - Car internal and external design features for occupant protection.

B - Car external design features for protection of other exposed road users.

C - Primary or preventive safety design features.

2. CAR OCCUPANT PROTECTION

The car occupant safety characteristics must be established as a function of the following two requirements:

A - Reduction of direct impact and consequential severity of injury in the various accident modes.

B - Elimination of indirect dangers ensuing from such accident events (fire, impossibility of timely aid, etc.)

The above two basic requirements should be met by specifying suitable performances for standard impact tests conducted on cars with restrained or suitably protected dummies.

The performances to be required could be as follows:

1 - Compliance with biomechanical tolerance limits.

2 - No bursting open of doors during impact.

3 - Possibility, after collision, of opening at least one door without tools.

4 - Possibility, after collision, of removing the complete dummies.

5 - No fuel spillage or fire.

2.1 Restraint Systems

Among the presently known restraint systems, the seat belts (3-point type, in particular) are certainly the most effective and simple in providing a reasonable direct protection of car occupants in the majority of road accidents.

It is desirable to have future regulations which make it mandatory to install and wear seat belts in all European countries. In view of this, utmost R & D efforts should be devoted to seat belts in order to improve their present features and performance. Ameliorations should be concentrated on the following aspects:

- Installation on car
- Dimensional and strength specifications of the different components
- Location relative to occupants
- Occupant comfort
- Manual fastening
- Automatic adjustment and locking
- Dissipation of occupant kinetic energy through absorbing devices
- Starter inhibition or some other interlock when belts are unfastened (possibly)
- Warning systems for when belts are unfastened.

The rational solution of the different problems associated with the use of seat belts will require the close coordination of all the effort spent in this field.

Further development of passive restraint systems should be investigated.

2.2 Test Methods for Impact Simulation

The discussion of the answers given by the various National Delegations to the questionnaire prepared by WG2 has led to a common attitude on the four main impact modes intended to verify the occupant protection performance.

For each of said impact modes, at this time, the alternative of different test methods was indicated: the final choice will be made once the comparative test results and accident analysis data will both be available.

The comparative tests on current production cars should highlight the severity level of each impact mode being investigated from the standpoint of damages to the car and possible consequences on the occupants.

In this connection, cooperation by European Car Manufacturers will be requested.

2.2.1 Frontal Impact Test

Test Procedure

To be selected between the following two tests A and B, both are considered to be practical modifications of the existing head-on test. They are likely to lead to further reductions in injury according to predictions based on existing accident studies.

A. Impact against barrier angled at 60° to vehicle main axis.

B. Offset impact against barrier with radiused edge (15 cm radius).
The impact must involve half of the vehicle front (provisional agreement).
As a rule, the impact half must be the steering wheel side but the test can be repeated on the opposite side, when found advisable.

Test Velocity

50 km/h.

Test Conditions

Vehicle in running order.
Two (2) dummies (50th percentile, male) in the front outboard seating positions.
Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 2, items 1 to 5 inclusive.

2.2.2 Side Impact Test

Test Procedure

Apart from improving the protection available for occupants of cars struck in the side, these tests should encourage compatability between the fronts of vehicles and the sides of cars which they strike. At present the test may be selected from A and B, but these may be further developed by substituting for the striking vehicle an impactor with a standardised front, representative of future European car frontal structures.

A. Stationary vehicle struck on its side by the front end of an identical vehicle.
The velocity vector of the striking vehicle must make an angle of 75° to the main axis of the struck vehicle.

The main vertical plane of the striking vehicle must pass through the driver's seating position H point.

B. Moving vehicle struck on its side by the front end of an identical vehicle. The main axes of the two vehicles must be set at 90°. The relative velocity vector of the striking vehicle must make an angle of 75° to the main axis of the struck vehicle.
The main vertical plane of the striking vehicle must pass, at the instant the impact begins, through the driver's seating position H point.

Test Velocity

40 km/h (relative velocity of striking vehicle to struck vehicle).

Test Conditions

Two (2) dummies (50th percentile, male) in the seating positions adjacent to the struck side.

Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 2, items 1 to 4 inclusive.

2.2.3 Rollover Test

Test Procedure

To be selected between the following two:

A. Rollover test with two full rotations
Test Velocity
50 km/h (initial speed).

Test Conditions
Vehicle in running order.
Windows closed.
Two (2) dummies, (50th percentile, male) in the front outboard seating positions.

Restraint systems in the normal position and conditions specified to enable them to act on the dummies.

Requirements to be met

As specified in Para 3, items 2 thru 5 included. Additionally, no ejection (even partial) of dummies and absence of excessive deformations (collapse) of roof.

B. Dynamic impact test on roof front corner by pendulum or moving barrier having a mass corresponding to 60% the curb weight of the test vehicle.

Test Velocity

10 km/h

Test Conditions

Vehicle body fast on ground. No dummy on board.

Requirements to be met

Absence of excessive roof deformations (collapse).

NOTE: The test could be run statically by applying to the roof front corner a pre-established load by means of a rigid flat plate. Complementary static tests could be carried out to verify the capacity of the door locks to prevent accidental door opening under loading from inside and outside the passenger compartment.

2.2.4 Rear Impact Test

Test Procedure

A. Stationary test vehicle struck from rear along the longitudinal axis by a moving barrier or pendulum of 1100 kg.

Test velocity

35 km/h

Test Conditions

Empty vehicle, in running order, unbraked and in neutral.

Requirements to be met

As specified in Para 2, items 2 to 5 inclusive.

2.3 Compatability

It is clear that the problem of compatability must be viewed within reasonable limits and that the possibility of compatability should therefore be ruled out in the event of collisions between vehicles quite dissimilar as regards mass, size, shape and structural characteristics (e.g. cars and trucks).

The objective of compatability should therefore be confined to cars and, presumably, to a limited range of these.

For an exact definition of the limits of said range, the following data should first of all be analysed:

- Characteristics of cars on the road in Europe (weights, size, mechanical layout, etc).

- Mass ratios in the various car accident modes.

The final compatability performance will almost certainly amount to meeting requirements 1, 2, 3, 4 and 5 listed under para 2 in front, side and rear impact tests.

The main problem will indeed be to define a representative impactor. Taken to the extreme, this could be reduced to a single structure simulating the front end of a car whose shape, size, mass and stiffness (local and overall) are representative of those of all cars pertaining to the range considered.

Another criterion could be that of testing using a standard obstacle (deformable barrier, large framed sheet-metal restrained at either side, etc.) on which to measure intrusion depth, space, piercing and etc.

3. PROTECTION OF PEDESTRIANS AND EXPOSED RIDERS

The problem of the protection of exposed road users is second only to car occupant protection.

However, potential solutions are not very encouraging and even the more optimistic proposals are somewhat lacking in terms of effectiveness. According to the present knowledge, there are only few possibilities of improving the safety features of cars for the protection of pedestrians at collision speeds above 10 Km/h.

The accidents covered by this area of safety can be classified according to topic of investigation as follows:

a - Pedestrian
b - Pedal cyclist and motor cyclist

3.1 Pedestrian Protection

The most important of the various types of accidents involving a pedestrian consists of three phases as follows:

1 - Pedestrian is hit at leg level by the outermost part of car front end
2 - Pedestrian hits bonnet and can be hurled onto windscreen
3 - Pedestrian falls on road

At low speed, impact severity and risk of fatality grow rapidly in phases 1 to 3, whereas at medium and high speeds phases 1 and 2 may already cause death.

Safety requirement investigation will be carried out in the above phase sequence in order to:

- Assess the effect of shape, size, stiffness and location of car front end protrusions on risk of fatality at initial impact.

- Evaluate the effect of shape, size, and stiffness of bonnet and windscreen on risk of fatality at second impact.

- Examine the potential of pedestrian restraint systems designed to prevent third impact.

3.2 Pedal Cyclist and Motor Cyclist Protection

Though no laboratory test information is available on simulated accidents with pedal and motor cyclists, it can be assumed that the sequence of events differs from that of accidents with pedestrians mainly at initial impact, when, in most cases, only the car and cycle come into contact with one another, involving the front, side or rear of the car. As a consequence, second impact can involve areas other than the bonnet or windscreen.

Some of the safety requirements for pedestrian protection may well apply also to pedal and motor cyclist protection, at least for straight-ahead impact against car front or rear end.

A definition of specific requirements is unlikely.

4. ORDER OF PRIORITY OF SECONDARY (OR PROTECTIVE) SAFETY MEASURES

The following numerical code is used for priority and practicability ratings:

PRIORITY,	1 = Maximum,	2 = Medium	3 = Minimum
PRACTICABILITY,	1 = Available,	2 = Foreseeable,	3 = Doubtful

Priority is an overall assessment indicating the need for work to be carried out, whether this be further investigation or final development of test procedures. Practicability is the engineering practicability for producing cars with the safety measure of the performance suggested.

	Priority	Practicability
Seat belts improvements to belts and cars to increase performance, convenience and comfort related to their use and standardisation of buckles.	1	1
Investigations to improve protection for pedestrians when struck by cars.	1	3
Frontal impact measures for restrained occupants	1	1
Side impact measures	2	2
Rollover measures (prevent door opening and roof collapse)	3	2
Rear impact measures	3	1
Fire prevention	3	1
Release of occupants whether injured or uninjured	3	1

5. PRIMARY SAFETY

The need for new or improved primary or preventative safety requirements seems to be much less urgent than that for secondary or protective safety for car occupants and other road users.

In fact, many primary safety improvements have been introduced in the past, and at present detailed accident investigations are showing to what extent various safety measures may actually contribute to safety. The following notes summarise tentative conclusions of this work.

	Priority	Practicability
BRAKES		
Antilocking systems (good potential but need assessment and further development for reliability)	2	2
TYRES		
Low pressure and deflation warning	2	2
Safety tyres	3	1
DRIVING AIDS		
Warning or driver control devices for unexpected hazards, driver fitness and car speed are all potentially useful, but need development and trials.	2	2
Ergonomics of driving task (comfort and optimisation of controls and layout)	3	1
HANDLING		
Research needed to study car behaviour, drivers and their inter-relationships	2	3
LIGHTING AND VISIBILITY		
Conspicuity of cars by warning and signalling lights and other means, need re-assessment. Driver's view at night and in adverse conditions also needs re-assessment	2	1

APPENDIX 1 LIST OF PARTICIPANTS IN WORKING GROUP 2

Prefices 1 and 2 indicates only the first and second meetings respectively.

	Sig. G Pocci	Chairman	Ministry of Transport	Italy
	Mr R Sharp		DOE	United Kingdom
	Mr W L Baxter		DOE	United Kingdom
	Mr R D Lister		TRRL	United Kingdom
	Mr I D Neilson		TRRL	United Kingdom
1	Mr P Finch		British Leyland	United Kingdom
1	Mr J Knight		SMMT	United Kingdom
2	Mr J Hollings		SMMT	United Kingdom
	M A Osselet		Ministère de l'Equipment	France
	M H-Herla		ONSER	France
	M Bluet		ONSER	France
	Herr Friedel		BAST	Germany
	Herr Kleinsteuber		Vd - TUEV	Germany
1	Herr Lincke		Volkswagenwerk AG	Germany
2	Herr Seiffert		VDA	Germany
	Sig G Danese		Director CPA	Italy
1	Sig C Schinaia		CPA	Italy
1	Sig C Lomonaco		CPA	Italy
2	Sig R Strampelli		Ministry of Transport	Italy
2	Sig A Palieri		CPA	Italy
	Sig C Tibiletti		ANFIA	Italy
2	Sig E Franchini		ANFIA	Italy
2	M Tarriere		CCMC	-
2	Sig Puleo		CCMC	-

ANNEX 4

REPORT OF WG3-HUMAN TOLERANCE LEVELS AND OCCUPANT PROTECTION EVALUATION TECHNIQUES

1. PURPOSE AND SCOPE OF THE WORKING GROUP

At the fifth meeting of the European Experimental Vehicles Committee at Crowthorne in June 1973 it was agreed that a common view should be established on a number of subjects relating to safety features for production cars coming onto the European market in the early 1980's. The objectives of these features would be to provide greatly improved safety at an economical cost.

Working Group 3 was set up by the Committee to consider one group of subjects, namely human tolerance and test techniques for assessment of car safety features. Two meetings of this working group were held at the Transport and Road Research Laboratory at Crowthorne. The membership of the group is given in Appendix I and consisted of experts from national administrations, some branches of the motor industry and testing and research establishments. In addition other interested parties were given the opportunity to comment on the various questions under consideration. CCMC did so but BPICA because of the short time available was not able to do so.

The objectives of the group were firstly to consider the maximum loadings (human tolerance) to which road users can safely be subjected in road accidents, and to state any doubts which exist about the loadings for particular types of impact, together with proposals for experimental work or other investigations necessary to determine what levels should be chosen and secondly to consider test techniques and dummies for verifying that human tolerance loadings are not exceeded in car test impacts.

The group felt that its report should be in realistic terms and proposals should be applicable to mass production vehicles.

The report which follows consists of four sections dealing with Human Tolerance Levels, Test Techniques, Test Devices and Recommendations.

2. HUMAN TOLERANCE LEVELS

If tolerance levels are specified their use must be justified by accident data, they must be representative of the population of vehicle occupants and the form in which they are specified must be suitable for evaluation in impact tests.

Many tolerance levels for various areas of the human body are quoted in the literature but relatively few of these are universally accepted. The collection and refinement of such data is of prime importance if a great deal of time and resources is not to be expended in designing safety features for cars to inaccurate specifications, such features as a result not being fully effective.

Nevertheless a list of human tolerance levels is given in Appendix 2 as the best guide for designing safer road vehicles that the group could present at this point in time.

Each of the tolerance levels listed cannot be specified in isolation, the total injury spectrum must be reviewed. For example, in extremely severe accidents, skeletal fracture in one part of the body may be acceptable if it precludes fatal organ decelerations in another.

The actual level of loading which it is appropriate to specify depends on how it is to be used. If, for instance, the design of the restraint system is such that the loading applied to the body is dependent on severity of the accident, as is the case with standard seat belts, then a high tolerance level which could be expected to injure say 25% of the people involved in relatively rare severe accidents, might be justified to improve the protection for the remaining 75% at high speeds and of the whole population at lower speeds. On the other hand if the loading is applied in all accidents, as is the case with pre-tensioned seat belt systems at present under investigation, then an injury rate of 25% in minor accidents would not be acceptable and a lower tolerance level must be specified.

Research is needed to provide information on the statistical spread of human tolerance levels in the population and how these levels vary with age and sex. In addition there is need for a summation technique to be developed to enable the more serious effects of multiple injury to be assessed.

Four methods of determining human tolerance levels have been used in the past, namely, tests of human volunteers, cadaver tests, interpretation of accident data and tests on animals.

Although each method has some advantages, scaling from tests on animals and extrapolation from human volunteer tests produce results of doubtful value. In order to approximate to tests on the live human being, tests reproducing road accidents are being performed using cadavers. There are problems of dispersion between individual cadavers, of obtaining cadavers representing the younger age range and of obtaining sufficient results for statistical validity. In addition there is the problem of knowing how measurements made on cadavers can be related to measurements made on dummies. Some research is being undertaken in which the performance of belted cadavers is being directly correlated with that of anthropomorphic dummies. In other investigations accident data is being interpreted using dummies and impact devices in simulations of the accidents, to obtain tolerance levels directly applicable to these dummies and impact devices, and relating to the type of people who are being injured in accidents.

The fact that human tolerance levels to deceleration or force, determined in tests with cadavers cannot be directly applied to tests with dummies, because of the difference in performance between dummies and cadavers, is extremely important and needs to be borne in mind when drawing up proposals for development objectives or legislation.

The human impact tolerance levels specified in Appendix 2 should be adjusted if comparative dummy tests under the same test conditions as those in which the tolerance levels have been determined using cadavers, produce output readings different from those obtained from the cadavers.

3. TEST TECHNIQUES FOR THE ASSESSMENT OF CAR SAFETY FEATURES

The selection of the impact conditions for which it would be most appropriate to assess car safety features was the assignment of a separate working group but working group 3 was asked to review the technical aspects of the currently available test techniques and appendix 3 of this report gives detailed comments on the various techniques. For technical reasons and economy is testing, relatively few key tests should be required, mainly on complete vehicles. These tests should be backed by test data from laboratory rig tests etc and, in some instances, substitution of such data in the event of failure of one or two instrumentation channels in the key tests rather than requiring a complete retest, might provide valid information.

It may not be possible to design a vehicle to provide optimum protection for both restrained and unrestrained occupants and it is probably impossible to provide effective restraint at the present time for all sizes of occupant. For example pregnant women or very large or small people may not be able to use restraint systems. So although every effort should be made to ensure that as many people as possible use the restraint systems provided and priority should be given to providing protection for restrained occupants, some protection should be afforded for unrestrained occupants, care being taken to ensure that the provision of such protection does not excessively impair the protection of restrained occupants. If additional requirements are proposed for unrestrained occuapnts, then either the same tests as proposed for restrained occupants but at lower impact severities, or simpler tests using dummies in body shells mounted on rigs or tests using test-forms to impact critical components as required in ECE and US regulations would be sufficient.

There are some arguments for limiting the speed of impact testing into blocks and paying greater attention to increasing the compatability between different vehicles in impacts. Other authorities think that car to car compatability is not a high priority problem and that more accident data are needed to define the problem more closely. If, as a result of safety research, cars with stiffer front ends are developed compatability might become even more important in future.

The performance of the vehicles in the tests listed in Appendix 3 could be assessed using test dummies together with the human tolerance criteria listed in Appendix 2 provided these values are adjusted to allow for the difference in performance between test dummies and living human being (where possible by correlation tests with accident data and cadaver tests) and provided that continued research effort is put into confirming or revising the criteria.

4. TEST DEVICES

Test dummies for occupant protection assessment should be sufficiently human like in performance, be strong, give repeatable results, be capable of calibration, be standardised and manufactured to comply with performance requirements. They should be calibrated before and after testing to ensure compliance with these requirements.

Some opinion has it that reproducability of results is of paramount importance and can only be attained by specifying in detail the design of the dummies and even, perhaps, the source of supply of the dummies and of spare parts. On the other hand some consider it too early a stage in dummy development to freeze the design of dummies and that a performance standard is more appropriate calibrating the tolerance levels measured with any particular design of dummy against established cadaver and accident data.

All dummies currently available commercially have limitations when assessed against the requirements for an ideal test dummy. These limitations included, non human-like performance, excessive frangibility and spurious readings. Problems have arisen with the Hybrid II dummy, which was originally only intended for evaluating air bags, in that dummies that have been purchased after calibration by the manufacturer, have been found not to comply with the required specification.

Greater simplicity would be an advantage in test dummies. Some of the points in the OPAT dummy and the HSRI dummy might be an advance in this respect. The TRRL side impact dummy is designed with more emphasis on load measuring capabilities than other current dummies. The design philosophy on which it is based was to build a dummy structure more rigid than the components it was intended to subject to impact so that a check is made on the stiffness and energy absorbing properties of the items impacted which can be correlated with data from real world accidents.

The ONSER frangible dummy in which an attempt is made to reproduce the strengths of the human bones is an interesting development as a research device but it is not intended to be used as a compliance testing dummy.

5. RECOMMENDATIONS

The following recommendation can be drawn from the report.

5.1 a) Tolerance readings in terms of accelerations or forces determined from tests on cadavers should not be applied directly to readings obtained from tests using dummies.

b) There is a need for a series of comparison calibration tests to determine what readings from tests using any particular design of dummy correspond to tolerances which have been determined using cadavers or accident data.

5.2 Data from effective, efficient continuing accident sttudies is needed to identify the important areas of the body for which tolerance levels should be assessed in impact tests and accurate human tolerance data is needed for these areas to enable safer cars to be developed as rapidly, efficiently and economically as possible.

5.3 More information is needed on the statistical spread of tolerances within the population and variations with age and sex.

5.4 A technique is needed for evaluating tolerances to multiple injuries.

5.5 The following areas have high priority for human tolerance research

a) Brain and cervical spine injury
b) Tolerance levels in side impacts
c) Thoracic and visceral injury tolerance
d) Confirmation or revision of tolerance levels for other areas.

5.6 The number and complexity of tests to which vehicles are subjected needs to be restricted on economic and test reliability grounds. For the same reason substitution of data from appropriate rig tests might provide valid information, in full scale compliance impact tests if some instrumentation channels develop faults during the test.

5.7 There is a need for tests to assess the protection afforded to both restrained and unrestrained occupants but the protection of unrestrained occupants should not be allowed to unduly compromise the protection of restrained occupants.

5.8 Test dummies should be strong, repeatable, standardised, capable of calibration, manufactured to comply with performance requirements and sufficiently humanlike in performance.

5.9 Of the different frontal impact tests available the one most representative of the major injury producing accidents should be selected by the comparison of test photographs with accident photographs and statistics.

5.10 There is need to develop a compatability assessment test for vehicles, particularly in front to side impacts.

5.11 Design requirements and performance tests for pedestrian protection assessment need further research and development.

5.12 Because both sides of the passenger compartment are stressed in a side impact test it will probably not be practical to carry out such a test on a vehicle which has undergone a partial frontal barrier impact test.

APPENDIX I

LIST OF PARTICIPANTS IN WORKING GROUP 3

D Cesari	(France)	ONSER
A Chapon	(France)	ONSER
H le Guen	(France)	UTAC
J Leroy	(France)	ONSER
H Guelich	(Germany)	BAST
W Reidelbach	(Germany)	Daimler-Benz
E Franchini	(Italy)	Fiat
G Schinaia	(Italy)	Centro Prove Autoveicoli
R Lowne	(UK)	TRRL (Secretary)
M Macaulay	(UK)	MIRA
J Wall	(UK)	TRRL (Chairman)
J Waller	(UK)	Vauxhall Motors Ltd

The CCMC viewpoint was given by Dr Tarriere (France). Professor B Aldman (Sweden) and Mr Bussemaker (Netherlands) were invited to comment on the draft report of the working group before it was finalised.

APPENDIX 2

A REVIEW OF TOLERANCE LEVELS FOR VARIOUS PARTS OF THE HUMAN BODY

The following list of human tolerance levels is the best guide for designing safer road vehicles that the group could present at this point in time.

Some values are omitted from this list either because insufficient data is available or it is thought that the problems of measurement at the present time or rarity of accidents involving such injuries, justify their omission. Some of the values quoted are not yet generally accepted and require further research to confirm or revise them.

The ONSER report 'Revue des connaissances apport des researches actuelles en matiere de tolerance humaine a l'impact' June 1973, was circulated to the group and used to help draw up this list together with a bibliography of relevant German biomechanical publications prepared by the German delegation as part of an evaluation of German and international publications on this topic being carried out by the German Federal Road Research Institute.

1. Head/Brain

Separate tolerance levels for the brain to linear and rotational acceleration are desirable as well as levels for forces applied to the head specified in terms of location direction, rate of onset, duration, maximum value, average value, pulse shape and force distribution. At present, no tolerance level is sufficiently well established to put forward. Criteria of 80g for 3 milliseconds and a 'Head injury criteria' of 1000 are currently used in many European countries but only because these values measured on dummies are required by American Legislation. Because of the nature of the brain some means of assessing pulse shape is required but, because the mechanism of brain injury is not yet understood, it is not possible to say what the appropriate assessment should be.

A tolerance of the brain to rotational acceleration of 1800 rad/sec^2 has been proposed by Ommaya of the US but this has not gained general acceptance. The measurement of angular acceleration on dummy heads would present problems of instrumentation and repeatability.

In the absence of established tolerance levels for the brain a requirement that restrained dummy occupants should not experience head contact in frontal impact tests would be extremely restrictive on the design of restraint systems.

There is urgent need for further research into Tolerance levels for the brain but the problem of determining such levels is not likely to be easily or readily solved.

2. Face

Tolerance levels for the bones of the face are better established than for the brain. This is probably because bone, being a somewhat brittle material, is more sensitive to peak force than to shape of the force-time curve. The published literature indicates that the Zygoma is the area with the lowest load tolerance and this could be taken as the tolerance limit for the entire facial area. Schneider and Nahum 'Impact Studies of Facial Bones and Skull', 16th Stapp Conference (1972) quote a force of 890 N applied on an area of 6.45 square cms. Measurement of the tolerance on a dummy would not be simple and it might be necessary to devise subsidiary rig tests to evaluate the facial impact area.

Whilst laceration can be detected using a double layer of moist chamois leather over a layer of foam plastic it is not easy to quantify and it might be preferable to try to design out contact with lacerative parts of the vehicle rather than specify a tolerance to laceration.

3. Neck

Because of the low tolerance of the front of the neck to direct load and the difficulty of measuring such loads it might be decided to specify no direct frontal neck contact. Gadd, Culver and Nahum 'A study of Responses and Tolerances of the Neck' 15th Stapp Conference (1971) indicate tolerance levels of 80° in rearward hyper-extension and 60° in sideways flexure. The Mertz data, 'Strength and Response of the Human Neck',15th Stapp Conference (1971) indicate a rapid rise in torque and moment as the hyperextension approaches 80° and in view of this it may be advisable to work to a somewhat lower figure. Rate of neck rotation and combination of head rotation and neck flexure might, as a result of future research, prove to be important parameters in determining neck injury.

4. Clavicle

In the future vehicles using seat belt restraints the important loading on the shoulder would be the load on the clavicle and this could be expressed in terms of seat belt webbing load and angle of the seat belt. In side impacts the transverse loading on the shoulder would need to be specified.

TRRL experimental interpretation of accident data indicates a tolerance level of 8 kN expressed terms of seat belt shoulder strap tension for the clavicle using the OPAT dummy (the belt making an angle of 35° with the torso line of the dummy) and a level of 6 kN for end loading on a clavicle in a side impact measured with the TRRL side impact dummy.

5. Thorax

The true cause of injury to the internal organs of the chest is not yet fully understood but in frontal impacts loading on the rib cage, deflection of the rib cage and deceleration of the chest will probably provide sufficient data to specify tolerance levels and in side impacts loading on the ribs and deceleration of the chest will probably suffice. Which of these parameters is important will need to be decided and may depend on the type of test dummy being used. Cadaver-dummy correlation tests carried out with seat belt restraints indicate that a tolerance level of 60g for 3 milliseconds for frontal impacts measured in the Sierra dummy is too high resulting in flail chest injuries in the cadavers.

Kroell, Schneider and Nahum, 'Impact tolerance and Response of the Human Thorax,' 15th Stapp Conference(1971) quoted data indicating a tolerable deflection of 60mm measured on cadavers. Some evidence indicated that this was too high and that 50 mm would be more appropriate figure Nahum himself quoting a figure of 50 mm for a single rib and loads varying between 580 and 850N. TRRL tests with the OPAT dummy to correlate with injuries in road accidents indicate a critical deflection of 45 mm measured on this dummy. If such tolerance levels are adequately determined and specified there will be no need to specify steering column collapse loads.

Accident correlation tests using the TRRL side impact dummy indicate a tolerance level of 1 kN measured at each of the four 'rib' stations on the dummy.

6. Abdomen

Because of the known low tolerance of the intra abdominal organs seat belts should not be permitted to ride up over the iliac crests of suitable dummies during the loading cycle in a frontal impact test. To assess this some sort of reference line might be established on the dummy.

7. Pelvis

Injury to the pelvis apart from the hip joint is thought to be unlikely in frontal impacts if the tolerance levels for other parts of the body are respected but in side impacts the loading in a lateral direction needs to be specified.

TRRL accident damage correlation experiments have indicated a tolerance level of 5 kN for the sum of the transverse loads measured at the iliac crest and hip joint with the side impact dummy.

8. Knee Thigh-hip

The axial force along the thigh to cause fracture dislocation of the hip, the force to fracture the femur and to produce patella fractures are all somewhat similar and from Patrick's data appear to be of the order of 6 kN in cadaver tests although TRRL correlations of accident damage and injury with measurements using a kneeform impactor indicated a lower tolerance level in the region of 4 kN measured with this device for hip joint injuries in actual accidents. Other data quote higher values and the US regulations specify a maximum level of 7.65 kN.

To avoid penetration injuries of the knee joint any force applied to the knee should be well distributed.

9. Lower leg

The bending load in terms of load and point of application is important both in the case of pedestrians and vehicle occupants. No published data is available but Young in unpublished data quoted a tolerance level of 4.5 kN for the tibia.

10. Whole body tolerance to acceleration

This might be of importance in extremely severe rear impacts where efficient head restraints prevented neck injury.

11. Fire

Rather than consider tolerance levels to fire, which is not practical, vehicles should be designed to guard against the risk of fire following impacts.

APPENDIX 3

TEST TECHNIQUES

The group reviewed the technical aspects of the various test techniques listed below which are available for assessing occupant protection in vehicles during different types of impact. A selection of suitable tests could be made from this list depending on the recommendations of the other working groups.

1. Frontal impacts

Three test methods can be used for assessing occupant protection in frontal impacts, full head on impact, partial frontal impact and angled frontal impact into massive blocks. The test most representative of frequent injury producing accidents should be selected and to enable this to be done accident statistics and photographs should be compared with photographs of vehicles from the three different tests.

If a partial frontal impact has been carried out on a vehicle it will probably not be practical to utilise the undamaged side of the vehicle in a side impact test as both sides of the passenger compartment are stressed in such a test.

1.1 Full head on impact perpendicularly into a massive block This is the conventional test for frontal impact protection.

1.2 Partial frontal impact into a massive block This test is more severe in the penetration damage inflicted on the vehicle structure than the full frontal impact but the deceleration levels on the occupant compartment can be somewhat lower. If the corners of the impact block are suitably rounded this test might be used to encourage car design to guard against inter penetration and structural interlocking of opposing vehicles in partial frontal impacts.

1.3 Angled frontal impact into a massive block At suitable impact speeds and angles of impact this test can induce unrestrained dummy head contact with items such as the windscreen pillar which are known to cause injury to real life accidents. However, this problem could also be assessed with laboratory rig tests and this would be preferable in order to reduce the number of full scale impact tests required by legislation and improve the repeatability of the tests.

2. Side impacts and compatability

A new approach is needed to the question of structural compatability assessment and side impacts are probably the next major area of research likely to produce high returns in injury reduction, particularly as compulsory seat belt wearing would substantially reduce frontal impact injuries. There is a need for a test to ensure that deformation of doors in side impact does not lead to door opening by the release of tension door latch mechanisms. A static crush test would be suitable for this. Three possible test techniques for compatability assessment are outlined below but there is a need for further research to investigate their practicability.

2.1 Assessment of compatability from force deflection records obtained from frontal car to barrier impacts and side impacts with a mobile barrier.

This technique is not yet sufficiently developed to enable it to be adopted but it is currently being investigated. It would enable the occupant protection afforded by interior padding to be assessed.

2.2 Frontal barrier impact into a barrier of specified stiffness to ensure that the front structure of cars is not excessively strong and side impact by a mobile barrier with the same stiffness to ensure that the side structure is adequately strong.

Such a test method might present problems in reproducing the required stiffnesses of the barriers and would need to be carried out at a speed different from that using a rigid barrier to maintain an equivalent impact severity. Such tests might be carried out using dummies in both front seat positions and the angle of impact in the car might be from 15^{o} forward of the perpendicular to its longitudinal axis.

2.3 Static side crush test possibly coupled with requirements that the front structure be not excessively strong (evaluated from frontal impact tests).

This method has the advantage of simplicity and reproducibility but it would require additional rig testing to evaluate occupant protection devices such as padding. Such rig tests are already developed.

3. <u>Roll over evaluation</u>

A dynamic 720^{o} car roll over test to assess whether doors will come open or restrained occupants be ejected has been suggested but current roll over tests are difficult to perform and show poor repeatability. A series of laboratory tests which are already developed to assess structural integrity by static loading on the roof and door latch performance by exerting a force on the release area could be substituted.

Additional tests of interior padding using impact forms might also be required. Again these tests are already available.

4. Rear end impacts

Such tests are probably not justified on cost and injury producing grounds but a rigid mobile barrier impact such as that specified by ECE or an equivalent rig test could be used to assess fire risk due to fuel leakage following rear impacts.

The rear impact protection provided for occupants could be assessed using existing regulations for head restraints (modified to ensure that head restraints are not positioned too low by the user) without the need for a full scale dynamic rear impact test.

5. Pedestrian Impact

No suitable full scale test is yet available and at present, design requirements on height of bumpers, length of bonnets and external protrusion are appropriate. The bumpers should be positioned to ensure that initial contact is below knee level and impact form tests might be used to assess their propensity to produce tibia fractures. External protrusions could be assessed under existing regulations.