FUTURE LINES OF RESEARCH IN THE FIELD OF TOXIC AND PSYCHOLOGICAL FACTORS IN ROAD TRAFFIC ACCIDENTS

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A study made on request of the Ad-Hoc Working Group on Toxic and Psychological Factors in Road Traffic Accidents of the Committee of Medical Research and Public Health of the Commission of European Communities, Directorate General for research, science and education.

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FOREWORD

The study reported here is based on a contract of the European Commission, and on the recommendation of the Ad-Hoc Group on Toxic and Psychological Factors in Road Traffic Accidents. It was agreed that the report should state, discuss and forecast the various aspects related to this field, and that the final report should include information on topics being investigated in the Member Countries, and in addition make proposals for future common action.

The study has been prepared by the Institute for Road Safety Research SWOV, in Voorburg, The Netherlands. The project leader was Dr. D.A. Schreuder; many of the staff of the Institute contributed to the report, and in particular the late D.J. Griep, Research Psychologist.

The report has been discussed at several meetings of the Ad-Hoc Group on Toxic and Psychological Factors in Road Traffic Accidents. On March 30th, 1976 a special Meeting of Experts was held at Scheveningen, The Hague, The Netherlands. The report was discussed by experts from Denmark, The Federal Republic of Germany, France, Ireland, The Netherlands and the United Kingdom. The contributions from these experts have been incorporated in the report.

The Institute for Road Safety Research SWOV wishes to thank all who contributed to the discussion for their efforts.

Ir. E. Asmussen
Director SWOV

1. ANALYSIS OF THE PROBLEM

1.1. Introduction

The scope of this report is to state, discuss and forecast on the various aspects related to toxic and psychological factors in road traffic accidents. The more specific aim is to prepare a basis on which future concerted action, (and more particularly the different priorities for these actions), can be defined. The report sets out the information, based on scientific knowledge, which is necessary for the decision makers to establish the order of priorities for further research.

Until recently, priorities - including priorities for research - were generally not established in a systematic manner. Therefore, this report will concentrate primarily on a number of formal and methodological considerations. Obviously, a systematic approach to the establishment of priorities has a much wider scope than the specific problems of toxic and psychological aspects by themselves. It should be kept in mind, however, that the system of setting priorities must be described in general terms, before it can be applied to any specific problem area.

The study is concerned with priorities for research in fields related to road safety. Road safety, (or more precisely, road traffic accidents) is a common, but unwanted side-effect of the road transportation system in general. Therefore, a brief survey of the transportation system, and of the concept of unsafety in this connection, will be given. In addition, it will be shown how the concept of safety can be incorporated in the traffic system and where "measures" or "countermeasures" can be effective. After this, the final statement of the problem can be given.

This elaborate method of setting up a statement of the problem (which might at first sight, seem to be rather simple) is necessary because of the complicated nature of the problem. In pure research, it would be possible, (although usually not very helpful), to isolate a small aspect within the general area of road safety. When one has to deal with applied research which should result in recommendations for measures or regulations that substantially improve the efficiency and/or the safety of the system under consideration, such an isolation is hardly feasible. Furthermore, because it is the intention of this report to give basic considerations for the establishment of priorities, such an isolation of some specific problem area, might lead to completely wrong conclusions. More specifically, road accidents are very complex phenomena. Traffic medicine, important as it is for specific problem areas, forms too narrow a basis for this purpose.

Chapter 2 deals more specifically with the "human factors" which are to be considered. It is explained that in this report the main emphasis lies on temporary and differential aspects.

In Chapter 3, the different approaches for research are discussed, particularly the role of behavioural studies in the total system, and the way they may be applied in order to predict the result of the statistical studies, which are more directly associated with road safety.

Chapters 4 and 5 discuss the actual establishment of priority lists for research.

Finally, in Chapter 6 the conclusions from the report are given and discussed.

The discussion in Chapter 4 will make clear that many data are still missing, thus the priorities given there are arbitrary to a degree. In order to increase the direct applicability of the report - without diminishing the theoretical bearing - three alternative approaches, which yield more direct, but less general results, are given in Chapter 5.

1.2. The road transportation system

The road transportation system can be described in terms of sets of decision making processes, which are relevant for both transportation policy and management and for road users. The former will be emphasised, in view of the importance to be given in considerations, regarding "measures" taken by those responsible for the transportation management (principally the government and local authorities).
In order to assess the results of measures it is necessary to translate the measures in variables which are relevant for the traffic process. The selection of the appropriate, relevant variables, on the other hand requires a detailed insight in the traffic process itself and in its components.

This suggests three structural models:
- the structural model for policy and management
- the structural model of the traffic process
- the structural model for research

It should be stressed that models of this kind do not provide additional information; their purpose is primarily to offer a framework in which complex phenomena can systematically be described. From the following discussion it will be clear that the road transportation system in reality is a unity, and that the subdivision in three models is arbitrary to a certain degree. The following discussion is based on Asmussen (1976). See also Asmussen (1972).

The structural model for policy and management describes the decision making process for policy making. See Fig. 1. The traffic process can be considered as a "black box" of which only the input and the output are considered.

Policy makers should state explicitly their views on the requirements of society with regard to the transportation quality characteristics. It is the task of the transportation management to run the system in such a way that, with respect to both the long-term and the short-term policy, the system meets these requirements, taking into account the marginal conditions resulting from consideration of governmental budgets, environmental preservation, physical planning and transportation economy. The desired quality is expressed in terms of indicators, such as safety, through-put, comfort, damage to environment etc.

Within the transportation management, the more specific goals of road safety policy can be defined. Some of these may be general, others aimed more in particular at certain groups of road users, or certain geographical regions. When the goals are decided upon, the tactics i.e. the actual measures can be selected. Measures can be taken in the field of physical and socio-economic planning, structurizing the road network, system building and system operation. These measures result in transportation demand, infrastructure characteristics etc. which in turn are the input of the traffic process.

The effect of the measures can be assessed in terms of changes in the indicators that define the quality of the road transportation system. A comparison with the desired quality - as expressed in the same indicators - may follow. Discrepancies between the actual values and the desired values may serve as a stimulus to adjust the measures. The system indicated in Figure 1 is, in fact, a closed-loop system.

In the model for policy and management, the traffic process was considered as a "black box". In Figure 2 a structural model for this process is presented.
In the decision making process and in the behaviour of travellers, microscopic (individual) and macroscopic ("sum total") behaviour can be discerned. The latter can be divided into a number of graded levels.
The first level of behaviour concerns the social activity which generates traffic. As far as individual travellers behaviour

is concerned, the selection of destination and the time-schedule are relevant. At the second level, the selection of the mode of transport is relevant. The third level concerns the more detailed selection of the route and itinerary; while the fourth level concerns the selection of manoeuvres by the driver.

The "sum total" behaviour cannot be described directly in terms of collective behaviour of a group. Therefore, research into individual behaviour is necessary in order to interpret the "sum total" behaviour.
On the other hand prediction of the "sum total" behaviour is necessary in order to forecast the influence of measures on the transportation quality characteristics. The "sum total" levels are:

1. trip generation and trip distribution,
2. modal split,
3. assignment,
4. traffic flow.

The higher the considered level of behaviour, the more the relations between transportation and society will be involved; the lower the level of behaviour, the more important the interaction between driver, vehicle and the road will be. In view of this, it might be logical to classify the traveller's (driver's) behaviour research according to the above mentioned four levels of behaviour. (See also Asmussen, 1972, 1976).
The <u>structural model for research</u> follows from the model given in Figure 1. This model shows a division into various research areas indicated as A, B, C and I categories.
The area of category A relates to the relationship between all possible measures in respect of policy implementation, within the transportation system on the one hand, and the transportation demands, the facilities and limitations (the infrastructure characteristics) on the other hand.
The research result of this area is directed towards optimising the facilities and limitations (from a technical point of view)

which are relevant to, or have a great influence on, the travellers' behaviour. The results of this A-research can not be interpreted in terms of quality characteristics such as safety, as long as the influence of the facilities and limitations on the traveller's behaviour is not sufficiently known.
Such research is often of a technological nature and monodisciplinary in realisation.

The area of category B relates to the effect of the transportation demands and the infrastructure characteristics, and the effect on travellers' decisions and on travellers' behaviour (the traffic process). Such research is typically inter-disciplinary. The research results of this area are directed towards providing functional requirements for design and construction of road networks, roads and vehicles, for traffic rules and regulations, etc. in terms of facilities and limitations regarding the man-vehicle-road subsystem.

The area of category C concerns the influence of travellers' (traffic) behaviour on the quality characteristics of the transportation system. This research is usually multi-disciplinary. The research results of this area are directed towards describing the desired driver behaviour, in certain traffic situations.

I-research is the integration of these more or less isolated areas. This leads to the relation between measures (input) and quality characteristics of the transportation system (output). The research result of this area is directed towards providing a forecast of the effect of measures, in terms of the quality characteristics, and assessing the effect of measures after their introduction (for example before-and-after studies).

Traffic accidents, generally, are the final stage of a series of events which lead to an unwanted (very often fatal) result. This means, first of all, that in the majority of cases the

accident is not caused by a single factor; from this, in turn, it follows that one single measure will not necessarily solve the problems. Quite often it is possible to prevent an accident by interrupting the series of events at a certain point. Secondly, the complexity of accidents means that in nearly all cases the factors 'man', 'vehicle' and 'environment' are of importance, sometimes separately, but quite often interrelated in a complex manner. As a result of this, the measures which can be taken to improve traffic safety can be of a technical nature (engineering), of an instructional-psychological nature (education), or of a legal nature (enforcement).
In order to establish measures, especially "combined measures", a well-founded traffic safety policy is required. The concept of traffic safety policy, however, can only be formulated, if there is an accurate definition of the concept "traffic unsafety" or, conversally, "traffic safety". Without such definitions, no standards or purposes for such policy, can be established.
From the point of view of society, traffic unsafety can be defined as follows:
"The total loss (for example in one year) sustained by society as a result of traffic accidents".
This loss is determined from the number of fatalities, the number of severely injured, the number of slightly injured and the total material loss.

It should be stressed that the term "loss" is used here in the overall sense: i.e. for casualties both the material and the non-material losses are included.
The policy of traffic safety cannot be limited only to reducing the number of traffic accidents, it must also aim at reducing the average loss per accident.

Considered as a problem of national welfare, traffic unsafety can be defined in terms of human losses (casualties), i.e. by quantifying the number of fatalities and/or persons injured

(for example annually). In this respect traffic unsafety can be compared with other epidemic dangers which affect the national welfare. Surveys in this field of problems generally relate the number of fatalities or casualties to the number of inhabitants (for example, expressed as a number per 100,000 inhabitants). In this connection the following terms are of importance:
mortality rate: = the number of deaths per 100,000 inhabitants
morbidity rate: = the number of injured per 100,000 inhabitants.
When the impact on the welfare-aspect of different social processes is to be compared, quotients must be applied, the numerator indicates the magnitude of the phenomenon, while the denominator is a normalisation factor. Such a normalisation factor can relate to the number of the population. In this way it is possible to indicate the chance of being killed or injured in traffic per inhabitant (e.g.: per year). The factor may also indicate the period of time during which the individual participates in the traffic process. If the factor relates to the number of kilometers travelled, the quotient will indicate the chance of being killed or injured in traffic per kilometer travelled. The factor (in this case usually called "exposure factor") can be used if it is constant, i.e. if it is not altered either by the process itself, or by the measures which are to be taken in order to influence the process. Thus, when selecting the "number of fatalities and/or casualties per million vehicle kilometers" as the traffic unsafety criterion, it is implied that travel performance is a value which will not be affected by traffic safety policy. In the case of a social criterion for traffic unsafety, however, the exposure factors "traffic performance" and "travel performance" are not applicable.

Based on social considerations it is desirable to define the criterion of traffic unsafety quantitatively as the number of fatalities and/or casualties per year as a result of road travel, per 100,000 inhabitants.

Although it should be possible to test the effect of each traffic safety measure by this criterion (i.e. the number of fatalities and casualties per 100,000 inhabitants), in practice it is often impossible to determine the effect of a specific measure. The reason for this is that most measures do not have a direct effect on the number of fatalities and/or casualties, but operate by intermediate processes. Consequently, both the effect of changes in the intermediate processes and also the final effect, which a certain measure has on the number of fatalities and/or casualties, must be established. A further discussion of this complex matter is given in SWOV, 1975, Chapter 2.

1.3. Cost-benefit considerations

In view of the possible complexity of the measures, implying that more than one aspect of the traffic will be affected, and in view of national and local influences, usually it will be impossible to arrive at an absolutely valid assessment of the effectiveness (positive or negative) of a measure.
In this respect it is customary to distinguish between the costs and the benefits of measures. The benefits in this case are related to the effect of the measure in reducing traffic unsafety. Research, and also the measures based on the results of the research, result in certain costs. Therefore, cost aspects cannot be disregarded. The costs of the research and of the resulting measures can be estimated. When the benefits are divided by these costs, a quotient is obtained, which represents its specific benefit-to-cost ratio. The higher this ratio, the higher the pay-off of the research, and the higher the place it deserves on the scale of priorities. This in fact is the classical (one-dimensional) cost/benefit approach: If the monetary gain from a measure under consideration is greater than the monetary cost, the measure should be adopted, and vice-versa. As Flury, (1972, 1976) has pointed out, two major

restrictions are inherent in this approach, which - in combination - greatly reduce the value of the calculations. The first restriction is that, while most costs can be expressed in monetary values, most benefits cannot. The problem is thus essentially multi-dimensional.
The approach followed in this report is a simplified two-dimensional variant of this: costs are expressed in monetary values (positive or negative); saving money by not spending it is thus considered as identical to earning money, (and vice-versa). Benefits can be expressed as the reduction in the number of traffic casualties. It should be pointed out that the system presented here is not complete, since all other "social" effects are disregarded, and furthermore it has been simplified because a rigid mathematical treatment of this type of problems is not available at the moment. It is felt, however, that the system presented here is of considerable help in the establishment of priorities for research within the European Commission, and is definitely more useful than the system currently in use.

The second restriction of classical cost-benefit calculations is related to the following: - The current system usually gives reasonable results, if the budget is considered as unlimited. The system breaks down, however, when the (realistic) assumption of a restricted budget is taken into account. In practice this means that very often the measures which promise the greatest benefits with regard to accident reduction, cannot be taken because the nation has not enough money available to put the measure into effect. This aspect presents considerable difficulties in the mathematical and logical treatment. Although it is felt to be of importance, particularly in relation to road safety, it will not be taken into account here, because this report deals with international undertakings, and national data - even if available - cannot be generalised.

Thus, the suggestions for priorities of research in this report will be based on the order of the quotients of the "benefits" and of the "costs". This system suffers from the fact (which is highly relevant in practice) that monetary value is a linear phenomenon, while experiences such as "the experience of safety" or "the impression of unsafety", can be described by a relationship which is somewhat similar to a logarithmic function (as is usually the case when describing the effects of experiences). Thus uncritical application of the system might easily lead to the result that those measures (and the corresponding research) which have a low cost, will be particularly favoured. This effect will often be reinforced by the fact that the range of possible benefits and the range of actual research costs are much narrower than the range of the costs of the measures. In the more refined system of Flury (1972), the fundamental limitation of the budget, to a certain extent provides some correction for this effect: it is not so much the order of priorities of the research (or measures), but the best overall way to spend the available budget, by distributing it over a number of items, which is of importance.

1.4. The statement of the problem

In the foregoing, the importance, within the total problem, of the exact description of the factors road traffic, traffic unsafety, and of the definition of measures to be taken by the responsible authorities in order to improve the quality of road traffic and road safety, is indicated.

The reasons why it is necessary to describe in detail a great number of aspects of a more general nature, before starting to deal with the influence of toxic and psychological factors in road traffic accidents are not always expressed sufficiently clearly. The general concept of traffic unsafety must be discussed, before the influence of certain factors on road traffic accidents can be described. The foregoing may be regarded as a framework in which the actual problem on hand may be placed i.e. the establishment of priorities for research, which may profit particularly from international co-operation within the framework of the European Commission, and which may lead to measures that can be applied in Member Countries.

Most 'motorized' countries have to deal with the same kind of transportation problems, although there may be differences in the specificity or generality of problems and in the time at which they arise. Research in the various countries therefore has to deal with the same problem. From the point of view of the road user, and from the point of view of efficiency, there is a need for uniform rules and regulations applicable to the vehicle (e.g. lighting system), the driver (e.g. alcohol-and-driving rules), the road (e.g. markings, signals and signs), within the uniform principles for classification or categorization of roads, vehicles, etc. Therefore transportation policy and management decision making must be carried out at an international level. This calls for close co-operation between research organisations and decision makers at an international level.

Most of the international rules and regulations do not, however, guarantee uniformly applied solutions in different countries; it appears that not all the international legal concepts are supported by research facts to the same extent nor are they of the same relevance to road safety. Moreover, it is found that for most of the specific short-term actions considered, systematic treatment in terms of general and long-term aims is lacking. The international decision making process is apparently even more complicated than the national one. In particular, the systematic treatment of problems in terms of problem analyses, stock-taking of all relevant solutions, and the drawing-up of functional requirements for the solutions based on the research findings, are essential. Since research results should play an important role in this process, international exchange of research findings is of the utmost importance.

With regard to international co-operation, the European Commission offer several possibilities for promoting research, notably within the responsibility of the CREST (Comité de la Recherche Scientifique et Technique), and of the CRM (Comité de Recherche Médicale et de la Santé Publique). The relevance of high quality scientific and applied research has been indicated above in general terms; the following report is concerned more particularly with the question of where it is preferable to concentrate the international research efforts. As will be indicated in more detail in later sections of this report, the present study is concerned primarily with the investigation of where, within the context of "toxic and psychological factors in road traffic accidents", the area of main interest should be indicated.

It is stressed again that in the first place, the indication of the areas of main interest is only a first step in the establishment of research priorities, and that secondly, it is necessary to keep in view the adjoining problem areas, and in fact the whole area of road safety research, when concentrating on toxic and psychological factors.

1.5. Concluding remarks

It should be emphasised that this report, is the first of its kind; until now, priorities for research have only been assessed subsequently. A new system for the assessment had to be developed, which until now has not been substantiated. Furthermore, it proved difficult to apply the theorectical models, presented in this chapter, to practical problems; not only are data not always available; but also other factors make the application difficult:-

- a generally accepted and readily applicable classification of intoxicants is not available.
- the systematic classification of the elements of the driving task, is not completed and not fully operational at the moment.

- the area of toxic and psychological factors is in continuous development.
- the area is very wide, even if it is restricted to temporary and differential factors (as will be explained later); this means that most sections cannot give more than only a brief survey of the state-of-the art.

2. HUMAN FACTORS IN ROAD TRAFFIC ACCIDENTS

2.1. Human factors and human engineering

In what is usually called the pre-crash phase of road traffic accidents, man is involved in several distinct ways. Apart from the role as victim of accidents - a role which is usually discussed in the crash and post-crash phases of accidents - man may on the one hand be considered as an element in the design of the system, and on the other hand as the user of the system. When considering measures aimed at reducing the number and severity of road traffic accidents, both aspects must be considered together. It has been customary in the past to consider only one aspect or only the other. One consideration led to the belief that the system should be adapted to man (more particularly to his possibilities and limitations as an operator of the system); the measures for this were usually related directly to ergonomics. The other consideration led to the opposite belief than man should adapt himself to the system, once the system had been planned, designed and realised on an engineering basis.

The basic error in this approach - which is still used in many instances, - is that the measures themselves cannot be divided into two categories; the two ways of considering the capabilities of man are in fact two different directions of emphasis, and two methods of evaluating the results; they are approaches and not subdivisions of measures.

Man, as an operational user of the system is, on the one hand, the criterion for the design; on the other hand, is he subjected to the requirements for behaviour, which must be followed in order to use the system properly. In this connection variations between individuals and also within one individual, must always be taken into consideration. Such variations may occur, in part of a design, for example, with respect to visual aspects connected with the use of roads, and participation in traffic; or in users of the system, for example, as variations in the speed at which they drive. When the average value and dispersion are given, with respect to the total population it is possible to achieve an improvement in vehicle and road design; for example the visibility from the car, the visibility distance along the road, regulations for road marking and lighting, vehicle and road signals. These measures result in simplifying the tasks, by providing better information.

In this connection it should be noted that as the variability which is taken into account becomes more extreme, the resulting solutions become generally more expensive. In practice, as a rule, a percentage figure is taken as a basis, for example 85% or 95%. The consequence of this is that for a given percentage of the population (100% minus the chosen percentage), the solution is not adequate. For example the distance at which traffic signs or route indications can be read.

It is assumed that this approach improves traffic safety. Furthermore, there is also a specific approach, based on the assumption that specific properties, such as the visual capabilities of certain types of road users, (for example elderly drivers), or their condition (for example after drinking alcohol), are the factors which have the greatest influence on traffic safety. According to this approach, traffic safety problems can be solved by the elimination of small groups and the solution of part-problems. The assumption here is that a relatively small group of road users is responsible for the majority of accidents, either on account of structural short-comings, or due to the faulty application of measures, as a result of offending regulations.

All this indicates the necessity of investigations into the permanent or temporary nature and into the general or specific nature of accident involvement as a characteristic of road users, it also indicates the necessity of investigations into the relationship between the characteristics of road users, or the conditions under which they are placed, and accident involvement.

When the field of interest is restricted more particularly to toxic and psychological factors, it is necessary to consider first of all the question whether all "human factors" are equally important. It is possible to divide human factors in long term or permanent, medium term and short term factors - taking into account the fact that a strict division is not always possible, and that intermediate sub-divisions may be defined. The fact that in several cases short term and long term factors interact is more important; they may counteract or they may reinforce one another. However, for the sake of simplicity, the division into permanent (or long term), medium term and short term factors will be kept.

The result from the discussion of these groups of factors, as given in sec. 2.2.2., 2.2.3., and 2.2.4. respectively, is that in this report, emphasis will be placed on short term factors, and more particularly, that permanent and long term factors are considered to be of less importance. Therefore, short term factors will be dealt with in some detail, while other factors are discussed more as examples. As an introduction, some methodological points are discussed in sec. 2.2.1.

2.2. Characteristics of drivers and accident involvement

2.2.1. Method

The contribution of the properties or the characteristics of drivers in relation to accident risk, can be defined as the product of the increased probability of accident involvement of drivers with a given characteristic, and the frequency of occurrence of drivers with this characteristic.

With regard to the measures to be taken, it is important to have more detailed data made available, concerning the drivers involved, the circumstances of participation in traffic and any special features of the accidents.

Data concerning the increased probability of accident involvement can be obtained by a comparison between the groups involved in the accidents and control groups. Such comparisons are made under circumstances which are as far as possible identical. The relevant data are collected from the groups involved in accidents. Regarding the control groups the data are collected from drivers, chosen at random, who are stopped at the road side. The data collecting should be carried out at places and at times, corresponding to those at which the accidents occurred.

Such comparison between accident groups and control groups is necessary in order to take into account the extent, to which the characteristic considered does not lead to accidents, and also in order to take into account the increased probability of accident involvement caused by characteristics other than the one under consideration. The relative increase can be established as follows.

Schematic representation of increased probability of accident involvement

	Accident group	Control group
Characteristic present	p	q
Characteristic absent	s	t
+	x	y

The relative probability of accident involvement can be expressed as a fraction, the numerator of which indicates the relationship between the number of drivers with the characteristic and

the number of drivers without it in the accident group $(\frac{p}{s})$, while the denominator indicates the relationship between the number of drivers with the characteristic and the number of drivers withour it, in the control group $(\frac{q}{t})$, thus: $\frac{p.t}{s.q}$.
The product $\frac{100.q}{y}$ $(1 - \frac{p.t}{s.q})$ represents the number of accidents as a percentage of the total number, which would occur under the supposition that the characteristic considered is present in the population. The latter is estimated by the relative frequency of occurrence in the control group $(\frac{q}{y})$. If the relative frequency of occurrence in the accident group $(\frac{p}{x})$ is used, the following expression is obtained: $\frac{100.p}{x}$ $(1 - \frac{s.q}{p.t})$. This expression provides a simple non-parametric approximation. A more accurate, although less simple assessment is possible on the basis of a parametric (correlation) analysis (see for example Peck et al, 1971).
Both methods are based on the assumption, that other characteristics, which have not been considered, and which may also have an influence on accident proneness, are proportionately present in the accident and in the control group, in combination with the considered characteristic present in or absent from the said groups. Another assumption concerns the equivalence of the characteristic considered for drivers involved in accidents.

2.2.2. Permanent and long term factors: accidents in the past

It is often assumed that it is possible to designate certain groups of participants in traffic (notably car drivers and pedestrians) as "accident prone" thus implying that such groups possess certain characteristics which result in the fact that they have a higher probability of being involved in accidents than the average person. If this assumption proves to be true, three types of countermeasures may be decided upon: -

- banning these persons from traffic;
- adapting the traffic situation to the characteristics of these persons;
- change the characteristics of these persons.

The first step in all cases, is to find out whether in fact such a group of accident-prone drivers (and pedestrians) exists; and to find out whether members of these groups can be found and individually selected.
Most research into accident proneness has been based on the consideration that an (abnormally) high probability of accident involvement will result in many accidents, which is not necessarily correct. The difficulty with this type of research lies, in fact, in the determination of whether a large number of accidents in the (recent) past was an effect of pure chance, or the result of a specific accident proneness.
The research into the field of accident proneness has been very wide and scattered, and not all of an adequate quality. Since it is not the main subject of this report, the problem will not be considered in depth; the various reports quoted here serve more as examples and illustrations of the conclusion. Many detailed studies are reported in the literature but the problem has not yet been solved. See e.g. Biehl (1971); Böcher (1962); Haight (1964); Kunkel (1973); Shaw & Sichel (1971).

When planning certain measures, for example the banning of drivers, who have been involved in a relatively large number of accidents within a relatively short period of time, or improving their driving skill, it must be assumed that the past history provides a fairly accurate guide for forecasting future accident involvement. Several studies have been undertaken in certain states in the U.S.A. where the "penalty-point system" in force provides a central registration of accidents and traffic-law violations.

In the state of California about 150,000 drivers were the subject of an investigation, aimed at establishing how many were involved in more than one accident during a period of two years. The proportion was found to be about 4% or 5%. It was then determined, how many were again involved in an accident in the year following the two-years period; this propor-

tion was found to be one out of eight. Of all the drivers, who were involved in that year in an accident, over 99% were not involved in any accident in the two preceeding years (see Table 1, according to Peck et al., 1971).
From the data in Table 1 it is possible to calculate the relative increase in accident involvement. This was found to be a factor of 2.7. As a percentage of the number of drivers involved in accidents in 1963, the contribution of drivers with an accident-history in 1961 and 1962 was found to be 1.3%. When the average number of accidents per driver is 1 in 14.6, this corresponds to less than 1% of the number of accidents.
These results have to be considered, taking into account the fact that in these investigations no comparison was made between accident and control groups under comparable circumstances; comparisons were only made of the same drivers in various periods of time. Consequently, differences may occur according to driving performance and driving conditions. In addition (similar) differences may occur between drivers involved in accidents and accident-free drivers. Thus, an interpretation expressed exclusively in terms of "accident proneness" may leave some doubts.
If for the sake of a less than 1% reduction in the number of accidents, 1,100 "drivers likely to have further accidents" were banned from driving, this would be to the cost of 955 out of the 1,100 drivers, who would be predicted to be involved in accidents in 1963 but who appeared to be free from accidents in that year, although they had been involved in accidents in 1961-1962; thus banning them from driving would be undesirable (87%). 6931 of the 129,524 drivers, who were not involved in accidents in 1961 and 1962 and who were predicted to be accident-free also in 1963, were in fact found to be involved in an accident; consequently their <u>not</u> being banned from driving would also have been undesirable (6%).

The question therefore arises:- is not the predictability of a future accident pattern more reliable for drivers, who were involved in several accidents in a shorter period of time? An investigation carried out in the state of Indiana (Goodson, 1972) shows that the group of drivers with three or more accidents in a year amounted to 0.7% of the total number of drivers involved in traffic accidents. This group, which was involved in 3,7% of the total number of accidents registered in that year, was then further examined with regard to its involvement in accidents during the four subsequent years. The results of this investigation, (See Tables 2a, b, c) prove that if drivers, involved in 3, 4 or 5 accidents in one year, had been banned from driving, it would have been an unjust decision for 70%, 60% or 40% of the cases respectively, because of the low accident frequency (0 or 1) in the subsequent period of four years. It was found that neither the number of registered violations, nor their severity (in terms of the penalty-point system), could be applied to the prediction of the persistance of the high accident frequency. Although the number of accidents was high, the severity of accidents seemed to be relatively low.

From these investigations, and others which yielded similar results, it can be concluded that the majority of the total number of accidents occurring in a given period, are not caused by a relatively small group of drivers involved in more than one accident; on the contrary, most accidents are the "first" accidents of the drivers concerned. Drivers, involved in several accidents in a given period, usually have a considerably lower number of accidents in a subsequent period. <u>Nevertheless, the risk of future accidents is greater on average, if a driver was involved more frequently in accidents in the past, within a short period of time</u>.

These data do not agree with the hypothesis that a large number of accidents are caused by a small number of "accident prone" drivers, who can easily be identified. On the contrary, if permanent or long term factors were predominant in accidents, this should lead to a high proportion of accident repeaters.

On the other hand, arguments can be put forward which point to an important contribution to road safety as a result of permanent or long term factors. An interesting summary of what may result from a phenomenological approach, is given by Kunkel, 1973, p. 13.

1. One may indicate behavioural aspects which represent abnormal high accident risk; but, only certain drivers behave in that way.
2. One may indicate behavioural aspects (general driving errors) which also present an abnormally high accident risk. However, most drivers behave in certain situations in this way. The additional risk may be explained by differences in driving experience.
3. Individual drivers have differences in accident proneness, which are dependant on differences in risk-taking and differences in general driving errors.
4. Because the difference in accident proneness results from differences in personality and from differences in driving skill one has to assume that accident proneness is a relatively constant, but individually different factor, which is not only quantitatively, but also qualitatively different, from one individual to another.

This set of statements is supported by additional experimental data. The statement 4, however, does not follow consequently from the statements 1 through 3.

As indicated above, the discussion <u>for</u> and <u>against</u> the idea of accident proneness is protracted, and is not conclusive.

Some important conclusions can be drawn, however, from the available data:

A. The influence of permanent or long term factors on accident occurrence is not very important; otherwise, it would have shown from studies of accident repeaters.
B. It is possible to indicate (but not precisely), a marked relationship between the number of accidents in a certain period and the number of accidents in a subsequent period - but then only "post hoc".

C. It is not possible to identify certain individuals as being accident prone, before they have been involved in several accidents.
D. The influence of permanent or long term factors on accident involvement seems to be of a complex nature, and seems often to act in an indirect way. More particularly, it seems that the combination of long term negative factors with short term factors, results in a cumulatively unfavourable effect. (This point will be discussed in following sections).

This study will concentrate on medium and short term effects, and in particular, on temporary and differential factors. Permanent and long term factors will only be discussed generally.
This decision is made on the following grounds:
1. As indicated in this section, measures which counteract negative long term factors are very difficult to make; in some cases, they cannot be predicted at all, and in most cases they will result in unjustified restrictions to a large portion of the driving population.
2. Even if measures of this type are considered, their effect in terms of accident reduction is usually small; for example from the data of Table 2, it follows that only the banning from traffic of a very small group of drivers involved in accidents, (about 1 in 5.000, i.e. the drivers involved in 5 accidents or more in one year) could be done on justifiable grounds. The benefit from this measure would be very small: only about 0,15% of all accidents (according to the data of Table 2)
3. When permanent or long term factors are investigated in relation to the subject of this report - the toxic and psychological factors - it is necessary to have additional data available concerning the exposure to traffic involvement and accident involvement of persons with different characteristics: in comparative studies it is necessary to relate persons involved in accidents not only to the number of inhabitants (as in epidemical studies) but also to traffic and travel performance (vehicle kilometers etc.). Exposure data are not available for the majority of the factors under consideration. As an example of the difficulties of collecting such data, it may be stated that the

Institute for Road Safety Research SWOV, the Netherlands, plans to start investigations for acquiring data on exposure; and it is estimated that the first step of the pilot study will take at least three years and will cost some two million dutch guilders!

4. Because it may be expected that most permanent or long term factors will show their negative effects primarily in combination with short-term factors, it seems justified to concentrate initially on these short term factors.

It may not seem logical to restrict initially the scope of a study which has the objective of determining priorities. This restriction should follow from the priorities. However, in view of the fact that the area of study would otherwise be too large to cover in a single report, and taking into account (as might be expected), that the end result will not be affected, the above course has been chosen. It is obvious that in a further follow-up study, this area should be included.

2.2.3. Medium term factors: traffic faults and offences

In some cases, it is suggested that the number of traffic faults or traffic offences should be used as a criterion for accident proneness. As will be seen in the following section, this approach does not yield results which differ greatly from those of repeated accident studies (Edwards & Hahn 1970).

The correlation found between driving errors and accidents, gives an idea of the order of magnitude of the expected correlation between accidents and the violation of the rules for driving behaviour. This correlation proves to be low, and the expectation is confirmed by the results of investigations which indicated that only small differences appear to exist between those violations which are assessed and those which are not assessed as points in the penalty point system. Small differences were also found in the violations which had been observed, (in connection with an accident or independent of it), with respect to the prediction value of such violations, i.e. whether the person committing them would be involved in an accident in the future (Peck et al., 1971).

What circumstances therefore, can provide an explanation for the limited relationship (as found up till now), between driving errors or violations and accidents?

1. A driving error or violation can be explained more easily if the involvement in an accident is affected by a large number of factors.
2. Accidents, per single road-user, are rare occurrences, which are caused by several factors, therefore determining the connection with a single factor is rather difficult.
3. The majority of violations are not registered; even the registration of accidents is not complete.
4. Violations which are important in relation to accident frequency are detected by the police in relatively few instances (most 'driving' violations cannot even be easily observed).

2.2.4. Short term factors

Here again, the literature quoted, should only be considered as an example; more in particular, the literature on alcohol and driving is astonishingly large, and it is difficult to list even the most important surveys. The principal publication promises to be the OECD-report on "new research on alcohol and drugs" which is to be published in the near future (OECD, 1976). See also Noordzij (1976).

Short term factors, relating to alcohol will be discussed as examples in the following section. Table 3 (SWOV, 1969) gives a survey of several investigations carried out with accident and control groups. The contribution of alcohol to the number of accidents appears to range from 7% to 67%, depending on the following factors: (these results are in agreement with other studies):-

1. <u>The severity of the accident</u>: The more severe the result of the accident, the greater will be the theoretical reduction in the number of accidents, if the blood alcohol content (BAC) of the drivers is limited

2. <u>Selected limiting value</u>: With lower limit values the number of avoidable accidents increases. Due to the steeply decreasing probability of accident involvement with decreasing blood alcohol content, this benefit will be only marginal for low BAC values.

3. <u>The method of carrying out the investigation</u>: For example: the composition of the accident and control groups; the method of determining the blood alcohol content (a detailed description of this has been given in SWOV, 1969 and Noordzij, 1976). Calculated on the basis of the Grand Rapids investigation (Borkenstein, 1964), the relative increase in accident proneness seems to amount to a factor of 3.26. The relative frequency of occurrence in the accident group was 10%. These values yield a contribution of about 7% (see Table 3). The limit value concerned is established as 0.5%.

4. <u>Detailed data concerning the drivers involved and the circumstances</u>: For example: - the record concerning (alcohol-caused) accidents and violations: about 1 in 3 drivers, fined as a result of Art. 26 of the Road Traffic Act of the Netherlands, repeated the offence within a period of 10 years; although the criminal record, the social-economic status, the age, the blood-alcohol content and the extent to which the car is required for the driver's profession, have come bearing, the repeatability of the offence cannot be predicted easily; in addition, the contribution of previous offenders (against Art. 26) to (fatal) accidents under the influence of alcohol is extremely small (Buikhuisen, 1971).

5. <u>Circumstances relating to driver-participation and special features of the accident</u>: The majority of accidents, in which the police are able to establish the effect of alcohol, take place during week-end nights. These accidents are, as a rule, single car accidents. The time of the accident can be explained

by drinking and driving habits, while the type of the accident depends on the volume of traffic, (see also SWOV-Investigation on drinking and driving, Noordzij, 1974).
The remainder of the assessment is not conclusive, due to other differences than BAC between the accident and the control group, which also affect accident involvement; (for example, higher driving experience in the control group than in the accident group, a circumstance which may over-emphasise the influence of alcohol).

2.3. Studies in human factors

2.3.1. General

Human performance theory has an important place at the centre of fundamental science. It provides hypotheses for applied research in such fields as driving performance and driving behaviour.
The link between human performance theory, driving behaviour and accident involvement is the model (or the hypothesis) that accidents are a result of certain behaviour; more particularly, they are the result of disturbances in the normal, appropriate, behaviour. Often, although not entirely adequately, these disturbances show up as driving errors.
As has been indicated above, the behaviour of traffic participants can be described in terms of a hierarchy of decision processes (see Figure 2).
It is not always possible to apply the results of theoretical laboratory oriented research, concerning human performance theory, directly to the practical situation of driving a car, which involves making decisions at one of the levels indicated in Figure 2. In the laboratory, the most relevant processes are investigated by themselves; this means that the results are not usually directly applicable in practice. Human performance theory provides the theories, the hypotheses and the models; the translation of these into terms of actual traffic situations, however, often proves very difficult.

2.3.2. Driver behaviour research

Manoeuvring behaviour research can be applied to various manoeuvres, parts of them, their common aspects, or factors affecting the manoeuvring behaviour.
The research methods which are applied, are also of different types:
1. Study of accidents or violations, as a result of dangerous behaviour;
2. Inconspicious observations made in actual traffic situations; for example measuring traffic flows, recording vehicle movements in special manoeuvres, or unusual manoeuvres, on a given sector of the road.
3. Experiments made, for example with instrumented vehicles, in the traffic or on a closed road sector, with the possibility of more detailed recording of vehicle movements, steering operations, driver's eye and head movements, etc.
4. Laboratory-scale tests, in which the surroundings of the vehicle are simulated and in which there is the opportunity to carry out part-operations separately.
5. Theoretical laboratory-scale investigations into the elementary forms of part-operations.

In an experimental method, it is possible to assess the efforts of the driver by various means, such as: -
physiological measurements;
the observation of secondary tasks;
variations in the information supplied;
or variations in the possible reactions.

The study of the elements of behaviour, is useful for amplifying data concerning increased accident involvement, since such study supplies additional evidence regarding the factor considered in relation to the total effect, which can be used in forming hypotheses.

Generally, in investigations into differential aspects (temporary or permanent differences within an individual, or between individuals), no numerical accident data are available; therefore generalisation of the findings of behaviour studies in relation to accident proneness is somewhat problematic. For example, generalisations should not be made from a single element such as visual acuity, in relation to part-functions, such as the perception of other traffic participants; and the part-functions of a complete manoeuvre, such as passing should not be related to accident involvement in general (Griep, 1968).
The effect of human performance, including toxic and psychological factors in road traffic accidents, can only be established in exceptional cases, by direct comparisons between accidents groups and control groups. As a rule, it is considered sufficient to investigate the more elementary aspects of behaviour; the findings of such investigations, however, are sometimes not suitable for generalisations with regard to the increased probability of accident involvement.

2.3.3. Behaviour investigation in relation to toxic and psychological factors.

Literature shows that driver behaviour research on toxic and psychological factors, is usually restricted to laboratory-scale tests, in which use is made of aspects which only have an indirect relationship to driving and traffic behaviour. The majority of investigations are concerned with drugs, and in particular, with psychopharmaceutical products and drugs affecting the nervous system and neuro-effectors, which originate from within the body itself, such as lack of sleep. Difficulties in the classification of drugs and with respect to the classification of tasks, prevent the generalisation of experimental results. More specific conclusions are given in Chapter 3. Only a limited amount of literature is available on the effects of environmental stressors such as heat, loud noise and vibration, on driver behaviour.

3. THE EFFECT OF TEMPORARY FACTORS: STATE OF THE ART

3.1. Introduction

This chapter discusses in brief the State of the Art in the major areas of temporary factors in road traffic accidents. A great deal of research has been carried out in the past, the results of which have been reported in many detailed studies and reviewed in many monographs. The aim of this chapter is not to review this material, but to indicate the main lines of research.

According to custom in the research in this area, the temporary factor will be subdivided as follows;-

- medicines and drugs (i.e. medicaments usually prescribed by medical doctors and/or made available by pharmacists; and "soft" and "hard" drugs. It will be made clear subsequently that a sharp division between the two cannot be maintained; therefore they are discussed together, although many differences, such as social differences, exist).
- alcohol
- stressors
- working sphere
- maladies and handicaps.

3.2. Medicines, drugs

3.2.1. Introduction

On treating illnesses by means of medicines, behavioural effects may arise which can be considered harmful with respect to traffic safety. In this case driving must be discouraged.
Similar effects are also encountered when substances are taken for preventing a temporary decline in performance, for example, as a result of exhaustion. Taking substances which heighten the feeling of well-being, can also have an effect on driving capability and can increase the accident risk.

It can be assumed that with respect to traffic safety, those substances which affect psychic functions must be considered first of all. Although the frequency of taking such substances, the dosages and the state of health of the user, may be of importance, the relevant data are not always available from the literature.

3.2.2. The difference between alcohol and other drugs

In order to obtain an insight into the problem of "drugs and traffic safety" the following comparison between alcohol and drugs, is quoted from Havard (1970).

(Quote) "Alcohol has many unique features and it is these features which have made it possible for research to be carried out, and for preventive methods to be applied, with some success. In the first place, far more is known about the absorption, distribution and elimination of ethyl alcohol than is known about most other drugs. It is absorbed into the blood exceptionally quickly, and eliminated from the body relatively quickly. A proportion is excreted in the blood, urine and breath in an unchanged state. Consequently, reliable and practicable methods of qualitative (screening) and quantitative analysis for ethyl alcohol have been developed. These have enabled research on its actions and metabolism to be carried out, and have facilitated the introduction of medico-legal measures.
But, in the case of other drugs our state of knowledge about their metabolism is relatively incomplete. They may be excreted as a mixture of the drug and its metabolites or as metabolites alone and different individuals may have different metabolic patterns. The effects of some drugs are cumulative and may continue for days. Only in a few cases have practicable methods of quantitative analysis been developed and usually much larger quantities of blood are necessary than is the case with alcohol. We are still awaiting the appearance of reliable qualitative (screening) tests for many drugs.

Because the consumption of alcohol is a commonly accepted social habit and alcoholic drinks are freely available in most countries, a relatively large proportion of the driving population drinks alcohol to a greater or lesser degree, with the result that it is not difficult to mount controlled accident surveys for the purpose of estimating the increased risk of accident involvement incurred at various concentrations of alcohol in the body. However, even if it were practicable to carry out routine qualitative and quantitative analysis for all drugs, difficulty would still be experienced in mounting accident surveys since the proportion of the driving population taking drugs is very much smaller than is the case with alcohol.
Finally, the effects of alcohol on driving performance are mainly direct, and, apart from the hangover syndrome and certain chronic pathological conditions, they are directly referable to the concentration of the drug in the body. But with many other drugs the side effect may affect the performance of the driver more than the main effects, for example, the antihistamines which cause drowsiness were originally introduced for the treatment of allergic conditions and later for travel sickness. For these and other reasons it has been said, with some justification, that research on the effects of drugs on driver behaviour is in its infancy and that we are in a position similar to that which existed in the case of alcohol 40 years ago" (unquote).

3.2.3. <u>The use of medicines and drugs in accident and control groups; and the effect on behaviour</u>.

The following points summarize the extent and effects of the usage of medicines and drugs. This summary is based on a large number of studies, particularly Havard (1970); Milner (1972); Sanders et al. (1971);Waller (1971). See also Crancer & Quiring (1968). Recently, a special issue of 'Accident Analysis and Prevention' was devoted to drugs and driving. This issue contains very comprehensive reviews, which generally agree with the data given here (Gordon, 1976; Hurst, 1976; Linnoila, 1976; Moskowitz, 1976; Sharma, 1976).

1. According to the data from inquiries made in England, Canada, U.S.A. and Japan, about 10% of the car drivers questioned used medicines or drugs (excluding alcohol). (Anon., 1964; Anon., 1969; Kibrick & Smart., 1970; Nishikawa., 1968; Smith., 1966). No indication regarding the kind or dosage of the drugs were given, while the frequency of use varied from: - within the last 24 hours, to regularly, or occasionally. Data on whether the drugs were, or were not medically prescribed, were not available; while the relationship to participation in traffic was not always clear.

2. According to investigations covering traffic casualties in Canada and the Federal Republic of Germany, the use of medicines or drugs (excluding alcohol) was established in 10% to 15% of the cases. (Kibrick & Smart., 1970; Wagner., 1962; Klein., 1964). Investigations into traffic fatalities, established the use of drugs in 4% of the cases in Switzerland, Ohio and Florida, and 10% to 13% in California. See respectively: Im Obersteg & Bäumler (1969); Sunshine (1966); Davis & Fisk (1966); Anon (1969) and Nielson (1966).

3. On comparing the frequency of occurrence of the use of drugs, it seems that the values obtained for the accident groups are not higher than those obtained for persons not involved in accidents. However, it must be taken into consideration, that the data give no information as to the kind, dosage, and frequency of intake of medicines and drugs, (excluding alcohol); and furthermore, that the possibility of detecting the presence of drugs is rather limited; in addition there are differences in the way in which random tests are made, and as a result of this, other differences may arise, which are also relevant to the accident. Investigations including representative accident and control groups, which cover both dosage and frequency of intake of the substances in question, and include other factors which might affect the chance of accidents, have until now usually been limited to alcohol.

4. Investigations in Canada and the U.S.A. concerning people who have been convicted and/or are undergoing medical treatment as a result of drug addiction, indicated a relatively higher probability of traffic accidents for amphetamine users (Smart et al., 1969). On the other hand, there is no definite proof that amphetamine in small doses considerably increases the accident risk. Hurst (1976) indicated that there are reasons to believe that people who have been drinking or are sleepy may have a smaller accident-involvement after a small dose of amphetamine.

4. On comparing a number of drivers in the U.S.A. convicted for using marihuana, with a control group of drivers of corresponding age, no differences were found in the number of accidents per kilometer travelled. (Waller, 1965; 1967). No data were presented as to whether the drivers were under the influence, while driving. It is well-known, however, that marihuana greatly impairs perceptual functions (Moskowitz, 1976).

6. The available data in literature on the effects of tranquilizers and their after-effects on driving behaviour (Linnoila, 1976) are not conclusive. In some enquiries it was found that the intake of tranquilizers (meprobamate and librium) in small doses, has no demonstrable adverse effects on driving behaviour. However, other studies suggest the contrary. The established absence of effects observed in tests on a group of healthy, highly motivated drivers, when carrying out a number of simple, short-term tasks (parking, slalom riding) cannot, however, be accepted as sufficient proof for generalisation of these results. Furthermore, as Linnoila (1976) states: "from most of the studies it is impossible to calculate the accident risk caused by a particular drug per se, because the drug user usually has more emotional and social problems than the rest of the population".
Obviously, this observation can be extended to other drugs than tranquilizers.

A review of the literature specialising on the effects of various drugs (amphetamine, hypnotics, tranquillizers, alcohol) and the effects of loud noise and lack of sleep, on human performance in tests such as the estimation of time, decision making, long term performance, tracking and memory, results in the following conclusions (Sanders et al, 1971):
(Quote) "The results are most consistent with respect to amphetamine, hypnotics and lack of sleep in that amphetamine prevents deterioration in long term performance whereas hypnotics and lack of sleep promote deterioration. In short lasting tasks or in initial performance level, these conditions have only minor effects. Hypnotics have the further effect of inhibiting organisational activity in some types of cognitive tasks like digit substitution and memory span. The studies on alcohol and loud noise provide often conflicting evidence, with the exception of effects of alcohol on bodily tracking. This suggests that effects of noise and alcohol are more complex and depend probably on dose and specific task conditions. It is highly likely that there are strong interactions between the mutual effects of various abnormal conditions.
Theoretical explanations of the various effects centre around the concept of arousal. Simple and attractive as it may seem at first sight, this is certainly insufficient to cover the available data". (unquote).

7. Barbiturates are considered to degrade skills which are components of driving (Sharma, 1976). However, the accident involvement seems to be small. Only about 1% of fatal accidents show barbiturates involvement (Konkle, 1969 and Kaye, 1970, as quoted by Sharma, 1976).

8. From laboratory studies and simulated driving tests it can be concluded that the combination of alcohol and medicines or drugs may particularly decrease skills involved in driving (Sharma, 1976; Moskowitz, 1976; Linnoila, 1976; Hurst, 1976).

However, the data from literature on the use of alcohol in combination with medicines and drugs are mainly limited to drivers, who are suspected by the police of an excessive consumption of alcohol. In 10% to 20% of cases there are indications that the suspect consumed other substances in addition to alcohol. This follows from a number of studies, quoted by Havard (1970).
Of the total number of holders of driving licenses, who use prescribed medicines, the percentage which would be in control of a vehicle, while under the combined influence of alcohol and medicines, at least once per year, would be about 7% (Milner, 1972).
On combining alcohol and other substances influencing the central nervous system, sometimes an intensification or prolongation, can be observed, and sometimes a counter-effect.

9. Statements on the danger to traffic safety, caused by taking substances which have an effect on mental functions, are primarily, limited to substances generally known as "drugs". Investigations carried out to date have indicated that the use of such "drugs" does not seem to increase the risk of traffic accidents, as compared to the use of medicines or stimulants, which have in their main and side-effects an influence comparable to that of "drugs". There is less information available regarding the use of medicines and drugs by traffic participants than there is regarding the use of alcohol and the consequent increased traffic unsafety.

10. These statements are in general agreement with the conclusions of an Invitational Symposium on Alcohol, Drugs, and Driving (Perrine, (ed), 1974). These conclusions are quoted in Appendix A. They are also in agreement with the conclusions from Moskowitz (1976a). Part of these conclusions are quoted here.

(Quote) "The first five papers in this issue reviewed current literature for five classes of drugs regarding the potential driving safety hazards associated with those drugs. The drug groups reviewed were amphetamines, tranquilizers, barbiturates, narcotics and cannabis.

In examining this group of papers, it becomes clear that statements about the effects of drugs in general with regard to driving safety can rarely be made. Rather the papers point to the necessity for evaluating each class of drugs and their individual members. Different drugs affect disparate behavioral mechanisms. Moreover they are likely to be used at different times in differing social contexts with varying motivations and expectations. These latter considerations will differentially influence the likelihood of a particular drug degrading traffic safety.

The papers make apparent that our knowledge is quite limited even in the most frequently studied of these drug classes. Most conspicious by their absence are epidemiological studies based on samples taken from accident participants and corresponding driving control groups. It was only by the execution of such studies for alcohol, as those by Borkenstein and Haddon, that the extent of the contribution of alcohol to traffic accidents, injuries and fatalities was understood.

Unfortunately, it is far more difficult to obtain adequate samples for drug analyses than for alcohol. Moreover, current laboratory analyses have difficulty in detecting the wide range of possible drugs which may be present.

The review papers reveal the sparseness of relevant data regarding the nature and extent of the behavioral side effects of many drugs. This is especially true of the behavioral effects that are directly relevant to driving, such as the areas of psychomotor performance, and perceptual changes. However, despite the incompleteness of the data base, it appears that at least three out of the five classes of drugs discussed are likely to lead to impairment of driving skills, namely, tranquilizers, barbiturates and cannabis. More definitive statements, which might distinguish between the members of these drug classes and assign an accident probility score to each, must await further research" (unquote).

3.3. Alcohol

3.3.1. General

This section is based to a large extent on a report of Noordzij (1976). It is concerned with published research which relates to actual participation in traffic and actual road accidents and their victims. Experiments related to physiological or psychological factors, under controlled laboratory conditions may give additional data. They are not described here; surveys are given by e.g. Perrine (1972); Levine et al. (1973). See also sec. 2.2.4.

Nearly all research deals with motor vehicle drivers. Concerning other traffic participants, data are almost entirely lacking. Data on non-motorists in countries with a large proportion of traffic casualties, are particularly required. As an example, data collected by Zylman (1974) are quoted in Table 4.

3.3.2. Accident risk

The effect of alcohol in the body on the probability of accident involvement is studied by comparing the blood alcohol content (BAC) of accident and control groups. The idea of using BAC as a yardstick for estimating the "influence" of alcohol seems to be a very old and well-established one. Early researchers' work, such as that of Schweisheimer, 1913; Miles, 1919; Mellanby,1919; and a full description of Wildmark's method (1932), is given by Weeks, 1938. Modern ideas, however, tend to include social and emotional aspects in addition to the effects of alcohol, on behaviour. Because definite proof, and quantifiable data do not exist, BAC will be used here.

Several investigations involving accident and control groups are reported. A number of them are described in some detail by Zylman (1971). The best-known, and also the most representative of these is the Grand Rapids study (Borkenstein et al. 1974). Hurst (1970)

assessed the probability of accident involvement in relation to the BAC. See Figure 3.
This in fact, only indicates that drivers with a certain blood alcohol content have a greater chance of being involved in an accident in comparison with members of a group of drivers with zero (or very little) BAC, under similar circumstances. The results depend upon the method of selecting accident and control groups, (time, place, severity and type of accident, etc.), on the representativity of the control group, and on the accuracy of the BAC measurement. It is not self evident that only the higher BAC is the cause of the accident. Hurst (1970) however, indicates three reasons for believing that it is primarily the BAC:

- only age and driving experience seemed to have an influence on the accidents.
- accustomed drinkers had a smaller accident involvement than unaccostumed drinkers at equal BAC.
- many psychological factors also indicate a decrease in performance.

The last point seems to be particularly weak: the relationship between alcohol and decrease in performance is not directly comparable with the relationship between BAC and accidents. (See Perrine et al., 1974; Levine et al. 1973). Furthermore, there are strong indications that the influence on behaviour (and therefore the decrease of performance) depends on other factors as well; finally it is well known that there are interactions between alcohol, drugs, medicines, and several somatic and mental situations (fatigue).

However, a further consideration of the data indicated that a relationship between BAC and accidents could be indicated, when age or drinking habits were also taken into consideration. The relationship however, may be somewhat different.

Hurst (1972) found that for habitual drinkers the accident involvement increased more slowly with increasing BAC, in comparison with other people. Zylman (1973) found that young drivers already have a marked increase of accident involvement at fairly low values of BAC. Similar, but somewhat conflicting results are quoted by Carlson (1972, 1973). Finally, it was found that high BAC usually coincides with more serious accidents (Hurst, 1972).
These results are sometimes criticised. Smart (1969) indicated that it is the alcoholics who also cause accidents when sober, and that it is not primarily the BAC per se. This statement, however, does not agree with the results quoted by Buikhuisen (1973) and with the fact that (according to Hurst, 1970) habitual drinkers have, at the same BAC, a lower accident involvement. Finally, Clark (1972) pointed out that there are important differences in age, offences, and accidents between persons convicted for driving under influence of alcohol, drivers with high BAC killed in accidents, and alcoholics.
It is concluded by Noordzij (1976) that on the basis on this material alone it is not possible to arrive at a definite maximum admissible BAC value. It is interesting to consider Moskowitz (1976a) once more: "We have passed well beyond asking whether alcohol is dangerous for drivers - we know that it is. However, we do need further information regarding the classes of drivers who drink, their drinking-driving patterns, the nature of their impairment produced by drinking and how to organize this knowledge into effective countermeasure programs".

3.3.3. Driving under influence of alcohol

In many countries the data related to drivers under influence of alcohol are derived from accidents in which the police (often without objective methods) have stated that the driver was "under the influence". There are reasons to believe that the registration method is not constant over periods of time. In Figure 4 some data from The Netherlands are given based on offical accidents statistics. There seem to be large variation in the per-

centage of accidents "caused" by alcohol, although there are no grounds for believing that either drinking habits or driving habits changed considerably. (It was only on November 1st, 1974, that certain BAC levels were prohibited by law for drivers). Similar results are also quoted from other countries, where the police reports usually tend to underestimate the number of alcohol accidents (Zylman, 1970; Waller, 1971; Goldberg & Bonnichsen (1970).
Zylman (1974) analysed a number of accidents where the BAC of drivers killed in accidents had been measured. It is indicated that of drivers involved in accidents with other vehicles, 32% had a BAC of more than 1 o/oo; for single vehicle accidents the figure was 57%; combined, it was 44%. For adult pedestrians the percentage is 36%. Further consideration of these data suggested that "approximately 36.4 percent of all motor vehicle deaths may involve alcohol in some causal fashion" (Zylman, 1974; see also Table 4). Nevertheless, as Noordzij (1976) has pointed out, a number of uncertainties are present in these calculations. There are even more uncertainties, in the investigations reported by Kielholz (quoted by Lutz & Leu, 1975), Codling & Samson (1974), Hoffmann et al. (1975) and Bø et al. (1974).

Another approach is reviewed by Stroh (1974). On the assumption that the relationship between BAC and accidents is well established, it is sufficient to estimate the magnitude of the problem, by measuring BAC's in random samples of drivers. Recent investigations along these lines are reported by Biecheler, et al. 1974; Wolfe, 1974; Clark et al., 1973; Smith & Wolynetz, 1975, and Noordzij, 1974.

3.3.4. <u>Characteristics of drivers under the influence of alcohol</u>

In several investigations, comparisons are reported between different groups, e.g. Clark (1972), drivers killed in accidents, convictions for driving under influence of alcohol, hospitalised alcoholics and random samples of driving licence holders. These groups proved to be different in many respects, such as age, traffic offences, convictions for driving under influence of alcohol, and repeated accidents. Similar investigations are reported by Waller (quoted by Haddon, 1970), Thomas (quoted by Pollack, 1970), Perrine et al., 1971. The results are, however, different and sometimes even conflicting.

Buikhuisen & van Weringh (1968) and Buikhuisen (1973) compared several aspects of persons convicted for driving under influence of alcohol, with other groups of the population. Not only behaviour in traffic (BAC, offences) but also factors such as age, occupation and criminal records, with and without alcohol, seemed to be of importance. However, the relationships are not marked enough to form the basis for the selection of drivers.
As Noordzij (1976) points out, this is only a limited sample of all the investigations. The results are not conclusive; there are indications that other factors play an important role. It is also well known that many accidents associated with the use of alcohol occur at week-end nights; this suggests a link with social activities and/or social needs.

3.4. Stressors, working sphere, illness, bodily handicaps

3.4.1. Stressors

The term "stressor" is used for a group of more or less specific factors in the external and internal environment of man, which produce an effect that manifests itself in a similar way by decreasing the feeling of well-being and by reducing the level of human performance.

As examples - fatigue, noise, glare and emotional stress may be cited. It is assumed that these factors affect traffic safety as a result of reduced performance with respect to attention, perception, information processing and reaction capacity. In several cases, data from laboratory investigations are available.

The results obtained, however, cannot easily be generalised in terms of driving performance.

A. Fatigue is, in fact, a complex phenomenon.
It can be divided into three factors:

1. time-on-task (the time during which the subject is actually engaged, e.g. with driving);
2. lack of sleep;
3. disturbances of the daily rhythm.

Interactions, of course, may be present. The first, actually, seems to be the least important factor, contrary to common belief. This should not be confused with the well-known fact that while at first alertness may be very high it diminishes rapidly after several minutes.
Regarding the overall effect of fatigue, accident data are available for only a few cases. As an example, the results of U.S. experience are quoted. This relates to the accident rate, dependant on the duration of driving. It was found that for lorry-drivers, the accident rate increases considerably after continuous driving for 6 hours, and it cannot be compensated by rest-breaks. A certain decrease in performance could be detected after driving continuously for 4-5 hours.
The more recent experience in this field, were collected at the Symposium organised under the auspices of the European Commission in Crowthorne (Anon, 1975).

B. With regard to the effect of loud noise (such as noise caused by engines and wind), it was found that these affect the perceptivemotor tasks, which are related to the driving task. Data regarding the influence of noise on accident involvement are not available, however.

C. In road lighting, glare is considered as a source of both discomfort and disability. In severe cases, perception may even be fully obstructed. Again, however, data concerning accident involvement are scarce (OECD, 1976a).

D. With regard to emotional stresses, so-called "psychological autopsies" are carried out on traffic fatalities, which could indicate the presence of emotional problems in the persons under investigation. (Zavala, 1972). However, in order to establish their specific effect on the accident rate it must be determined to what degree these problem situations differ between the accident and the control groups. This also applies to the effect of the mental attitudes, the character and the personality of the driver (SWOV, 1967; Griep, 1970).
It should be noted that this section only deals with these aspects by themselves. Their individual contribution to accident involvement is not fully understood, and it does not seem to be important if they present themselves simultaneously. Nevertheless, sometimes they seem to have very important results (Anon, 1975).

3.4.2. Working sphere

It is assumed that the working sphere (the micro-climate) of the car influences the performance of the drivers and, consequently, the accident involvement. This problem is widely discussed in literature, in connection with the ergonomy of the vehicle. In this respect the following should be mentioned:
- the effect of vibrations on, for example, the visual acuity.
- the effect of temperature, the degree of humidity and carbon monoxide concentration, and other factors which affect alertness.
- the effect of the design of the seat on fatigue, etc.

The relationship with road accidents cannot be quantified because there are no data available concerning the effect on the accident involvement; and only limited data, on those aspects of performance, which can be related to driving behaviour.

In some cases (stressors, carbon-monoxide concentration) the effect seems to be greater in relation to the state of health (heart and bloodvessel diseases), than to traffic safety, since it involves a continuous exposure to the risk factor. See also the Symposium quoted above (Anon, 1975).

3.4.3. Illness and physical handicaps

The report of the Dutch working group "Medical deficiencies in the Prevention of Traffic Accidents" (SWOV, 1965), discusses the effect of more- or less chronic illness and physical handicaps, on traffic safety. A definite increase in the risk cannot be proved. The use of adequate medicines (for example, in the case of epilepsy), special provisions in the car for the physically handicapped and/or compensations for certain deficiencies (for example, single-eyed or deaf persons), seem to have an adequate compensating effect. Regarding heart and blood-vessel diseases, the participation in traffic seems to be more dangerous to the diseased person than the disease to the traffic, (in the case of a heart-attack the driver, as a rule, is still able to stop his car at the side of the road).

3.5. Visual performance, reaction capacity, information processing

3.5.1. Visual performance

The relationship between the extent of the probability of accident-involvement and individual differences in visual functions, seems to be slight (dynamic visual acuity, static visual acuity, field of vision), or not detectable (eye-dominance, sensitivity to glare, colour deficiency, reduced stereopsis, single eye) (See Burg, 1971: Gramberg-Danielsen, 1967; Schubert, 1965; Goldstein, 1961).

In this connection several remarks may be made.

1. In ergonomic design, limitations of visual power are taken into account, mainly with regard to marking, lighting and signalling for the vehicle and the road.
For example, in setting up standards for the colours of road traffic control signals, people with reduced colour discrimination are taken into account (Anon, 1973); the minimum and maximum intensity of lights, taken into account the sensitivity to contrast and glare

(Schreuder, 1971); the positioning of traffic signs the field of vision; the dimensions of traffic symbols the visual acuity (SWOV, 1970); standardisation of the position of vehicle signalling lights the perception of movements (Roszbach, 1975) etc.

2. Restriction of visual performance is allowed for in the driving behaviour. The compensation may be either the adaptation of cue functions, or it may also involve the cueing system itself. For example, increased driving experience may compensate to a certain degree for the declining visual performance with age. Furthermore, the exposure to risk (time of day) and driving style (speed) depend upon age and sex. It is not fully known however, to what extent the perceptive and visual functions, (which are important for traffic participation), depend on the effect of age, sex and experience. As far as is known, an inexperienced driver aged over 65 represents only a marginally increased accident factor, as compared with a young inexperienced driver (Roszbach, 1973). However, it is known in which way functional shortcomings are compensated for in a given risk situation and driving style.

Limitations of vision can be compensated for in various ways, for example, by moving the eye or head, in the case of inadequate or stationary field of vision; or by determining the speed, in relation to visual acuity. However, not all driving circumstances permit such adaptations to the same degree, as for example in rush-hour city traffic, or the compulsory minimum speed limit on motorways.

3. In connection with the true relationship between vision and accident involvement, some methodological circumstances can be mentioned.

a. The frequency of accidents is relatively low: approximately one casualty or fatality per 100 million kilometers. The fact that the relationship between visual performance and violations is more marked than the relationship between visual performance and accidents (Burg, 1971) may probably be explained (at least partly) by the higher number of violations, as compared to accidents.

b. In most countries drivers are allowed to participate in the traffic after a simple screening test; extreme deviations are detected by the screening. This may be followed by the exclusion of the persons involved. Thus variations in the driver population is reduced, as compared to the population as a whole. This obviously reduces the chance of finding a correlation between visual deviations and accidents. The spread of the range of these deviations is however, not a constant. Thus the standard deviation from the average visual acuity is higher by a factor of 3 for drivers aged over 65, than for drivers aged 25 or less (Burg, 1968).

c. The usual investigations do not relate explicitely either the accident type and circumstances, or important perceptive tasks and visual functions, or finally, specific groups of drivers. In this connection it must be considered, whether shortcomings in perception due to reduced visual functions are not of decisive importance in all types of accidents (for example, in single car accidents). Sometimes the (time-dependent) condition of the driver, (for example blood alcohol content and/or fatigue, which influence the visual functions and/or central processes), may have more effect on the accidents.

d. If a connection between visual function and accident involvement can be established, it must still be determined to what extent this connection is affected by extreme cases, or if it is affected in a more uniform manner, by less extreme variations of vision. Furthermore, it is still not clear, whether the connection can fully be justified in terms of casuality on account of the possibility that variations in visual performance may be combined with other factors, which are also important in relation to the probability of accident involvement. To solve this problem, additional experimental investigations should be carried out, in which the conditions which are actually interrelated in practice, are systematically studied.

3.6. <u>Provisionary evaluation</u>

1. Research into the effect of toxic and psychological effects is complicated by the non-predictability and highly temporary character of the situations presented to the road users. This problem is mainly manifested in studies which compare accident and control groups.

2. The comparison between accident and control groups provides explicit data concerning the increased probability of accident involvement in only a few cases. These are alcohol, age and driving experience.

3. The majority of investigations into accident involvement and the frequency of occurrence in road users are concerned with motor vehicle drivers. In only a few cases are data available on other groups of road users.

For example: the higher blood alcohol content of pedestrians as compared to that of car drivers, above which (related to the sober state) an increased risk of collision between pedestrians and the motorised traffic can be statistically proved (SWOV, 1969);

- the lower frequency of alcohol consumption by motor cycle riders involved in fatal accident (DMV, 1969);
- the extra-risk, resulting from the combined effect of alcohol consumption and insufficient driving experience (Zylman, 1974).

4. Behaviour investigation into the effect of toxic and psychological factors can be useful for obtaining supplementary evidence, when comparing the results of the investigation of accident and control groups. As long as these are absent, generalisations of the findings of behaviour investigations, in terms of accident involvement, are rather dubious. However, as in the case of task analysis, which is based on the selection of criteria for testing the influence of the situation under consideration, a more or less complete inventory of tasks and circumstances must be available, before the whole effect of the situation under consider-

ation can be estimated in a generally valid manner.

5. Toxic and psychological factors also have effects outside traffic situations such as industrial working situations. In fact, sometimes more research effort has been put in those areas. Thus, such result could be of interest in connection with road safety. When considering toxic states as a consequence of either being exposed to certain working conditions, or as a consequence of taking medicines and drugs, it seems, that in industry investigations are mainly made, and measures taken relating to the former case.

6. Because psychopharmaceutical products and medicines affecting the central nervous system, also may have unwanted behavioural influences in situations apart from traffic, it seems desirable to arrive at more general behaviour criteria. However, a difficulty which arises in this connection, is that there is no generally accepted classification of these products, or a generally accepted and valid summary of behavioural criteria. Special attention must be paid to the risks which arise caused by the combination of medicines/ drugs and alcohol.

7. A review of the literature concerning the effects of some drugs (amphetamine, hypnotics, tranquillisers, alcohol), loud noise and lack of sleep, on human performance, in such tests as estimating time, decision making, long term performance, tracking and memory, give rise to the conclusions of Sanders et al (1971) quoted above.

8. One problem relating to behavioural criteria, is the possibility of compensating for deficiencies or influencing the performance of tasks. This means that in the case of one aspect of behaviour, (for example, vision), the influence must not be generalised, by taking into account the compensation possibilities (for example, slower driving).

In connection with medicines and drugs, it may also happen, that continuing driving under a state of stress for example, without taking a certain medicine (for example valium), can be more dangerous than continuing driving (in the state of stress) and taking the medicine. Strictly prohibiting both the state (of stress) and the medicine (valium), does not always produce the desired effect. Since this problem is related to considerations other than traffic safety, such as national health and economy, a more thorough, basic approach to the problem seems to be required.

9. Toxic and psychological factors can also play a part in sectors other than the pre-crash sector, which is mainly concerned with increased accident-proneness. In this connection psychological factors can be applied to the use of safety measures, for example, in connection with possible psychological objections against legally enforced use of seat belts and crash-helmets. However, in this area, the legal arguments seem to prevail over the medical and psychological aspects.

10. Toxic and psychological factors in the form of dependence or addiction, can play a part in the ownership and use of vehicles. A particular motivation to acquire a car and to use it, can overshadow the rational choice of alternatives. Propaganda and education can have some influence in this respect, but first of all a systematic investigation is required into the adequacy of the various means of transport (private or public transportation in various forms), related to different aspects, such as travelling distance, destination, degree of occupancy, energy and space requirements.

4. PRIORITIES FOR RESEARCH I (GENERAL APPROACH)

4.1. Introduction

4.1.1. Alternative approaches

Research in the field of toxic and psychological factors in road traffic accidents will be considered useful only if it forms the basis for measures to be taken, which really help to reduce the number of accidents. Thus, the most appropriate way to assess priorities for research in this field, seems to be the following:

a. the priorities of measures are set up, based on some cost-benefit considerations;

b. the gaps in the knowledge regarding these measures are assessed;

c. the research needed to fill these gaps is identified;

d. priorities for research are set up, based again on cost-benefit considerations (in this case, the costs of the research and of the measures, and the benefits of the measures which are made possible as a result of the outcome of the research)

The first step is, therefore, the assessment of the priorities for the measures. This is, however, a very difficult matter, for the following reasons. Firstly, the number of accidents related to the unfavourable situation, which is to be counteracted by the measure should be known. Secondly, the causal sequence which leads to accidents in these conditions, should be known (at least to a certain extent) in order to define and localise the most appropriate measures. Thirdly, the frequency of occurrence of the particular unfavourable condition should be known. And finally, the percentage of accidents which may be expected to be avoided by the introduction of the particular measure should also be known. For this, the frequency of occurrence of the situation both in accident and in control groups, and the efficiency of the measure, must be known.

A suggestion to set up priorities of research, which closely follow these ideas, is put forward by Sugden (1976). This approach is very interesting and deserves to be pursued further and is summarised in sec. 4.7. However, it will not be followed in the main part of this report, due to its restricted applicability.
It would necessitate setting up a complete inventory of all possible measures, a task which is clearly beyond the original terms of reference for this study. Apart from this approach, three further alternatives will be introduced. The first, consists of a set-up of the priorities based on the idea that accidents can be described in terms of errors in the manoeuvring behaviour of drivers. All aspects of the driving task are considered, the reasons why some errors in performance may occur are investigated, and this leads to areas of possible research. The priorities of these research areas are assessed by taking into account their relevance, their costs and the amount of data already available. This is explained in detail in secs. 4.2 to 4.5.
A second approach involves the following alternatives: when accident data are available in a certain area, the effect of measures can be estimated when some data exist on the causal sequence. Here, driving behaviour studies may be of use. All this may yield a qualitative or even semi-quantitative assessment of the cost/benefit relationship of the measures and of the research. An alternative presents itself when accident data are not available, but when driving behaviour studies may be made. Based on the data that are available, and taking into account hypotheses following from the behaviour studies, one may indicate what further data are still needed. Here, the introduction of a hierarchy of problem areas (in fact the areas of evidence) may be set up, which allow an estimate of the required data. These alternatives are explained in sec. 5.2.

A third approach may be indicated for the case in which most (or nearly all) of the required data are not available. A first approximation of the order of priorities for research may be obtained, by looking at "clusters" of factors, each of which is unfavourable but not quantitatively known as accident-provoking, and which often happen to be present simultaneously. In fact, this method relies to a certain extent on intuition and common sense, but by being systematic about the approach to it, it is believed that a somewhat higher validity may be obtained, as compared with the way in which priorities are usually allotted at present *).
This system is explained in sec. 5.3.

The difference between these alternatives as set out here, is not as large as it might seem to be at first sight. For the first approach, which is based on theoretical considerations regarding the driving task, the benefits can only be derived (on a purely theoretical basis) when the measures which come into consideration are known. A set of priorities based on cost/benefit considerations can be given only when it is known what additional (experimental) data are available. These data include accident data. Moreover, as indicated in sec. 4.2., the evaluation of the measures and of the research requires data on the frequency of occurrence (in general, in accident groups and in control groups), and this, in turn, requires road-side sampling and detection methods. The second approach requires accident data and data from road-side surveys as the elements, and data on driving performance as additional material. Thus, a fairly large overlap exists.

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*) Footnote: In all the cases indicated above, a considerable mass of data are necessary. When these data are not fully known, an estimation must be made. In most cases the process of estimation requires additional information not usually available in research institutes.

4.1.2. A system for establishing priorities for research

The order of priorities for research is based on the order of benefit-to-cost relationship. As long as resources may be regarded as unlimited, it is sufficient to be able to list the researches in sequential order, and to start with the research at top of the list etc. In reality, however, resources are never unlimited, not only with respect to monetary budgets, but also with respect to man power and research facilities.
As indicated by Flury (1972), in the case of limited resources an ordinal scale is not sufficient. A metric scale or at least a ratio scale is required. It is the aim of this chapter to determine such a scale.

The system used here can be described as follows:
1. A complete list of all possible research "items" (n_i) is drawn up covering the complete area under consideration (n_i: i = 1 ... N). (Note: the items should be mutually independent. This condition can always be fulfilled by the careful selection of the items).
2. A complete list is drawn up of all criteria (k_j) that are considered to be of importance for the establishment of the benefit of the research (k_j:j= 1 ... K).
3. Weighting factors g_j are defined for each of the criteria, taking into account the terms of reference for the research in general.
4. Relevancy factors r_{ij} are estimated for each of the items, in relation to each of the criteria.
5. Summation per item $\sum_{j=1}^{K} r_{ij} g_j = b_i$ yields the benefit-factor of each of the items.
6. Two cost factors are defined and taken into account:
a. the effort (in terms of finance, manpower, time, facilities) required to arrive at the answer regarding the different items (m_i);
b. the fraction t_i of the effort which still remains, in order to arrive at the answer.

7. The numerical values of m_i and t_i are estimated for each item. Thus, $(m.t)_i$ is the cost factor per item.

8. $R_i = \left(\frac{b}{m.t}\right)_i$ is the benefit-to-cost ratio for each item. Ranking R_i yields the order of priorities.

Each of the steps indicated here will be explained more in detail, and will be applied as far as possible in the following sections.

In principle, the system for setting up priorities can be applied to a variety of cases, in fact to all cases where the costs can be expressed by one scalar, and the benefits also by one scalar. On introducing appropriate rules for summation, even multi-dimensional vectors for costs and benefits can be used. When this system is applied to research with a practical aim, the matter is complicated in so far that the benefits have to be divided into two groups: those benefits which are related to the results of the research, and those which are related to the outcome of the measures, which are introduced on the basis of the results of the research.

For the purposes of this report (toxic and psychological factors in road traffic accidents), however, the application of the system is difficult, because a number of essential factors are difficult to estimate or to express quantitatively, more particularly because the priorities do not refer to research in this area in general, but specifically to those areas of research which could benefit particularly from the kind of international co-operation which could be sponsored or stimulated by the European Commission. In order to indicate how the proposed system could be applied, some numerical data are given in this report. It should be pointed out that they serve primarily as examples.

It will be clear that considerable time will be required, in order to apply the system as set out here, to its full extent.

In some cases this time is not readily available; therefore, in Chapter 5 some indications will be given, as to how, by using more conventional points of view, short and medium term priorities, in the area of toxic and psychological factors in road traffic accidents, can be obtained.

One final remark should be made regarding the summation $\sum rg$. It could be argued that a multiplication system would be more appropriate, since if one of the weighting factors, or one of the relevance factors is zero, the research is worthless. This is in fact a theoretical matter, which falls outside the scope of the report. For practical purposes the matter can remain, as long as none of the factors is zero. (In practice, one would not expect this to happen). When the factors are all greater than zero, there are no appreciable differences between summation and multiplication. As Flury (1972) has pointed out, a more refined system should take care of this:
i.e. - multiplication for factors within one level, and summation <u>between</u> levels of decision making. Such an elaborated system is, however, not immediately available. Therefore summation will be used in the following-discussions.

4.2. <u>The "items" for further research</u>

4.2.1. <u>Introduction</u>

In the foregoing chapters and sections, the different considerations related to the problems on hand have been discussed in detail. The emphasis falls on temporary, or more generally, on differential aspects related to human behaviour. It has been pointed out that research in areas relating to the general restrictions of human possibilities (notably the processing of the visual information), may lead to improvements - particularly ergonomic improvements - of the vehicle/road system; these however, fall outside the main scope of the research area considered here. Furthermore, it has been decided that those factors, which are constant in time, but for which there may be individual road-user differences, will also be regarded as falling outside the scope of this report, principally because most long-term deviations for individuals, are almost completely compensated. It has been concluded that primarily those factors in road traffic accidents which are both variable in time and differential for individuals, are considered to be the most promising for further research.

The majority of these points have already been discussed in detail. Therefore, they will be listed without much further comment. This list may yield, (together with the criteria listed in another section, and the different weighting factors), the order of priorities which is required. It should be stressed again, however, that this list of "items", and consequently the order of priorities, is only relevant within the restricted area of toxic and psychological factors in road traffic accidents. It should always be borne in mind that the measures based on results of research in this field, will generally interfere with other measures, and thus they will often not result in the best possible solution. This best possible solution can be found only when the road safety problem is investigated on a wider scale. If this is taken into consideration, a more restricted approach can still be valuable.

A completely systematic survey of all items of interest could be prepared on the basis of a complete understanding of the details of the driving task, or more generally, of the task of the road user. This task is not fully understood at the moment, so that the list which follows, is not completely systematic.

4.2.2. Influence of toxic and psychological factors

4.2.2.1. General

A decision itself, is preceded by a process of perception, and followed by a process of action. Driver behaviour may be indi-

cated by the Stimulus - Decision - Response process. Toxic and psychological factors may influence each of the three elements of the SDR process or two, or all three.
In present day road traffic, perception is almost exclusively visual perception. The stimuli are therefore almost exclusively visual stimuli. The visual perception system may deteriorate as a result of "peripheral" or "central" malfunctions. The peripheral malfunctions relate to the eye itself. In this case important differences exist between individuals, but they are nearly always constant, or nearly constant in time,
There are some exceptions, e.g. various acute pathological disturbances of the eye, and disturbances in its correct functioning, resulting from the micro-climate in the vehicle.
The central malfunctions can result from maladies and intoxication; again here most maladies are almost constant in time. Intoxication may lead to an increase in reaction time, an increase in discrimination thresholds etc., which results in not perceiving important objects, or perceiving them partially, or incorrectly, or too late.
In conclusion, it can be stated that the travellers' decision making process may be influenced, in relation to the stimulus aspects, by "agents" which may be classed as toxicants, environmental factors, and maladies.

Decision making itself, does not add information: the decision is made on the available information, in the light of past experience and the level of risk adopted by the driver. Thus, incomplete or incorrect information, may lead to inadequate decisions. However, if the information is adequate, the decision may be inadequate.
It should be noted that at the level of manoeuvres, making the proper decision is mainly a matter of training, and also to a certain extent, of education.
For reasons explained above, these cannot be considered as differential aspects in time and between persons, and therefore they will not be discussed in this report.

The response and the driver performance may be not appropriate, even when perception and decision were correct. It seems justified however, to disregard the performance part of the process in this report since motor-performance and co-ordination are impaired only in extreme cases of intoxication.

Furthermore, in most cases, insufficient data are available to justify the SDR process for the present study, although it is felt that for a further understanding of the relevant processes, such a behaviour model would prove to be useful; for the present report, it will be indicated simply by "driving performance".

4.2.2.2. Inventory of factors: intoxicants

It is customary to subdivide intoxicants into the following groups: alcohol, drugs (medicaments), drugs (non medical), and toxic substances. Most intoxicants should be classified as exogenous; endogenous intoxicants are probably more directly related to maladies and stressors.
The broad groups indicated here should be further subdivided actual research items. It might prove helpful to consider a primary classification of exogenous intoxicants as follows:

effect	usage: on purpose	usage: by accident
known	I	III
unknown	II	IV

This subdivision is particularly of use, for the consideration of measures.

The category I (effect known, usage on purpose), seems to be very important. This category includes alcohol and nearly all the (non-medicaments) drugs. The category II includes medicaments, notably those where the influence on driving capacity was not indicated. The category IV relates primarily to "agents" such as CO, 0_3, NO_x etc. At first sight, the category III (effect known, usage by accident) seems to be very small.

Furthermore, it is necessary to indicate the impairments in the elements of the driving task, which follow from the presence of these "agents", and finally, it is necessary to known what the contribution of the "agents" to traffic un-safety could be, notably with regard to the frequency with which they occur in traffic, and with regard to the causal connection between the specific impairment of the driving task and accident causation.

In order to indicate the impairments, it is useful to give a classification of the "agents", listed here as intoxicants. In the literature, many classifications are given. For this report, however, the existing classifications cannot be applied directly; and an additional classification has therefore been added to those already in existence. (It will be clear that it is a pertinent disadvantage that so many classifications exist). The proposed classification is based approximately on the classification given by Claridge (1970, p.20).

Class	Negative effects on driver performance *)	Examples
Sedatives	important	alcohol
Hypnotics	important	barbiturates
Stimulants	none or small	amphetamines,caffeine
Major tranquilizers	important, but negligeable in small dose	chlorpromazine
Minor tranquilizers	none	benzodiazepine
Antidepressives	unknown	phenelzine
Hallicunogens	unknown, probably important	LSD, mescaline

* Note: only the major negative effects are given.

Thus, the major projects for research with regard to toxicants, can be indicated as follows: -

A. The influence of alcohol on driving performance.
B. The influence of drugs (major tranquilizers, antidepressives and hullucinogens) on driving performance. (These groups could be split up into sub-groups relating to perception and decision making. Such a subdivision will be particularly useful, when the detailed proposals for the actual research are considered).

The research items refer to the intoxicants which are taken purposely, i.e. - category I and II of the earlier classification. The category IV (usage by accident, effect unknown) is vague and wide. Three sub-categories may be indicated: substances taken before or during the trip, which have no direct relationship to traffic (such as poisoned food etc.); those coming from outside the vehicle; and those coming from within the vehicle. The latter two may be attributed directly to traffic, and mainly from industrial and/or vehicular air pollution. CO, CO_2, NO_x, O_3 and compounds containing sulphur and lead are especially important. For convenience, these may be classified as "air pollution factors". CO, however, seem to deserve special attention for road unsafety. (When considering the influence on the general or social well-being, the priorities may be quite different!)
C - The influence of air pollution factors (others than CO) on driving performance
D - The influence of CO on driving performance.

4.2.2.3. Inventory of factors: environmental factors

The environmental factors relate primarily to the micro-climate within the vehicle. They include relative and absolute humidity, temperature etc. Lack of ventilation may lead to a concentration of CO. This is covered in sec. 4.2.2.2. Vibration and noise are disturbing and uncomfortable, and could lead to accidents. Both may be particularly important, under otherwise unfavourable weather and/or driving conditions.
E - The influence of the vehicle micro-climate on driving performance.
F - The effect of vibrations and noise on driving performance.

4.2.2.4. Inventory of factors: illnesses

It is to be expected that most somatic pathological disturbances cannot be classified as being of short duration. Therefore they are not covered in this report.

4.2.2.5. Inventory of factors: fatigue and stressors

As indicated above, it is difficult to see how fatigue and stressors could influence perception. Some investigations, however, seem to suggest that the decision making process may be impaired. Common sense seems to indicate that fatigue will impair simple decisions, and stress the more complicated areas. Scientific research is still lacking. Furthermore, it seems justifiable to make a clear distinction between the effects of fatigue and stressors which results from traffic itself, and those which result from other sources. Here, only the former are considered. In Sec. 3.4.1. it has been pointed out that fatigue is in itself a complex phenomenon.

G - The influence of fatigue on driving performance.

H - The influence of stressors on driving performance.

4.2.2.6. Inventory of factors: surveys

In all cases quoted above, measures can be assessed only if data are available regarding the frequency of occurrence (see sec. 4.1.1.). In spite of the fact that these research items fall, to a certain extent, outside the system quoted here, they have been included. It should be noted that these research items are particularly of interest in the pragmatic approaches as described in Chapter 5. The research items refer to all toxical factors quoted above.

I-Systems of roadside surveys, including methods of detection.

J-Occurrence in traffic and outside traffic.

K-Occurrence in traffic casualties.

As explained above, in order to asses the dimensions of the problem on hand, data regarding "exposure" are needed. Here, it is not only the kilometers or hours driven, but also the subdivision of this, into terms of time of the day, type of trip, type of vehicle etc.; broken down according to age, sex, driving experience etc. This may be summarised as:
L-Traffic participation.

4.2.2.7. Interactions

It should be stressed that this chapter deals with the primary influence of a number of factors. It is well-established that many of the aspects which are particularly unfavourable for driving, are related to the combined influence of several toxic factors. Furthermore, it is equally well-established that the influence of a particular toxic agent, on complicated aspects of human behaviour (such as driving performance), is by no means a simple relationship. "Higher" factors, (many of them not short term, such as social or personality factors) may influence the effect of the toxic "agent", both favourably or unfavourably.

These factors are not discussed in this section, because data are not available, for establishing priorities for research. They may be included, when actual research proposals are decided upon, and a few of them are discussed in Chapter 5.

4.2.3. Travel performance aspects and occupancy aspects

Contrary to the pre-crash aspects quoted above, the influence on travel performance and occupancy is only of interest as a direct result of measures which may be taken to reduce the number and/or severity of accidents. Furthermore, both are related to measures which seek to prevent persons who are (temporarily) disabled as a result of toxic and psychological factors, from taking part in traffic, or at least not as drivers. *) Therefore, research into this area need not be concentrated on the underlying phenomena, but rather should be directed to the effectiveness of the measures.

* Temporarily disabled includes all toxic factors, of which alcohol is the most predominant.

M - The influence of education (including propaganda and information) on the degree to which temporarily disabled persons abstain from travelling.
N - The influence of enforcement on the degree in which temporarily disabled persons abstain from travelling.
P - The influence of enforcement on the degree to which temporarily disabled persons abstain from driving themselves.

Measures related to education and enforcement, particularly those influencing the traffic performance and/or the degree of occupancy, may have side-effects, and may interact with aspects of the traffic system. It is therefore questionable whether the statement given earlier (that all other factors are considered as constant) is justified in these cases.

Q - Side-effects of measures related to education and enforcement: (increase in number of pedestrians; increase in pedestrian accidents etc.).
R - Interaction of measures related to education and enforcement with other aspects of the traffic system: (interference of pre-crash and/or crash measures, etc.).

4.2.4. Concluding remarks

It will be noted that "smoking" is not included in the list. The reason for this is, that nicotine has a weak and not fully understood influence on the bodily and mental functions, but could be included within the group of "drugs". The other main effects of smoking while driving, are concerned with the distraction of the driver's attention (which falls outside the scope of this report) and with the increase in the amount of carbon monoxide within the vehicle. This aspect must be taken into account when discussing the influence of CO.

In order to arrive at decisions with regard to the priorities for research in the area of toxic and psychological factors,

the items given above might be specified.
In this respect, it may be noted that all items given here can be characterised by the fact that they contain an agent "X" which is unfavourable for road traffic (often also for the human wellbeing in general) and that this agent is, in one way or another, introduced in or to the persons. Based on this, a number of types of measures can be identified, to reduce the adverse effects, and thus certain groups of research. These types of measures relate to:

a, a warning of the fact that agent "X" will present itself in the near future;

b. information and education regarding the action, results and consequences of the agent "X"; this can be arranged in categories of the agents, and can be diffused among groups of people or to individuals (taking into account their particular situation);

c. the reduction of (the possibilities of) the intake of the agent "X";

d. the reduction (the possibility of) the combination of driving and the influence of the agent "X";

e. the reduction of the adverse effect of the agent "X" (either by making available an antidote, or by reducing the adverse side-effects).

As indicated earlier, in order to make research useful in these areas where measures can have effect, some additional data are required, which in turn, make research necessary. These are related to:

1. the actual presence of the agent "X", and its distribution amongst the driver and non-driver population, including pedestrians; divided according to age, sex, etc.

2. the influence of the agent "X" on the driving task in general, and on separate elements of this task in particular.

3. the combined effect when more than one agent is present at the same time. Here, one has to reckon with the following possibilities: the agents counteract each other, they work independently of each other, or they reinforce each other.

4. the influence of the agent "X" on aspects of human life, other than road transportation.

The items for research are grouped together in Table 5.

4.3. The criteria for research, and for road safety measures

4.3.1. Introduction

In the system presented in this chapter, priorities for research can only be indicated on the basis of a set of criteria. Taking into account the fact that for practical research, no matter whether the research *as such* leads to further knowledge, the results of the research may lead to measures or decisions which help to improve road safety, the set of criteria therefore turns out to be rather elaborate. In order to make the set more easily understandable, all criteria are classified as "relevancies", and furthermore they are subdivided in two groups, i.e. those relating directly to research, and those relating to the measures or decisions, which will (or may) be made, based on the results of this research.

4.3.2. Criteria for research

1. *The theoretical relevance* of the investigation is determined by the degree to which the results of the investigation contribute to the general increase of knowlegde concerning traffic safety problems (in the widest sense of the word).
It is possible (although not very useful) to extend theoretical relevance to traffic in general, or even to the limits of all human knowledge.
Theoretical relevance involves the expansion of knowledge by research. As a rule (and not without justification), one considers only objective knowledge in this connection and in consequence, the acquisition of additional knowledge which can be tested by experimental (empirical) investigations. In order to estimate whether a certain investigation deserves a high priori-

ty on the basis of a high theoretical relevance, it is necessary to find out, whether the relevant hypotheses can be made operational and can be tested, and whether the validity and accuracy are sufficient, etc. (This aspect should not be confused with the possibilities of investigation, Sec. 4.3.2.3.). However, the necessity for testing by experiments is not required for all cases. Investigations, leading to new hypotheses, and mathematical investigations, can also have high theoretical relevance (See also SWOV, 1965, pp. 144, 145).

2. <u>The applicability</u> of the investigation is determined by the degree to which the results obtained can be incorporated (built-in) into measures, which are intended to improve traffic safety. This relevance can be split up into <u>direct</u> and <u>indirect</u> relevance. Indirect relevance in this respect, means that the results of the investigation cannot be applied directly, but that they are important (or necessary) as 'inputs' for other considerations (investigation, etc.), which in turn, have a "direct" relevance (e.g. improving the accuracy of breath alcohol detection is not directly a basis for measures, but may improve the effectiveness of drinking-and-driving regulations).
In these considerations it is not important whether the measures themselves have a high priority, or whether they are applicable, etc., contrary to the system proposed by Sugden (1976) (see Sec. 4.7.), although in the final priority procedure there is, of course, a certain relationship between the relevance of the investigation and the relevance of the measure to be taken.

3. <u>The chance of success</u>. The degree to which the investigation can be carried out depends on the extent to which the required data are available, the reliability of the data, and the possibility of collecting the required data. (SWOV, 1965, p. 156).
It could be argued that this "chance of success" (as described here) does not belong to the criteria of establishing priorities: the conditions for an investigation of very high priority, <u>must</u> be provided. However, particularly, for the EEC-project, the "international" aspects should be kept in mind.

4. Conclusion

Concepts have thus been established for the following: (See Table 6)

- theoretical relevance (K1)
- applicability (K2)
- possibility of realisation (at an international level) (K3)

4.3.3. Criteria for measures

This report aims at establishing priorities for research. When discussing criteria for measures, in this connection, it is meant the criteria for research, considered and estimated in relation to the measures, which could be based on the results of the research. Thus, (among other things) it is the effectiveness of the measure which determines the priority of the investigation, on the results of which, the measure should be based. It is an advantage of the system presented in this chapter, that it is not necessary to know the measure in full detail, in order to apply the system.

1. The practical relevance of the investigation depends on the practical relevance of measures, based on the results of the investigation, (i.e. on the degree to which the investigation contributes to practical measures which are aimed at improving undesirable aspects of the road traffic system). In this respect, it is important to have a specific and socially acceptable definition of traffic safety. See sec. 1.2.
Furthermore, in order to establish the contribution to the priorities for research, a reasonable estimation of costs and an estimate of the benefits must be given for the measure in question. It is evident that this will often create problems. There are reasons to believe that it is just for this reason, that social relevance is replaced by policy relevance; this, in view of the stated definition, must be considered theoretically incorrect.
If - as is customary in recent times - traffic safety is consider-

ed as a problem of national well-being, the social relevance of the investigation must be determined in each case.

2. The policy relevance of the research depends on the degree to which both the setting of problems and the investigation itself, are brought to the attention of the authorities laying down the policies. Policy relevance is determined by the degree to which the results of the investigation actually solve the essential problems for the authorities. As a result of breaking down criteria into those which refer to research, and those which refer to measures, the relevance for policy can be specified more particularly: it depends on the degree to which the research can yield measures which are in accordance with the policy. Policy relevance and social relevance are related to one another. When only social demands are considered, both relevances might, to a large extent, even coincide.

The requirements for a ("good") policy can be described in terms of criteria, opinions, standards and aims, marginal conditions, effects of the application of measures, control of trends and prediction. However, if a policy is established it is not certain that policy relevance will always co-incide completely with social relevance. Mainly, due to the fact that there are "marginal conditions" (limitations of space, air, power, etc.) a policy might be compelled to use criteria which, from the social point of view, are not the most desirable ones.
At present, however, decisions are sometimes made as a reaction to what happens in the outside world. In this reactive policy, no "a priori" standard is involved (i.e. a trend is not pre-determined); the aims are not chosen systematically, and are usually based on opinions; measures are chosen as a result of this, while their effect is usually unknown.

3. The political relevance of research is determined by the degree to which the measures, based on the investigation, are in accordance with short or long term political aims.
Political relevance is introduced into this discussion for the

following reason: firstly it is important to find out in connection with this particular project, but also in connection with other complex problems , in what way the measures will correspond to present or future political traffic decisions (national standardization, and/or international harmonisation) and also to more general political and economic systems. This would appear to be a legitimate and valuable criterion. Furthermore, this criterion is connected with the possibility of introducing (and/or enforcing) the measures based on the results of the research. The possibility of enforcement can be limited for theoretical reasons (for example, in the case of measures requiring a change of the climate of the region), and also for practical reasons (for example, the limited possibilities of control and police enforcement).

4. Conclusion

The following concepts have been established (See Table 6)

- practical relevance (K4)
- policy relevance (K5)
- political relevance for (international) realisation (K6)

4.4. Benefit factors for research items

4.4.1. Weighting factors for the criteria

As indicated in sec. 4.1.2. the benefit factor b_i for each of the research items n_i is defined as $b_i = \sum_{j=1}^{K} r_{ij} g_j$.
The first step is the assessment of the weighting factors g_j for each of the criteria used. It should be stressed that the assessment of the weighting factors is a matter of decision. Those responsible for the policy, have to decide which criterion is to be considered as the most important etc. It is a matter of further discussion as to where this responsibility should be placed. It should not, however, be placed at the research establishments which are involved in the realisation of the research itself. Thus, the numerical values of the weighting factors, which are given in this report, should be considered as sugges-

tions only.

Further, it should be kept in mind, that, although the criteria K1 ... K6 are applicable for all research, the weighting factors will be different for the area of toxic and psychological factors in road traffic accidents (which are to be sponsored or stimulated by the European Commission) as compared to those which are relevant for a university laboratory, which is undertaking a theoretical study, on a nation-wide basis.

All this leads to the fact that the suggested numerical values for the weighting factors which are given in Table 6, are to a certain extent arbitrary. For this study however, it seems justified to give measures a greater weight than the research itself, and to place most emphasis on practical relevance (K4) and on the applicability (K2). The possibilities for realisation of research internationally (k3) and the relevancies for international politics (K6) also are considered important.

The weighting factors, for obvious reasons, add up to unity.

4.4.2. Relevance factors

For each of the items A ... R it can be indicated to what extent each of the criteria K1 ... K6 are relevant. This is expressed in the relevance factor r_{ij}. The numerical value of a specific relevance factor r_{ij} indicates to what extent that particular item n_i fulfils that particular criterion K_j. Multiplication of the relevance factor r_{ij} with the weighting factor g_j gives the contribution of that criterion for the problem under consideration, for the benefit of that particular item n_i. Summation over j (all criteria) yields $b_i = \sum_{j=1}^{K} r_{ij}g_i$, the benefit factor related to the research item n_i.

The relevance factors are <u>not</u> normalised on unity, because in this case, different items have to be compared within the same frame-work of weighting factors. Furthermore, the relevance factors are not decided upon, or selected, but follow from the consideration of the items themselves. The relevance factors can be proved (or disproved) after the research has been completed, and the measures put into operation.

Neither weighting factors nor relevance factors are constant in time. A shift in the judgement of the ethical and social values may result in a shift in the weighting factors for the different criteria; as may the shift in the emphasis of the field of application. The relevance factors may change with time when (and especially when the research is in progress), more insight is gained into the processes involved.

Regarding the relevance factors r_{ij} given in Table 7, some additional remarks can be made: in general, the factors are logarithmically spaced i.e. 1; 3; 10; 30.

Regarding K_1 (theoretical relevance).

The items related to interaction are of particular importance in order to understand the theory of driving behaviour; these are followed by the items related to driving performance (30 and 10, respectively). Matters related to occurrence in traffic, being of practical importance have little theoretical relevance.

Regarding K_2 (applicability)

The applicability for measures is primarily important with respect to the research which is related to the occurrence in traffic (I-L). Alcohol is important because so much is already known (But this affects the cost factors). The interaction effects are also important. The other items are of less importance for the purposes of this report.

Regarding K_3 (possibility of realisation)

It seems that none of the items under consideration is particularly important with respect to international research effects.

However, an exception appears to exist for the items E-G (vehicle design and fatigue).

Regarding K_4 (practical relevance)

The major importance of practical relevance, appears to be the size of the problem; and as regards research, the areas which give the most data. In this respect, it is probably the items which are directly related to the assessment of these data (I - L). Furthermore, the items which are known to have a large influence (alcohol and stressors, A and H), are given high priority. This, of course, reflects to a certain extent the same opinion, as is obtained from the approach, dealt with more in detail, in sec. 5.3. Roadside surveys, and all items related to education and enforcement have been given a low rating in this respect, because it was felt that within the limits of practical realisation, they do not appear to be particularly promising.

Regarding K_5 (policy relevance)

Here, the prime importance is in research which may result in the possibility of providing data, on which political measures can be based. Education is a good example of this, as are also alcohol and/or drugs, and their occurrence in traffic, etc. Policy relevance may be interpreted as: providing sufficient data to continue with the measures which are already under consideration (see sec. 4.7).

Regarding K_6 (political relevance)

It does not appear that the research items listed here are very promising for providing measures which could particularly benefit from international co-operation. Nevertheless, it should be noted that the more direct research (A-H; M-P), deserves a higher rating in this respect, than the more method-oriented research (I-L; Q-R).

It should be noted that the numerical values given in Table 7 are to be regarded only as provisional. Although the assessment of relevance factors falls within the scope of scientific judgement, the international aspects of research, politics and of measures, make it difficult for a national research institute to estimate the related relevance factors.

4.4.3. The assessment of the benefit factors

Table 6 and 7 set out the weighting factors and the relevance factors respectively. Table 8 gives the multiplied values $r_{ij}g_j$ and also the sum b_i for each item. Finally, Table 9 gives a ranking order of the items with regard to the benefit factors. This ranking order can be considered as the list of priorities which are required: Research may be started on the item at the top of the list, then proceeding to the next etc. In each case, the first step in the actual research should be to prepare a detailed statement and analysis of the problem, then to ascertain the results of the research already carried out in that particular area, then to define the still unknown areas, and to select the most appropriate research method, etc.; in other words the normal sequence for practically orientated experimental research. It should be pointed out that consideration of the existing knowledge, presents itself only at this stage. According to the system adopted it would be incorrect to include the existing knowledge (being essentially a cost factor), in the criteria. It is only a matter of costs, that a certain part of the research need not to be executed because of the fact that it has already been done. When, however, costs factors are included in the establishment of priorities (see sec. 4.1.1.) or when an alternative approach to the establishment of priorities is followed (see Chapter 5), obviously the extent of existing knowledge is of great (and sometimes of crucial) importance.
The list of benefit factors as given in Table 9, is arrived at by multiplying the relevance factors and the weighting factors, and summing these products for each individual item. Because the relevance factors are not normalised on unity, the resulting

series of items, when grouped from high to low values of the benefit factors, is not only an ordinal scale. Within the area for which the particular set of weighting factors is valid (and here: the possibility for international practical research under the auspices of the European Commission is important) the sequence of the items also gives an indication of the magnitude of the difference between two "adjoining items" on the list. It is therefore an interval scale.

4.5. Cost factors

4.5.1. General

From the above discussion, it follows that a number of items classified earlier A ... R, belong together, when they are regarded from the experimental point of view. Three main groups may be discussed, those related to driving performance, those concerned with road side surveys, and those concerned with education and enforcement.

4.5.2. Driving performance

The first group includes items A, B, C, D, E, F, G and H. The relevant research requires, generally speaking, rather complicated laboratory and field tests, as well as real-life validation. Thus the research is mainly expensive, long term and highly specialised.

As a first approximation of the "effort factor m_i", Table 10 gives suggested values, expressed in arbitrary units. The effort is considered to be equal for all research items which require driving performance. Obviously this can be regarded as a first approximation only.

In order to arrive at the actual "costs", these effort factors must be multiplied by the fraction of what is still to be investigated. Thus, this fraction is small, when many research results are already available, and it is large, when only a small amount of research has been carried out to date. It seems appropriate here, to apply a fraction t_i (of value between 0 and 1.0).

The estimated values of this factor t_i have been given in Table 11, and they have been estimated, taking into account the data from Chapter 3, the "state of the art".
The table also contains the results of the multiplication of t_i and m_i. Finally, the benefit values quoted earlier (Table 12) have been divided by the cost factors.

4.5.3. Roadside surveys

In fact, this subject is more complex than the title might suggest. Firstly, the subject deals with the collection of statistical material concerning the occurrence of certain "toxic" factors, in various sections of the general population: - in the driving population and its sub-groups, and in the different groups involved in accidents of different types. Although rather extensive collections of data already exist, they are usually not accurate enough, and not specific enough, to be useful for the research under consideration here. This implies that much more research is required, which is of a complicated, time consuming and expensive type. Therefore, high values for t_i would seem reasonable. Suggested values for t_i and m_i are also given in Table 10 and 11 for the items I, J, K and L.

This type of research concerns the subject of this report only indirectly. Statistical data and roadside research are tools for testing the importance of problems and the effectiveness of measures. They presuppose the availability of screening methods for different toxic agents. In this context, the screening methods are considered as part of roadside surveys.

4.5.4. Education and enforcement

Education and enforcement factors are very difficult to assess within the context of experimental research. The difficulties concern fundamental, methodological ways of selecting adequate control groups etc. rather than purely experimental difficulties. This type of research is often very time-consuming and not very

conclusive, so that it must generally be carried out on a large scale.
Again, suggested numerical values for t_i and m_i are given in Table 10 and 11 for the items M, N, P, Q and R.

4.6. Priorities for research

The data are collected in Table 12. The ranking order is again repeated in Table 13. This sequence is in fact the final proposal for the order of priorities for research in the area of toxic and psychological factors in road traffic accidents, and particularly for those research subjects which may benefit from an international approach under the aegis of the European Commission.

It is worth while to repeat once more, four important points:
First, the order of priorities given in Table 13 may be substantially different, when the basic assumption regarding weighting factors, relevance factors, and the estimated factors for the research effort and for the availability of data, are changed. In fact, in some cases, only a small change in the assumptions may lead to an important difference in the order of priorities.
It is to be expected that such changes will occur in future; therefore, the order of priorities should not be considered as finalised, once and for all.
Second, measures which may be based on the results of the research are not specified. When setting up the list of criteria for measures (and the weighting factors attached to them), only an overall, non-specific view of the possible measures is taken into account. It is felt that a detailed discussion, and thus also a detailed cost/benefit consideration, of individual measures, falls outside the scope of this report.
Third, the priorities given here relate exclusively to short term, temporary and differential aspects, and therefore do not cover the complete area of all toxic and psychological factors; specifically they exclude long term (somatic and psychsomatic) maladies and handicaps. Furthermore, all items are regarded as

independent; in particular, interactions between short term toxic and long term psychological factors, are not included. Finally, when determining the priorities, resources in monetary budgets, availability of research staff and equipment etc. are regarded as unlimited.

It will be clear that each of these four points restricts the system of setting up priorities to some extent, and in particular, limits the results, arrived at in this report.

4.7. Research priorities based on measures

4.7.1. General

A fundamentally different approach to the problem under consideration is suggested by Sugden (1976). The following section is based on the (unpublished) material that has been presented at the Meeting of Experts which was held during the preparation of this report.

The basic difference between the approaches presented in sec. 4.2. to 4.5., and the approach presented in this section, is that the former uses as a starting point the items which would be possible to investigate within the particular area, then works towards the best sequence in which to do the research. The latter starts off with the consideration that decisions whether or not, to take measures will be made anyway, and that research serves primarily to assess beforehand more precisely the cost/benefit ratio of the measures. This implies, therefore, that decision makers will have a prior subjective judgement about the benefit of the measures (and about the costs). In this section a model will be described which follows the out-line sketched here; in this section Sugden's (unpublished) work has been extensively quoted.

4.7.2. The place of research in governmental decision

It is assumed that the government must choose whether to implement particular "policies", each of which is intended to reduce the number of road accidents.

The government's objective is to maximise

$vx - c$

(Where x is an index of the number of casualties which would be prevented from occurring by the implementation of the road safety policies; c is the cost of implementing these policies, measured in money units; v is the government's valuation of the benefit to society of preventing one 'casualty').

This objective can be re-stated as: - implement a policy, if and only if

$$\frac{x_i}{c_i} > \frac{1}{v}$$

(x_i and c_i are the casualties prevented by, and the cost of, policy i), respectively.

In this context, two types of research may be relevant:

I. Research, the intention of which is to improve the efficiency of road safety policies

The aim of such research is to change the relationship between the costs and the benefits of particular policies: in order to 'reduce the cost of policies'.
For example, a 'policy' might be to ensure that at least 1 in every 1000 violations of a prescribed blood-alcohol limit, were detected and punished. Research into the design of breath-test devices would attempt to reduce the costs of this policy.

II. Research, the intention of which is to discover the benefits of policies

The aim of such research is to find out what are the benefits

(x_i) of some particular policy (i), without in any way <u>changing</u> these benefits. Research into the causes of accidents is normally of this kind (e.g. knowledge of the relationship between alcohol-consumption and the probability of being involved in a road accident, increases the knowledge about the benefits of a policy of prohibiting people with certain blood-alcohol levels from driving).

Research of this kind, pre-supposes that at present the benefits of some policies are not known with certainty, otherwise the research would be unnecessary. Any attempt to evaluate such research, should take account of this uncertainty.

4.7.3. A probabilistic cost/benefit model

When considering a typical policy, it may be assumed that its costs, c, are known with certainty, but its effect, x, on the number of casualties is not known with certainty. Given the prevailing state of knowledge, decision-makers will attach subjective probabilities to different ranges of x. These can be expressed as a probability density function g(x). The social value v, is attached to each casualty prevented. Thus the net benefit, b, of the policy is given by $b = vx - c$
(b is not known with certainty, but has a probability density function f(b)).
If no more information is available, the government must decide whether or not to implement the policy. If it seeks to maximize the expected value of the net benefit, it must follow the rule:-
- accept the policy, if $E(b) > 0$
- reject the policy, if $E(b) \leq 0$

(here E(b) is the prior expectation of the benefit of the policy)
Consider now the possibility of further research, ('type II research') into the value of x (i.e. into the effects that the policy would have if it were implemented). Suppose that a research project would cost R and would result in knowledge, with certainty, of the value of x. This implies knowledge, with certainty, of the value of b. There are four possible cases to consider which are

defined by the values of E(b) (the <u>prior</u> or pre-research expectation of the net-benefit of the policy) and of b^* (the actual value of the net benefit of the policy, as revealed by the revealed by the research project). These are: -

1. $E(b) > 0, \quad b^* > 0$
2. $E(b) > 0, \quad b^* \leq 0$
3. $E(b) \leq 0, \quad b^* > 0$
4. $E(b) \leq 0, \quad b^* \leq 0$

In cases 1 and 4 the research merely confirms that the decision which would have been made in the absence of complete knowledge, would have been correct. (In case 1, to accept the policy; in case 4 to reject it). Thus the research project, viewed after the event, has involved costs (or R) but no benefits.

In case 2 the prior (pre-research) decision would have been to accept the policy, but the research demonstrated that this decision would be incorrect. The benefit of the research project, is that it leads to the policy <u>not being implemented</u>, thus saving the community $-b^*$ (the net loss from implementing the policy). The net benefit of the research project is $(-b^* - R)$.

In case 3, the prior decision would be to reject the policy, but research demonstrates that this decision would be incorrect. The benefit of the research is that it leads to the policy <u>being implemented</u>, bringing a social benefit of b^*. The net benefit of the research project is $(b^* - R)$.

4.7.4. <u>Some implications of this model</u>

1. The benefit of research is not necessarily a reduction in the number of casualties. Its benefit may lie in the fact that a road safety policy is <u>not</u> implemented, when, in the absence of research, it would have been implemented. This would imply a saving of "money" costs, and perhaps also save an increase in the number of casualties.

2. The benefits of research are crucially dependent on prior subjective judgements about the effectiveness of policies. For example, if it is felt certain that the net benefits of a policy will be greater than zero (or that they will be less than zero) the research has no value.

4.7.5. A comparison between the two alternatives

1. The approach presented in Sec. 4.7. concentrates on the 'policy' or 'measure' rather than on the research 'project' or 'item'. This seems to be the correct standpoint, given that 'research ... is to be considered useful only if it provides the basis for measures which really help to reduce the number of accidents'.

2. A central place is given to the concept of prior subjective judgements about probability. It seems that it is impossible to evaluate properly research projects, the purpose of which is to generate information, without explicitly considering the prior state of knowledge. These considerations influence the 'relevance' of research. In the approach given in this section, the judgements which must be made, are made explicitly.

3. The approach followed in this section, is very close to that which was briefly suggested in Sec. 4.1.1. The reasons given for rejecting this approach are weakened, if it is accepted that the existence of uncertainty is crucial in any problem involving research. The first stage is the cost-benefit analysis of 'policies' or 'measures'. But, and this is the key point, the benefits of these policies cannot be known with certainty, otherwise further research would be unnecessary. The 'difficulties' listed in the second paragraph of Section 4.1.1. explain why research could conceivably be beneficial. It is the essence of the problem that "the information available is inadequate"; inadequate, that is to say, for a cost-benefit analysis, which does not admit the existence of uncertainty. The 'prior' cost-

benefit analysis must be based on prior subjective judgements about the propabilities of alternative outcomes. According to Sudgen, such judgements do not require complete information, since they are merely statements of degrees of belief.

4.7.6. Conclusion

The system described in this section is included in the report, because it seems to provide very interesting possibilities for a further study of cost/benefit relationship. Further study seems to be justified with regard to the assessment of the subjective judgements about the different possibilities. It is, however, precisely this point - the fact that they are merely statements of degrees of belief - which renders the approach inapplicable for this report: the European Commision is not one single "government", and therefore does not hold one specific set of "beliefs". Furthermore, as already indicated in Sec. 4.1.1., this approach would require even more data, which are presently not available, concerning the alternative approaches indicated in this report. And finally it can only give information with regard to a selection of measures or policies, out of those which are already under consideration. It is a pre-supposition that the "government" will make a conscious decision, as to whether taking, or not taking a measure, implies prior knowledge of the possible measures. Thus, contrary to the approach given in Sec. 4.2. to 4.5., the approach of sec. 4.7. cannot provide any assistance for the selection of new and original measures. The final reason for this is that the former approach is centered on the requirements determined by the road-user; the latter approach centres on the decision making process of the policy-makers. Therefore, interesting and intriguing as it may be, this approach will not be elaborated in this report.

5. PRIORITIES FOR RESEARCH II (SPECIFIC APPROACH)

5.1. Introduction

In this chapter, two alternative systems for determining priorities for research in the field of toxic and psychological factors in road traffic accidents, will be briefly discussed. The reason for the introduction of these alternative systems is, as indicated above, the fact that the systems developed in Chapter 4 require a considerable amount of data, which are not always available in the short term. The alternative systems developed in Chapter 5, however, lack the possibilities for generalisation and subsequent validation, of the earlier system.

5.2. Priorities based on a hierarchy of problem areas

5.2.1. General

The principal aim of the present study is to determine priorities for research which will lead to measures which really contribute to the reduction of the number and/or severity of road accidents. In order to be able to judge whether a measure really contributes in this way, a cost-benefit relation must be available, which in turn, can only be determined when data regarding the number of accidents in relation to the exposure in traffic are available, together with data regarding the frequency of occurrence of the situation under consideration, and the accident involvement in that situation. When these data are available before and after the introduction of the measure, the well-known methods of before-and-after-studies, may yield the benefits of the measure. When the costs are also known, the cost-benefit ratio can be assessed, so that after its introduction, the effectiveness of a measure can be established.

When a measure is considered, but not yet introduced, it is necessary to estimate the accident and/or frequency data required for the after period. Sometimes this can be done on the basis of the results of similar measures. Usually, however, a (hypothetical) construction is needed. This construction (or model) can be described in the form of a hierarchical set of problem areas, such as:

a. accidents;

b. driving behaviour;

c. human performance;

d. medical fitness;

e. psychological and social well-being.

This hierarchical model can be explained as follows:-
When the influence of a measure on driving behaviour is known (e.g. based on laboratory experiments) and when a hypothesis is available which describes traffic accidents on the basis of driving behaviour, the accident data of the after period are not required to predict the effectiveness of a measure which is not yet in operation. This, of course, can be extended to the "higher" levels such as human performance, medical fitness etc. It should be noted that this model is relevant to those measures which reduce the probability of being involved in accidents. The "exposition" should be considered in another way. (See e.g. Sec. 1.2.).

A further consideration of this hierarchical model, indicates that the higher the level, the more general the applicability is. For obvious reasons, data on traffic accidents only have relevance for questions of road safety. Data on human performance, however, are more generally applicable, e.g. also in industrial situations; data on the psychological and social well-being are even more widely applicable. On the other hand, the data are less specific, and they need more (hypothetical) steps between levels. Therefore, these data are mostly not directly applicable for the actual question at hand, which is related exclusively to road safety.

When, as is often the case, accident and travel data for the before period are also not, (or are only partially) available, the same set of hypotheses must also be applied to the before period. As in the case where accident data (and similar data on other hierarchical levels) are required to prove the hypotheses, the situation where no accident data are available, is difficult to deal with. For this kind of situation, the "clustering method" as described in Sec. 5.3. is suggested.

5.2.2. Application

A set of research proposals can be established on the basis of this hierarchical model in the following way. For each of the levels, fundamental research of a psychological or physiological nature, is considered. From this, it is determined, by means of clinical (endocrinical) methods, what, at each of the levels, is, the influence of the toxic and psychological factors. From this, the hypotheses which interconnect the different levels, may be determined. When all this has been done, the system can be applied in two ways:

1. For those cases where accident data regarding the before period are available, the different hypotheses can be proved, so that the data for the after period can be estimated. Thus, a first approximation of the effectiveness of the measures in this particular area, can be arrived at.
2. For those cases where accident data are not available, but other data are, it can be indicated (based on the non-proven hypotheses), which data are additionally required, in order to obtain a reasonable assessment of the effectiveness of the measure. Furthermore it is possible, based on these hypotheses, to indicate measures which can be expected to have positive results.

5.2.3. Priorities for research

The discussion in this section clearly indicates the following priorities for research, quoted in order of diminishing priority:

1. The set of hypotheses which interconnect the hierarchical levels should be determined and (as far as possible) proved. The usual type of experiments regarding driving behaviour are very useful for the lower levels, and it is to be expected that medical and socio-psychological studies will yield valuable results for the higher levels. As the study under consideration relates directly to road safety, the highest priorities should be allotted to the lower levels (accidents, driving behaviour, human performance).
2. The relation between the different toxic and psychological factors which are considered here, and accidents, should be established (as indicated above, these are temporary, and differential factors). For the factor "alcohol" a considerable amount of data already exists. For other factors (medical and non-medical drugs, exhaust fumes, etc.) however, the data are inadequate.
3. The influence of the relevant toxic and psychological factors at higher levels should be established. Again here, the level of driver behaviour has the highest priority for the study under consideration. This is followed by human performance.
4. The investigations as quoted under 2 and 3 will benefit from an unambiguous classification of (temporary and differential) toxic and psychological factors. The priority here, however, is lower, because the present - more or less arbitrary - classifications may be used, contrary to the requirements indicated in Sec. 4.2.2., where the classification is required, in order to enable a logical framework of research to be determined.
5. For the present study, which is primarily concerned with road accidents, the influence of toxic and psychological factors at higher levels, is less important. For other fields of research, however, this influence may be of the highest priority. It should be noted, that it is not at all obvious that, for the higher levels, (and notably for the level of psychological and social

well-being), only temporary and differential psychological factors are important. Furthermore, it should be noted that when the influence at such a (higher) level is established for the purpose of considering measures which relate to that level, for obvious reasons, the hypotheses which interrelate the levels, are not required.

5.3. Priorities based on clustering methods

5.3.1. General

As indicated in Sec. 5.2.1., when accident data are not available, neither for the before period nor for the after period, and the hypotheses which interrelate the level of accidents with levels for which there are data, are not proved, the method described below, may yield useful results. For reasons which will be clear from the discussion, the method is called the "clustering method".

The method is based on the idea that the traffic situations may be expected to be particularly serious, when a number of unfavourable factors are present simultaneously ("cluster"), even if the degree to which each separate factor contributes to the road unsafety in general, is not known in detail.

5.3.2. Application

The selection of the most important clusters can be made in several steps.

1. A list of unfavourable factors is determined, subdivided into factors which are toxic or psychological, and other factors.
2. Combinations of these factors are selected which can be expected to be particularly unfavourable. It should be noted that in most cases, proof as to whether the factors, or the combinations, are really unfavourable, cannot be given . In most cases, common sense, practical experience, or induced proof, will have to be relied on.

3. The frequency of occurrence of the selected combination both in the normal driving population and in accident groups is established. It should be noted that these data are required for two reasons: firstly it is necessary to know the extent of the problem (it makes little sense to determine measures which help for situations which hardly occur in reality) and secondly it is necessary to know the relative accident involvement (it is not useful to design measures which improve situations which are not dangerous).
4. The causal sequence between the combination of factors and accidents should be established. This is necessary in order to know which element in the causal sequence is the most appropriate for the introduction of countermeasures.
5. Countermeasures should be designed, introduced and evaluated.

5.3.3. Priorities for research

In Table 14 the lists of unfavourable factors, and a number of combinations are given, which are considered to be of special importance. In this table, the following combinations may be indicated as deserving a particularly high priority, because they are known to be associated with a considerable number of accidents: -

- alcohol and medical drugs
- alcohol, age and driver experience
- fatigue, darkness and reduced visibility.

6. CONCLUSIONS

6.1. General remarks

The aim of this report is to suggest priorities for further research in the field of toxic and psychological factors in road traffic accidents, more particularly for research which could profit by international efforts. Three different approaches have been presented, aimed at determining these priorities. As was to be expected, the three approaches yield similar but not identical results. The results form the final conclusions of the study, and are summarized here. The drafting of the actual research proposals is considered to be the first phase of activities for the research institutes which are actually undertaking the research.

6.2. Priorities based on the general approach

The discussions in Chapter 4, and their results as set out in Table 13, clearly indicate that the first priority is to be allotted to item A. Not only is this item the highest in the (ranking) order; but also - based on the assumptions given in Chapter 4 - the difference in the cost/benefit ratio between this and the second and third items, is very large indeed.

Based on the marked difference in the cost/benefit ratio between the items A and I, H and G, G and J, K and D and the other items, it seems justifiable to give item A first priority; items I and H, second periority; item G third priority; items J and K fourth priority; and the other items a lower priority. This results in the following list:

Priority 1:-
The influence of alcohol on driving performance (item A)
Priority 2:-
Systems of roadside surveys, including methods of detection (item I).
The influence of stressors on driving performance (item H).

Priority 3:-
The influence of fatigue on driving performance (item G)
Priority 4:-
Occurrence in traffic and outside traffic (item J)
Occurrence in traffic casualties (item K)

Note 1. It should be stressed once again that the priorities quoted here follow directly from the assumptions given in Chapter 4. These include the availability of information; thus, it is quite possible that for individual research institutes, or for individual countries, the priorities may be different.
Note 2. It may be noted that the suggestions of the Ad-Hoc Group on Toxic and Psychological Factors in Road Traffic Accidents, are in good agreement with the order of priorities derived in this study.

6.3. Priorities based on the specific approach I

The second approach (Sec. 5.2.) is based on a hierarchy of problem areas. This has been specified in a model containing five levels, ranging from accidents through driving behaviour, human performance and medical fitness to psychological and social well-being. In Sec. 5.2.3. some general remarks have been made regarding the priorities to be derived from this approach. They can be summarized as follows:

1. The set of hypotheses which interconnect the different levels should be determined and proved. Experiments regarding driving behaviour are used for the lower levels, and medical and socio-psychological studies for the higher levels. The highest priorities should be allotted to accidents, driving behaviour, and human performance.
2. The relation between toxic factors and accidents should be established. For the factor "alcohol" a considerable amount of data exists. For other toxic factors similar data should be collected and evaluated.

3. For the present study, which concentrates primarily on temporary and differential factors in road accidents, the influence of toxic and psychological factors on higher levels is less important. For the higher levels, and notably for the level of psychological and social well-being, other factors than only the temporary and differential psychological, are important.

Note: When the influence of toxic and psychological factors on a certain level is established, in order to consider measures which relate to the same level, the hypotheses which interrelate the levels are obviously not required.

The given considerations yield the following actual research areas which deserve high priority:-

- the relationship between accidents and driver behaviour (driver behaviour studies) and between driving behaviour and human performance or medical fitness (medical and socio-psychological studies).
- the relation between accidents and the usage of alcohol, and other toxicants (statistical and epidemiological studies).

Note: here again it is clear that the ad-hoc groups's suggestions are in good agreement with these priorities.

6.4. Priorities based on the specific approach II

The third approach (Sec. 5.3.) is based on the idea that traffic situations may be expected to be particularly serious when a number of unfavourable factors present themselves simultaneously ("cluster"), even if the degree to which each separate factor contributes to the road unsafety in general, is not known in detail.

A list of unfavourable factors and a number of particular combinations is given in Table 14. From this table the following combinations deserve a high priority because they are known to be associated with a considerable number of accidents:

- alcohol and medical drugs
- alcohol, age and driver experience
- fatigue, darkness and reduced visibility.

6.5. General conclusions

The three approaches for determining an order of priorities for research yield very similar results. They can easily be combined and thus form the final list of areas of priority for research:

I. The area of alcohol in driving

I.1. The influence of alcohol on driving performance (6.2)

I.2. Alcohol and accidents (6.3)

I.3. Alcohol in combination with medical drugs (6.4)

I.4. Alcohol in combination with age and driver experience (6.4)

II. The area of other toxicants

II.1. Other toxic factors and accidents (6.3)

III. The area of fatigue

III.1. The influence of fatigue in combination with darkness and reduced visibility (6.4)

III.2. The influence of fatigue on driving performance (6.2.)

IV. The area of general driving behaviour

IV.1. The relation between driving behaviour and accidents (6.3.)

IV.2. The relation between driving behaviour and human performance, and medical fitness (6.3)

V. Methodological studies

V.1. Systems of roadside surveys including methods of detection (6.2.)

V.2. The occurrence in traffic and outside traffic, and in traffic casualties (6.2.)

In view of the foregoing, the area of alcohol (I) clearly deserves the highest priority within this set of areas. The priorities of the other areas (II ... V) do not necessarily follow from the foregoing, and therefore may be regarded as approximately equal. The items within each area again are set out in the order of priority.

It should be noted once again, that the priorities indicated here depend upon the assumptions given in Chapter 4. More particularly, if the emphasis is not placed exclusively on road traffic accidents, other psychological and socio-psychological factors may be of great importance.

It has been stated that the actual drafting of a research proposal is the first concern for the research institutes involved. Nevertheless, some broad indications can be given with regard to the type of research which will probably be appropriate.

A. Research on driving behaviour (laboratory, test vehicles, field studies)
- The influence of alcohol and fatigue on driving performance (6.2.)
- The influence of alcohol and medical drugs, of alcohol, age and driving experience (6.4)
- The relation between driving behaviour and accidents (6.3)
- The relation between driving behaviour and human performance, and medical fitness (6.3)
- The influence of fatigue, combined with darkness and reduced visibility (6.4)

B. Statistical and/or epidemiological studies
- Accidents and alcohol (6.3)
- Accidents and toxicants (6.3.)
- Occurrence in traffic and out traffic, and in traffic casualties (6.2).

C. Methodological/technological studies
- Roadside surveys, detection methods (6.2)

6.6. Concluding remarks

It was the purpose of this report to consider those areas of research in the field of toxic and psychological factors in road traffic accidents, which could benefit from an international approach under the aegis of the European Commission.

Determining priorities for research, which could lead to useful measures, appeared to be an area in which only little systematic study has been made. Thus, this report is in a way a first attempt to examine this complex question. In this respect, two important simplifications have been introduced.

- the study is primarily directed towards the differential and temporary aspects of the toxic and psychological factors.
- the different actions of toxic and psychological factors on the (human) individual are primarily considered as being mutually independent.

A future further elaboration on the area under survey should be directed towards the further consideration of these points. With this in mind, it is not surprising that the problem of "alcohol" again received the highest priority. It is a common belief that everything concerning alcohol in road traffic is an established fact; but it is the fact that much data are available and that only relatively small areas require further research, which results in the high priority of the research item.

So long as the factors are considered as independent, for obvious reasons, interaction effects will not be prevalent. However, in the specific approaches, and more particularly, in the clustering methods, it is quite clear that interaction effects (such between alcohol and medical drugs) are important. An elaboration of the general approach which will also include interactions, may provide a more specific basis for priorities in this area.

It is important to note that in all these approaches which have been examined in the report, more general (methodological, technological, statistical and epidemiological) studies prove to be of importance.

It should be pointed out that the determination of actual research projects is not a part of this study. Here, areas of interest only are indicated and it is a matter for further consideration by research institutes as to in what way these areas of interest should be transformed (translated) into the requirements for research.

Finally it should be noted that the report contains yet another approach to the determination of priorities for research, which, as a result of a lack of the necessary data, was not elaborated, but which deserves further attention in the future.

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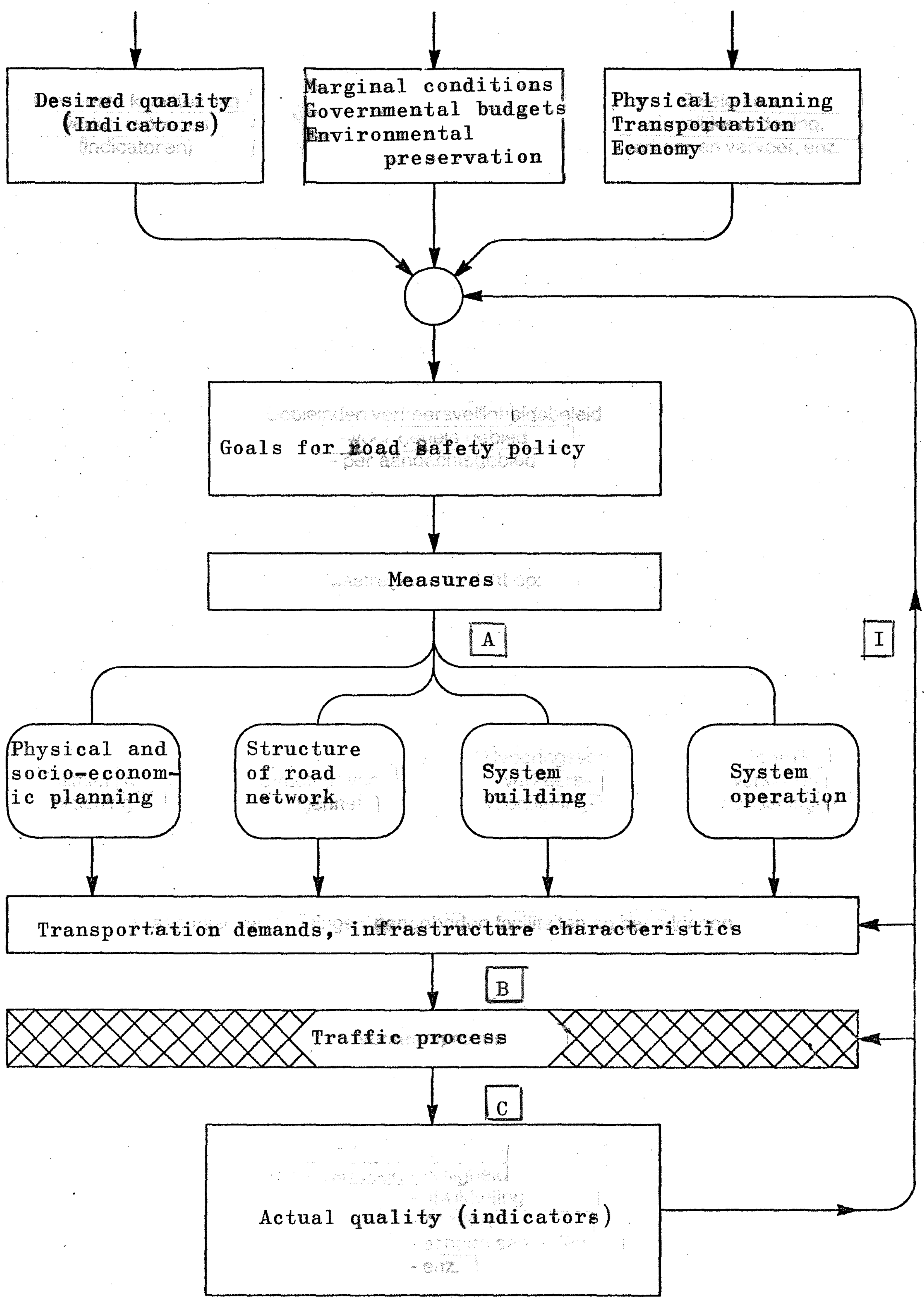

Figure 1. The structural model for policy and management

LEVEL	TRAVELLERS BEHAVIOUR	
	INDIVIDUAL	- SUM TOTAL -
1	Selection of destination and arrival time and realization	Trip generation Trip distribution
2	Selection of transport mode and realization	Model split
3	Selection of route and itinerary and realization	Assignment
4	Selection of manoeuvre and realization	Traffic flow

Figure 2. The structural model for the traffic process.

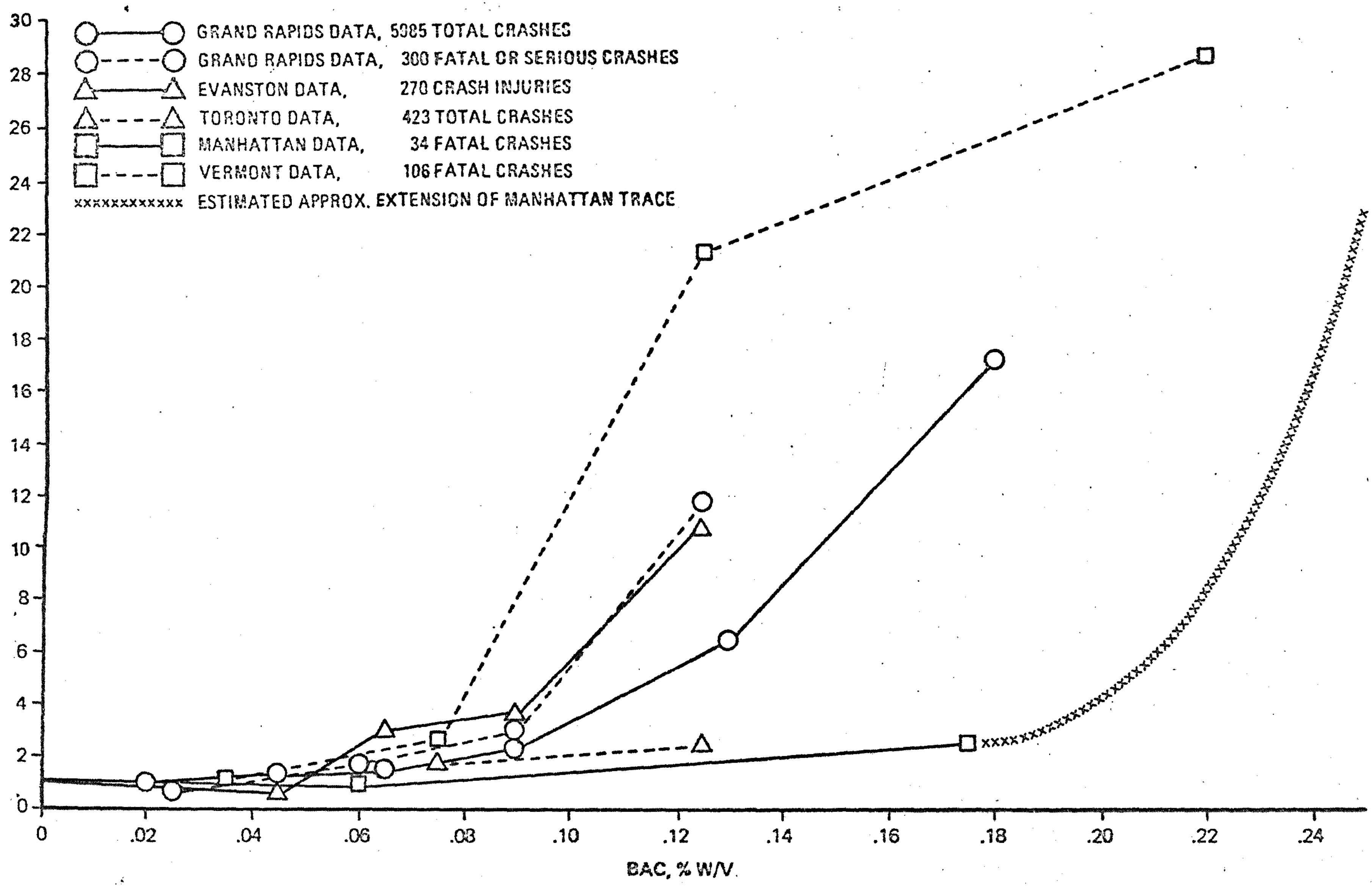

Figure 3. Relative probability of crash involvement as a function of BAC. Where 1.0 = relative probability at zero alcohol (after Hurst, 1974).

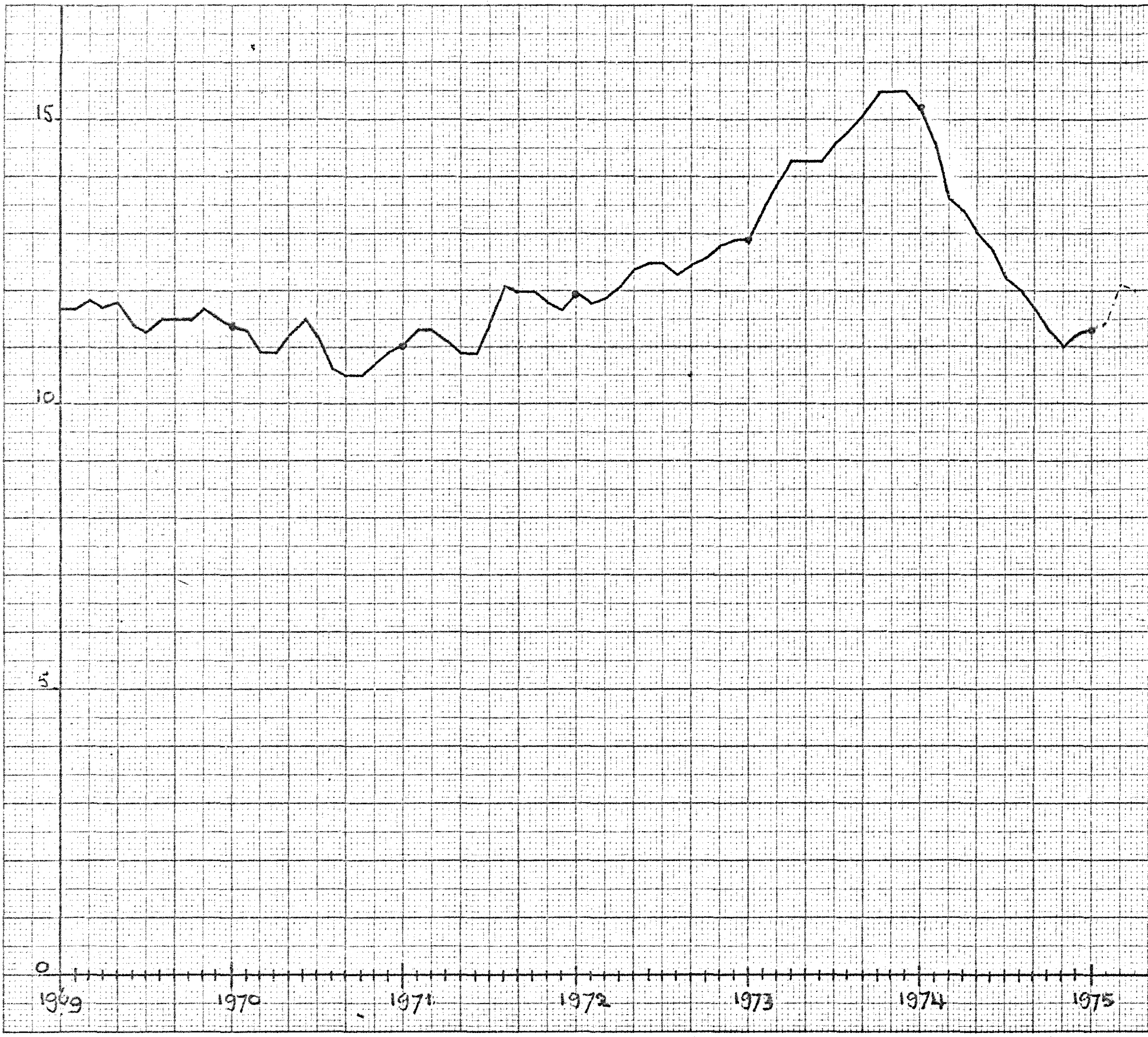

Figure 4. Moving 12-month percentages of fatal accidents involving alcohol.
SWOV (Noordzij) 1976 (Total number fatal accidents = 100%)

	Total number of drivers	Drivers involved in accidents in 1963		Drivers not involved in accidents in 1963		Total number of accidents in 1963	
		number	percentage of total number of drivers	number	percentage of total number of drivers	number	average of total number of drivers
Drivers involved in accident in 1961 and 1962	1,100	145	13	955	87	161	14.6
Drivers not involved in accidents in 1961 and 1962	129,524	6,931	5	122,593	95	7,340	5.7
	130,624	7,076		123,548		7,501	
Drivers who had accidents in only one of the two years further (left out of account)	17,382						
	148,006						

Table 1: Prediction of accidents on the basis of accident history (Source: Peck et al., 1971)

Number of Additional Accidents During the Following Four Year Period 1968-1971	Drivers With Three Accidents During the Year 1967					
	Number of Drivers	Total Accidents During Four Year Period 1968-1971	Percent of Drivers	Percent of Total Accidents During Four Year Period 1968-1971	Cumulative Number of Drivers	Cumulative No. of Total Accidents During the Years 1968-1971
0	728	0	41.3	0	1763	2102
1	481	481	27.3	22.9	1035	2102
2	291	582	16.5	27.7	554	1621
3	140	420	7.9	20.0	263	1039
4	56	224	3.2	10.6	123	619
5	23	115	1.3	5.5	67	395
≥ 6	44	280	2.5	13.3	44	280
	1763	2102	100.0	100.0		

Table 2a. Additional accidents during 1968-1971 by drivers with three accidents during 1967 (Source: Goodson, 1972).

Number of Additional Accidents During the Following Four Year Period 1968-1971	Drivers with four accidents during the year 1967					
	Number of Drivers	Total Accidents During Four Year Period 1968-1971	Percent of Drivers	Percent of Total Accidents During Four Year Period 1968-1971	Cumulative Number of Drivers	Cumulative No. of Total Accidents During The Years 1968-1971
0	79	0	32.8	0	241	393
1	62	62	25.7	15.8	162	393
2	45	90	18.7	22.9	100	331
3	24	72	10.0	18.3	55	241
4	16	64	6.6	16.3	31	169
5	5	25	2.1	6.4	15	105
≥6	10	80	4.1	20.3	10	80
	241	393	100.0	100.0		

<u>Table 2b</u>. Additional accidents during 1968-1971 by drivers with four accidents during 1967 (Source: Goodson, 1972)

Number of Additional Accidents During the Following Four Year Period 1968-1971	Drivers With Five Accidents During The Year 1967					
	Number of Drivers	Total Accidents During Four Year Period 1968-1971	Percent of Drivers	Percent of Total Accidents During Four Year Period 1968-1971	Cumulative Number of Drivers	Cumulative No. of Total Accidents During The Years 1968-1971
0	8	0	17.4	0	46	116
1	10	10	21.7	8.6	38	116
2	12	24	26.1	20.7	28	106
3	7	21	15.2	18.1	16	82
4	4	16	8.7	13.8	9	61
5	2	10	4.4	8.6	5	45
$\geqslant 6$	3	35	6.5	30.2	3	35
	46	116	100.0	100.0		

Table 2c. Additional accidents during 1968-1971 by drivers with five accidents during 1967 (Source: Goodson, 1972)

BORKENSTEIN				
B.a.c. in mg/100 ml	Accident group	Control group	Drivers whose involvement in accidents can be attributed to alcohol: Estimated number $a_1 - \frac{c_1 \times a_0}{c_0}$	Drivers whose involvement in accidents can be attributed to alcohol: Percentage of accident group $\frac{100}{5985} \times \left(a_1 - \frac{c_1 \times a_0}{c_0}\right)$
	1	2	3	4
0— 49	5398 (a_0)	7345 (c_0)	0	0
50— 99	210 (a_1)	187 (c_1)	73.6	1.2
100—149	186 (a_1)	44 (c_1)	153.9	2.6
⩾150	191 (a_1)	14 (c_1)	180.9	3.2
total	5985	7590		7.0 %

LUCAS				
B.a.c. in mg/100 ml	Accident group	Control group	Drivers whose involvement in accidents can be attributed to alcohol: Estimated number $a_1 - \frac{c_1 \times a_0}{c_0}$	Drivers whose involvement in accidents can be attributed to alcohol: Percentage of accident group $\frac{100}{423} \times \left(a_1 - \frac{c_1 \times a_0}{c_0}\right)$
	5	6	7	8
0— 49	328 (a_0)	1839 (c_0)	0	0
50— 99	30 (a_1)	109 (c_1)	10.4	2.4
100—149	17 (a_1)	39 (c_1)	9.9	2.1
⩾150	48 (a_1)	28 (c_1)	42.9	10.1
total	423	2015		14.6 %

HOLCOMB				
B.a.c. in mg/100 ml	Accident group	Control group	Drivers whose involvement in accidents can be attributed to alcohol: Estimated number $a_1 - \frac{c_1 \times a_0}{c_0}$	Drivers whose involvement in accidents can be attributed to alcohol: Percentage of accident group $\frac{100}{270} \times \left(a_1 - \frac{c_1 \times a_0}{c_0}\right)$
	9	10	11	12
0— 59	183 (a_0)	1671 (c_0)	0	0
60—109	28 (a_1)	56 (c_1)	17.4	6.4
110—149	22 (a_1)	16 (c_1)	19.0	7.0
⩾150	37 (a_1)	7 (c_1)	35.7	13.2
total	270	1750		26.6%

VAMOSI				
B.a.c. in mg/100 ml	Accident group	Control group	Drivers whose involvement in accidents can be attributed to alcohol: Estimated number $a_1 - \frac{c_1 \times a_0}{c_0}$	Drivers whose involvement in accidents can be attributed to alcohol: Percentage of accident group $\frac{100}{418} \times \left(a_1 - \frac{c_1 \times a_0}{c_0}\right)$
	13	14	15	16
0— 29	123 (a_0)	370 (c_0)	0	0
30— 99	89 (a_1)	37 (c_1)	76.8	18.3
100—149	82 (a_1)	8 (c_1)	79.4	19.0
⩾150	124 (a_1)	3 (c_1)	123.0	29.4
total	418	418		66.7%

a = Accident group
c = Control group
index o = number of persons with blood alcohol concentrations lower than 50 mg/100 ml (60 mg/100 ml; 30 mg/100 ml).
index I = number of persons with blood alcohol concentrations higher than 50 mg/100 ml (60 mg/100 ml; 30 mg/100 ml), divided into three classes.

Table 3. Drivers involved in accidents attributable to alcohol (SWOV, 1969)

		Sober not responsible	Alcohol involved	Sober responsible	100 mg°o not responsible	Alcohol involved	100 mg°o responsible	Alcohol involved	Total
Driver-multivehicle		4245	1275	5860	475	235	4270	4270	14,850
Adult pass multivehicle		6170	780		2170	1760			8,340
Driver-single vehicle				5225			6925	6925	12,150
Adult passenger single vehicle		4115	1030		1445	1300			5,560
Child passenger		2800	280						2,800
Adult Pedestrian		2525	250	2525	855	430	1995	1995	7,900
Child Pedestrian		700	70	2100					2,800
Bicycle		275 adult 165 child	40	265 adult 385 child			10	10	1,100
Non-traffic	1100								1,100
Total per cent	1100 1.9	21230 37.5		16205 28.6	5325 9.4		12740 22.5		56,600 99.9
Total "Alc Inv" per cent			3725 18.0			3725 18.0		13200 63.9	20,650 *

* Approximately 36.4 per cent of all motor vehicle deaths may involve alcohol in some causal fashion.

Table 4. Categorized estimates of motor vehicle deaths in the United States in 1972 and the portion that may have "involved alcohol" in some causal fashion.

Table 5.

ITEMS FOR FURTHER RESEARCH

A. The influence of alcohol on driving performance.
B. The influence of drugs on driving performance.
C. The influence of air pollution factors (other than CO) on driving performance.
D. The influence of CO on driving performance.
E. The influence of the vehicle micro-climate on driving performance.
F. The effect of vibrations and noise on driving performance.
G. The influence of fatigue on driving performance.
H. The influence of stressors on driving performance.
I. Systems of roadside surveys, including methods of detection.
J. Occurrence in traffic and outside traffic
K. Occurrence in traffic casualties
L. Traffic participation
M. The influence of education on the degree to which temporarily disabled persons abstain from travelling.
N. The influence of enforcement on the degree in which temporarily disabled persons abstain from travelling.
P. The influence of enforcement on the degree in which temporarily disabled persons abstain from driving themselves.
Q. Side-effects of measures related to education and enforcement.
R. Interaction of measures related to education and enforcement with other aspects of the traffic system.

Table 6

WEIGHTING FACTORS FOR THE CRITERIA g_j (SUGGESTED VALUES)

Criteria related to the research itself

K1 theoretical relevance	0.05
K2 applicability	0.15
K3 possibility of realisation (at an international level)	0.10

Criteria related to the measures based on the results

K4 practical relevance	0.50
K5 policy relevance	0.05
K6 political relevance for (international) realization	0.15
	1.00

Table 7

RELEVANCE FACTORS FOR ITEMS FOR FURTHER RESEARCH r_{ij}

criteria k_j	K1	K2	K3	K4	K5	K6
weighting factors g_j	0.05	0.15	0.10	0.50	0.05	0.15
items						
A	10	10	1	30	10	3
B	10	1	1	3	10	3
C	10	1	1	3	3	3
D	10	3	3	1	3	3
E	10	1	10	3	1	3
F	10	3	10	1	1	3
G	10	1	10	10	3	3
H	10	1	1	30	1	3
I	1	30	3	30	1	1
J	3	30	1	30	3	1
K	3	30	1	30	3	1
L	3	30	1	30	10	1
M	3	3	3	3	30	3
N	3	3	1	1	10	3
P	3	3	1	1	10	3
Q	30	3	3	1	1	1
R	30	10	3	1	1	1

Table 8

<u>BENEFIT FACTORS</u> $r_{ij}g_j$

Item	K1	K2	K3	K4	K5	K6	$b_i = \sum_{j=1}^{K} r_{ij}g_j$
A	0.5	1.5	0.1	1.5	0.5	0.45	18.05
B	0.5	0.15	0.1	1.5	0.5	0.45	3.2
C	0.5	0.15	0.1	1.5	0.15	0.45	2.85
D	0.5	0.45	0.3	0.5	0.15	0.45	2.35
E	0.5	0.15	1	1.5	0.05	0.45	3.65
F	0.5	0.45	1	0.5	0.05	0.45	2.95
G	0.5	0.15	1	5	0.15	0.45	7.25
H	0.5	0.15	0.1	15	0.05	0.45	16.25
I	0.05	4.5	0.3	15	0.05	0.15	20.05
J	0.15	4.5	0.1	15	0.15	0.15	20.05
K	0.15	4.5	0.1	15	0.15	0.15	20.05
L	0.15	4.5	0.1	15	0.5	0.15	20.4
M	0.15	0.45	0.3	1.5	1.5	0.45	4.35
N	0.15	0.45	0.1	0.5	0.5	0.45	2.15
P	0.15	0.45	0.1	0.5	0.5	0.45	2.15
Q	1.5	0.45	0.3	0.5	0.05	0.15	2.95
R	1.5	1.5	0.3	0.5	0.05	0.15	4.0

Table 9

RANKING OF BENEFIT FACTORS b_i

No.	Item	$b_i = \sum_{j=1}^{K} r_{ij} g_j$
1	L	20.4
2	I	20.05
3	J	20.05
4	K	20.05
5	A	18.05
6	H	16.25
7	G	7.25
8	M	4.35
9	R	4.0
10	E	3.65
11	B	3.2
12	F	2.95
13	Q	2.95
14	C	2.85
15	D	2.35
16	N	2.15
17	P	2.15

Table 10, 11, 12

THE COST OF RESEARCH

	Table 10	Table 11		Table 12	
Item	Effort factors m_i	Availability t_i	Costs $m_i t_i$	Cost/Benefit $(b/mt)_i$	Ranking
A	10	0.3	3	6.02	1
B	10	0.8	8	0.4	13
C	10	0.5	5	0.57	11
D	10	0.3	3	0.78	7
E	10	0.6	6	0.61	10
F	10	0.4	4	0.74	9
G	10	0.5	5	1.45	4
H	10	0.8	8	2.03	3
I	30	0.3	9	2.23	2
J	30	0.7	21	0.95	5
K	30	0.7	21	0.95	6
L	30	0.9	27	0.76	8
M	10	0.8	8	0.54	12
N	10	0.8	8	0.27	15
P	10	0.6	6	0.36	14
Q	30	0.7	21	0.14	17
R	30	0.8	24	0.17	16

Table 13

RANKING ORDER OF ITEMS

No.		Item	$(b/mt)_i$
1	A	Alcohol	6.02
2	I	Roadside surveys	2.23
3	H	Stressors	2.03
4	G	Fatigue	1.45
5	J	Occurrence in traffic	0.95
6	K	Occurrence in casualties	0.95
7	D	CO	0.78
8	L	Traffic participation	0.76
9	F	Vibrations and noise	0.74
10	E	Vehicle micro-climate	0.61
11	C	Air pollution	0.57
12	M	Education	0.54
13	B	Drugs	0.4
14	P	Enforcement/driving	0.36
15	N	Enforcement/travelling	0.27
16	R	Interactions/education etc.	0.17
17	Q	Side-effects/education etc.	0.14

Table 14

TOXIC AND PSYCHOLOGICAL FACTORS (TEMPORARY AND DIFFERENTIAL)

Alcohol
Medicines
Non-medical drugs
Air pollution factors
Carbon Monoxide
Vibrations and noise
Fatigue
Stressors

Other factors

Darkness
Reduced visibility
Age
Driving experience
Bodily handicaps
Ergonomic vehicle factors

A few examples of unfavourable combinations

Alcohol and medical drugs
Alcohol and darkness
Alcohol and fatigue
Fatigue, darkness and reduced visibility
Alcohol, age and driving experience
Fatigue, ergonomic vehicle factors and vibration and noise
Carbon monoxide, fatigue and bodily handicaps.

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Annex A

USE OF PSYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK

Reginald G. Smart

In: Perrine, M. (ed). Alcohol, Drugs and Driving. Proceedings of an invitational symposium held in Warren, Vermont on October 13-15, 1972. DOT HS 801 096. Psychological Research Foundation of Vermont, Inc., Burkington, 1974.

SUMMARY

This review of data on drug involvement in vehicular accidents indicates that few propositions have been clearly established and no studies have been replicated. An assortment of figures on "drug" incidence in accident and non-accident drivers is available, but few investigators have inquired about the same drugs. Still fewer have made laboratory screenings for them. Also, no two investigators have used similar criteria for selecting their cases, and thus different populations are described. Many "procedures" for data collection do not seem to be reliable nor can they be reproduced by others for comparative purposes.

The following conclusions can be supported:

1. Studies of rates of psychoactive drug use show that 35 to 50% of the general population run the risk of driving after drug use at least once per year. About 7% of the general population are exposed to risk of drinking and driving while on psychoactives.

2. The extent of use of amphetamines by accident and non-accident drivers is especially uncertain as few relevant studies have utilized laboratory analysis for these drugs. Most studies have

been concerned with barbiturates or selected tranquilizers.

3. There is a substantial problem of psychoactive drug use among drinking drivers. At least 7% of drinking drivers have a psychoactive drug in their system, and 50% of fatally injured drivers with drugs in their system have also been drinking. This suggests that drugs and driving may be much the same problem as drinking and driving.

4. At least some psychomotor impairment in drivers with low or non-existent blood alcohol concentrations is due to their use of psychoactive drugs. It follows that some highly impaired drivers will be missed by alcohol screening procedures. Few studies have analyzed for narcotics, but those which have suggested that they may constitute a large proportion of the total positive analyses for accident drivers and victims in some areas. Barbiturates are the psychoactive drugs most commonly found among accident and non-accident drivers.

5. Less is known of the contribution of opiates and hallucinogens to driving risk than of prescription drugs. Difficulties in easy roadside or laboratory analysis are at least partly to blame, especially where marihuana is concerned. There has been no determined effort to associate the use of psychoactive drugs by drivers with specific driving errors or with responsibility for accidents. Further, it is not known whether drivers who need psychoactive drugs, would actually be more dangerous on the road without them than with them.

6. Hallucinogenic drugs such as cannabis and LSD have not been analyzed for their frequency in fatal accident drivers. Few analytic or questionnaire studies have been made of how many drivers were using these drugs alone or with alcohol before their accident.

7. Studies of cannabis users are inconsistent as to whether such users have higher than average rates of accidents, and their

accidents can not be attributed to cannabis use rather than to social, demographic, or personality characteristics. However, some heavy users of drugs, especially heroin addicts, do have elevated accident and/or violation rates. However, it is not clear whether their accidents and violations are mainly due to their drug use or to other associated social and psychopathologies.

At present, the largest gaps in knowledge concern the role of hallucinogens, narcotics, and to a lesser extent amphetamines in driving risk. The difficulties of securing body fluids and analyzing for these drugs mean that they have rarely been examined for a role in traffic accidents.

Relative to some driving risks (e.g., drinking), drugs would appear to be a small problem -- based on existing evidence. It should be strongly emphasized that this could be more a feature of the state of the art and current research inadequacies than a representation of reality. The possible reduction in accidents and fatalities represented by eliminating <u>known drug use</u> before driving could not be more than 10% at the outside. It probably would be much less because it is not known that all drug using drivers were at fault or that their "fault" resulted mainly from their drug use.

Extensive work on countermeasures against drugs and driving is not indicated currently. Education, in terms of fair, unbiased information given to physicians and young people is recommended for the present. The most valuable countermeasure may, however, be suggested from some of the further research on drugs and driving, especially the narcotic and hallucinogenic drugs. Serious application of countermeasures will, of course, depend on the outcome of this research and on the establishment of drugs as a priority investigation and social policy area.